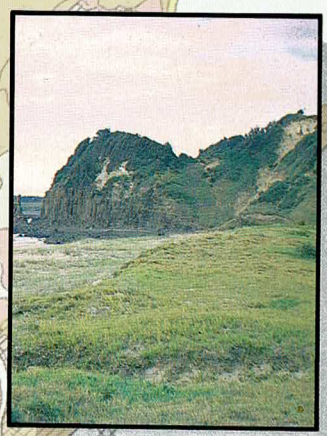
Soil Landscapes of the Kiama 1:100 000 Sheet



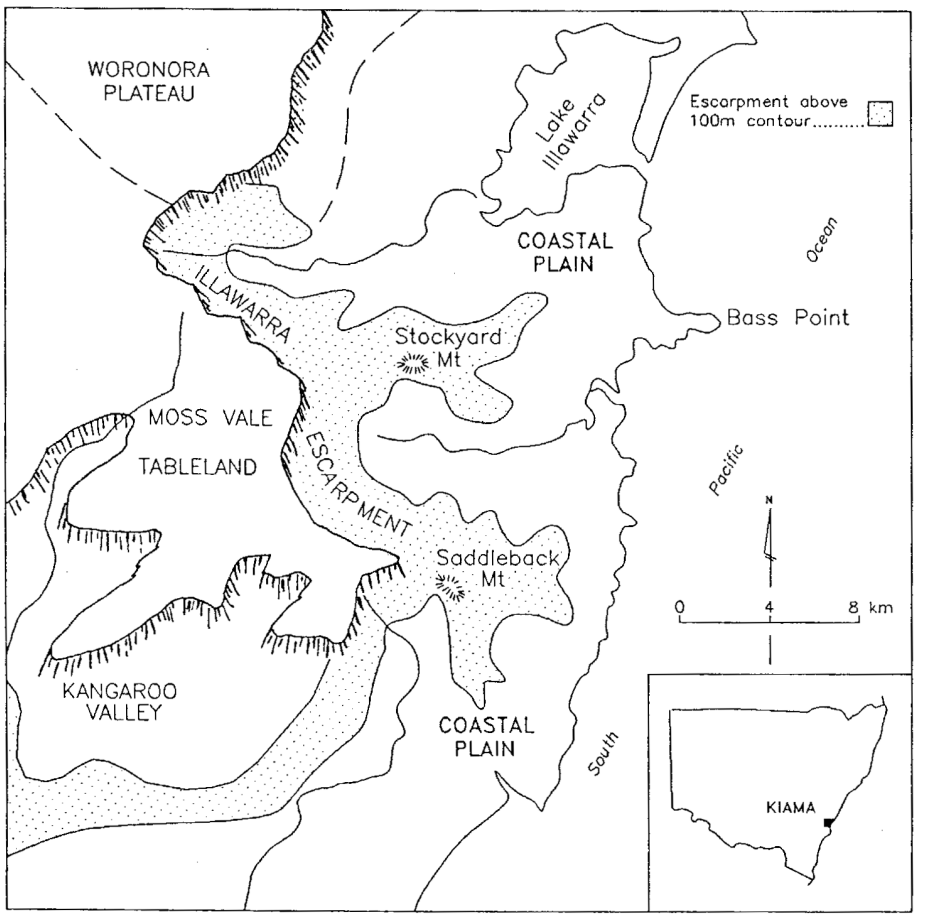
Soil Landscapes of the

Kiama

1:100 000 Sheet

P.A. Hazelton

1992



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The mapping program was initiated by R.J. Morse and G. Atkinson.

Mapping procedures were vetted by the NSW Soil Survey Committee.

CONTENTS

1 INTRODUCTION

This report and the accompanying map have been produced in response to the many enquiries received each year from land planning authorities and the general public by the Soil Conservation Service of NSW about the nature and limitations of soils in Kiama and surrounding areas. This is the fourth of a series of soil landscape maps based on the CMA 1:100 000 topographic map series and is designed to provide soil and landscape resource information in a form accessible to a wide range of users.

The use of the soil landscape concept permits the integration of both soil and topographic constraints into one unit so that the map can be viewed in terms of limitations to urban and rural development.

A feature of the mapping is that characteristics of the soils within each soil landscape are described in terms of the composition and distribution of "soil materials" (Atkinson *et al.* 1985) in addition to the traditional methods of soil classification (Stace *et al*. 1968; Northcote 1979).

2 PHYSICAL ATTRIBUTES

2.1 Location

The Kiama 1:100 000 map sheet covers a land surface area of approximately 2 000 km^2 and is bounded by latitudes 34°30′ S and 35°00′ S and longitudes 150°30′ E and 151°00′ E. The mapped area is located on the central and southern Illawarra coast of New South Wales encompassing the southern suburbs of the City of Wollongong and the towns of Kiama, Berry and Nowra. It extends from Lake Illawarra in the north-east to the Robertson Tableland in the north-west and Jervis Bay in the south-east to Nowra Aerodrome in the south-west.

2.2 Physiography

There are five physiographic regions within the Kiama 1:100 000 map sheet (Figure 1):

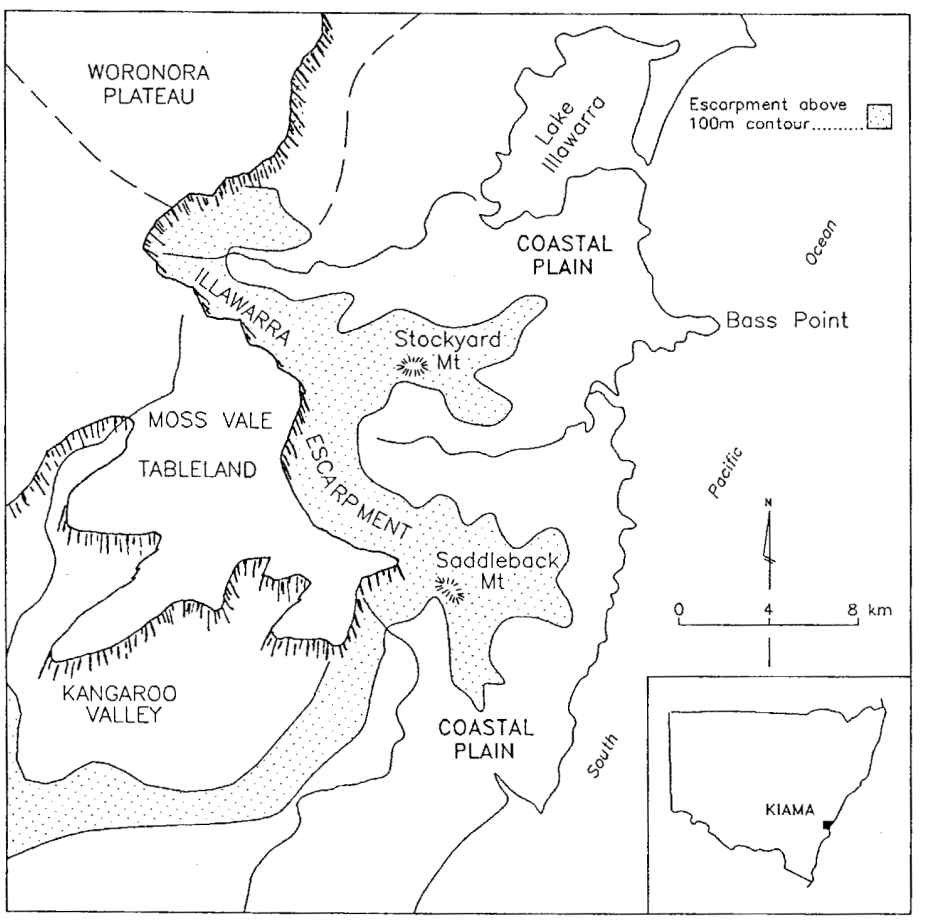
- Woronora Plateau
- Illawarra Escarpment
- Coastal Plain
- Moss Vale Tableland
- Kangaroo Valley.

The Woronora Plateau lies on the northern extremity of the map sheet. It is a deeply dissected Hawkesbury Sandstone plateau with Wianamatta Group shales occurring as thin caps in the south-western region. Upland swamps are a common feature along the eastern fringe.

The Illawarra Escarpment marks the eastern edges of the Woronora Plateau and the Moss Vale Tableland. The escarpment comprises cliff faces below which lies a continuous talus mantle on steep slopes of bedrock.

The Coastal Plain lies between the Illawarra Escarpment and the sea. It consists of gentle rises of the Illawarra Coal Measures, rolling to steep low hills of volcanic materials, moderate to steep slopes of Berry Siltstone, undulating Budgong Sandstone and Quaternary alluvium.

The Moss Vale Tableland, an elevated plateau, lies in the north-western region of the map sheet.



■ *Physiographic Regions of the Kiama 1:100 000 Sheet.*

Hawkesbury Sandstone outcrops cover much of the deeply dissected undulating plateau with residual outcrops of Wianamatta Group shales and Robertson Basalt occurring as rolling hills on the western extremity.

The Kangaroo Valley is bounded by the Illawarra Escarpment to the east and the Moss Vale Tableland to the west. It comprises gentle rises of the Illawarra Coal Measures, moderate to steep slopes of Berry Siltstone, undulating slopes of Budgong Sandstone and broad flats of Quaternary alluvium.

2.3 Geology

A wide variety of geology exists within the mapped region. According to Bowman (1974) the stratigraphy of the Kiama map sheet ranges from Tertiary Robertson Basalt to Permian Wandrawandian Siltstone.

Robertson Basalt, which occurs on the Moss Vale Tableland, consists of olivine in a fine-grained groundmass of plagioclase augite, magnetite, chlorite and analcite. Examples include Knapsack Hill and Kangaloon.

The Middle Triassic Wianamatta Group (Bringelly Shale consisting of mid grey shale and lithic sandstone) underlies the Tertiary Robertson Basalt which also occurs on the Moss Vale Tableland. Examples include Mount Murray, Wildes Meadow and Glenquarry. This group overlies the Middle Triassic Hawkesbury Sandstone comprising quartz sandstone with minor shale and laminite lenses. Examples include Barren Grounds and Knights Hill.

The Narrabeen Group, consisting of chocolate claystone and quartz lithic sandstone, underlies the Hawkesbury Sandstone and occurs along the ridges of the Illawarra Range and around the rim of the Kangaroo Valley.

The Narrabeen Group overlies the Illawarra Coal Measures consisting of interbedded quartz lithic sandstone, mudstone, carbonaceous claystones and coals. This formation occurs throughout the Illawarra Escarpment.

The Permian Illawarra Coal Measures are underlain by the Permian Shoalhaven Group, which includes the following formations: Budgong Sandstone, Berry Siltstone, Nowra Sandstone, Wandrawandian Siltstone and several latite flows. The latite flows include:

- Cambewarra Latite Member, felsic latite—examples, Cambewarra Range and Kangaroo Valley
- Saddleback Latite Member, mafic latite—examples, upper slopes of Kangaroo Valley and midslopes of the Cambewarra Range
- Bumbo Latite Member, aphanitic to porphyritic latite—examples, Bombo and lower slopes adjacent to Macquarie Rivulet
- Blow Hole Latite Member, mid grey latite generally aphanitic—examples, Kiama, Gerroa and Gerringong.

These latite flows are underlain by and interbedded with the Budgong Sandstone which consists of red, brown and grey volcanic sandstones, which outcrops on the lower slopes of the Kangaroo and Jamberoo Valleys.

The Budgong Sandstone overlies the Berry Siltstone which interfingers with and overlies the Nowra Sandstone. Berry Siltstone consists predominantly of massive indistinctly bedded to flat bedded mid to dark grey siltstone, mudstone and fine sandstone and outcrops on the Coastal Plain from Yallah in the north to Nowra in the south and to Kangaroo Valley in the west.

Nowra Sandstone consists of fine- to coarse-grained often pebbly quartzose sandstone, the lowermost and uppermost few metres being passage beds into the underlying Permian Wandrawandian Siltstone and the overlying Berry Siltstone respectively. This sandstone member extends along the Coastal Plain from Stockyard Mountain in the north to Nowra in the south and to Kangaroo Valley in the west.

Wandrawandian Siltstone consists of poorly sorted pebbly lithic sandstone and outcrops at Greenwell Point, Orient Point and Culburra.

A volcanic agglomerate neck occurs at Saddleback and has intruded the Budgong Sandstone and the Triassic Bong Bong Basalt Sill. This sill is one of the numerous occurrences in the region and intrudes the Illawarra Coal Measures between Jamberoo Pass and Woodhill. It is also referred to as Bong Bong Basalt. Other Triassic sills include the Minnamurra Falls Tinguaite, Wallaya Dolerite also intruding the Illawarra Coal Measures and the Kangaroo Mountain Sill outcropping in the vicinity of Kangaroo Mountain. The latter sill has been renamed Kangaroo Basanite.

Quaternary peat occurs in the Wingecarribee Swamp on the Moss Vale Tableland. The Bass Point Sandstone, poorly lithified well rounded fine- to medium-grained light grey sand of quartz and shell grit, outcrops at Bass Point on the Coastal Plain.

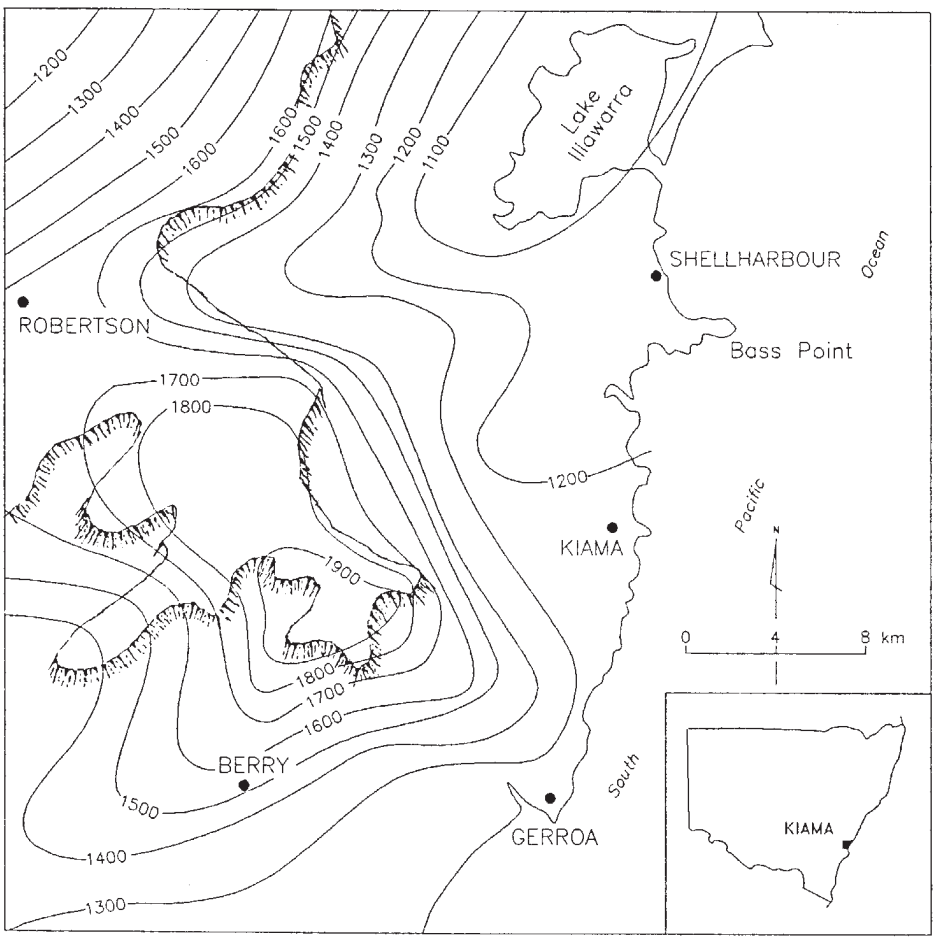
Quaternary alluvium occurs along the major watercourses. The nature of the alluvium varies considerably, depending especially on the lithology of the source material and the distance it has been transported. Quaternary marine sediments are found along the coast. These usually consist of quartz sands, shell fragments and mud.

2.4 Climate

The climate of the mapped area varies from temperate with a maritime influence on the coast to cooler temperate conditions on the plateau. Summer and autumn are characterised by moderate to high temperatures, high humidity, on-shore winds and peak rainfall. One third of the mean annual rainfall occurs during January, February and March. There is also a marked secondary rainfall peak in June.

Temperatures vary widely from warm summers and mild winters on the coast to warm summers and cold winters in elevated areas. North of the survey area at Port Kembla, the mean daily maximum temperature for February, the hottest month, is 24.4°C. The mean daily minimum for July, the coldest month, is 9.8°C. At Moss Vale west of the mapped area, the mean daily maximum for February is 25°C, and the mean daily minimum for July is 1.5°C.

The mean annual rainfall varies throughout the mapped area from 1 210 mm at Kiama to 1 420 mm at Berry and 1 007 mm at Nowra to 1 600 mm at Robertson. Rainfall distribution is attributed to winds blowing from the south. Generally warm seasonal rainfall is more reliable than cool seasonal rainfall. Uplift causes a high rainfall up to 275 mm (Neville 1977) in 3 days, especially on Saddleback Mountain. On the northern side of Saddleback Mountain and Barren Grounds, the sudden drop from the mountains into the Jamberoo Valley is accompanied by a decrease in rainfall. There is a rain shadow effect at the upper end of the Macquarie Pass Valley. The number of rain days varies throughout the region from 31 days (summer) to 28 days (winter)



■ *Distribution of Average Annual Rainfall in Central Illawarra.*

on the Moss Vale Tableland to 37 days (summer) to 27 days (winter) on the Coastal Plain.

During winter westerly airflows dominate the weather producing cooler, drier conditions. There are few or no frosts on the Coastal Plain, but frosts do occur on the Tableland. For example, the average frost-free period for Nowra is 343 days whereas at Moss Vale it is 134 days (Foley 1945). Snow falls rarely at Robertson and on the highest parts of the Plateau.

2.5 Vegetation

Major vegetation structural formations are described for each soil landscape according to the classification of Specht *et al.* (1974) with a supplementary vegetation classification provided in brackets. Common names are provided for conspicuous, common or indicator species. Alphabetical lists of scientific names and corresponding common plant names are provided in Appendix 7.1. Further information on vegetation of the mapped area is available in Fuller and Mills (1985). Common names used follow Fairley and Moore (1989) or Fuller and Mills (1985).

Local combinations of geology, landform, soil and climate have contributed to the diversity and distribution of the vegetation of the mapped area.

The vegetation can be divided into:

- tall open-forests where the most common species are *Eucalyptus,* especially blackbutt (*Eucalyptus pilularis*), sydney peppermint (*Eucalyptus piperita*), white-topped box (*Eucalyptus quadrangulata*) and forest red gum (*Eucalyptus tereticornis*). The trees are 30 m high with canopy cover of 30–70%—for example, Blackbutt Reserve at Shellharbour
- closed-forests which are divided into:
  (a) warm temperate rainforest where the most common species are coachwood (*Ceratopetalum apetalum*), giant stinging tree (*Dendrocnide excelsa*) and sassafras (*Doryphora sassafras*) which grow on the escarpment—for example, Macquarie Pass, Cambewarra Mountain Road
  (b) littoral rainforest including red cedar (*Toona australis*) and cabbage tree palm (*Livistona australis*) growing for example within the Jamberoo Valley
- woodland and open-forests, where the height of trees varies from 5–30 m and the canopy 10–70%. The tree cover is incomplete and permits entry of sunlight. Common tree species include rough-barked apple (*Angophora floribunda*), spotted gum (*Eucalyptus maculata*), scribbly gum (*Eucalyptus sclerophylla, Eucalyptus racemosa, Eucalyptus haemastoma*) and turpentine (*Syncarpia glomulifera*). This type of vegetation occurs in State Forests—for example, Nowra and Shoalhaven
- heathland and shrubland including swamp heath (*Epacris paludosa*), prickly broom-heath (*Monotoca scoparia*), coral heath (*Epacris microphylla*) and taller shrubs—for example, heath banksia (*Banksia ericifolia*), and scrub she-oak (*Allocasuarina distyla*). Examples of this vegetation type grow on Barren Grounds Nature Reserve.

Many areas have been extensively cleared, especially along the Coastal Plain. In the early nineteenth century, loggers moved into the rainforest areas cutting red cedar (*Toona australis*) for the fast growing settlement of Sydney. The loggers were quickly followed by the dairy farmers clearing land for pastures.

2.6 Land Use

There is a variety of land use throughout the mapped area. Moderate to extensive urban development has occurred along the foreshores of Lake Illawarra (for example, Windang), the coast (for example, Shellharbour) and the hinterland (for example, Oak Flats and Albion Park which has a small aerodrome). Further ribbon development occurs along the coast from Minnamurra to Kiama Heights including the service and tourist centre of Kiama. Small centres such as Gerringong and Werri Beach are located in close proximity to Kiama. The largest service centre, however, in the southern section of the region is Nowra, with the nearby townships of Bomaderry, Berry and the coastal settlements of Orient Point and Culburra. Included within the Nowra hinterland are Albatross Naval Base and Nowra Aerodrome.

Further inland on the gently undulating country and alluvial plains, cattle grazing and hobby farms on improved pastures are the most common land use (for example, in Jamberoo and Kangaroo Valley). Scattered pockets of vineyards have been planted in close proximity to Bomaderry.

Numerous State Forests including Currambene and Yarrawa and nature reserves and National Parks including Barren Grounds Nature Reserve and Morton National Park are located throughout the mapped area.

Coalmines and quarries are scattered throughout the Kiama map sheet.

3 METHODS

3.1 Definitions

Terminology used follows McDonald *et al*. (1984) and Morse *et al*. (1982).

Soil Landscapes. Soil landscapes are 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).

Landscapes can be used to distinguish mappable areas of soils because similar causal factors are involved in the formation of both landscapes and soils. Similarly, constraints to rural and urban development of land are related to both landscape and soil limitations. The soil landscape concept permits the integration of both soil and landform constraints into a single mapping unit.

Each soil landscape is given a name based on the locality where a typical example occurs. On the map this is represented by a two-letter alphabetic code. For example, the Robertson soil landscape occurs on basalt on the Robertson Tableland. It is represented on the map by the code letters '**ro**'.

Soil Materials. A feature of the methodology is the use of the "soil materials" concept to describe the soil. Soil materials are "three-dimensional soil entities which have a degree of homogeneity and lateral continuity" (Atkinson *et al*. 1985). Each soil material is defined and described in terms of its readily recognised and characteristic morphological properties. The definitive attributes may vary from one soil material to another, depending on what is recognisably characteristic of the material. In most cases each soil material has a consistent set of properties and limitations. This is because soil materials are not necessarily defined by soil formation processes or position within a soil profile. Introduced fill, weathered rock or unconsolidated alluvium may be included. However, soil materials usually correspond with soil boundaries. The vertical association of soil materials in a soil profile can be classified using traditional soil taxonomic systems such as Great Soil Groups (Stace *et al*. 1968) or Principal Profile Forms (Northcote 1979). However, soil materials often cross these traditional taxonomic boundaries.

Each soil material has a unique code consisting of two letters and one number. The letters are taken from the soil landscape in which the material is found, and the number distinguishes it from other soil materials in the same soil landscape. For example, **ro2** is the second soil material described in the Robertson soil landscape.

Included Soil Landscapes. Included soil landscapes are small areas of other soil landscapes found within a predominant landscape. They are too small to be delineated at 1:100 000 scale.

Associated Soil Landscapes. Associated soil landscapes occur in most instances on adjacent map sheets but occupy relatively small areas (<5 ha) of land on the Kiama 1:100 000 sheet. Associated soil landscapes are described at the end of Chapter 5. Laboratory results for these landscapes are from the adjacent Wollongong 1:100 000 sheet.

Associated Soil Materials. Associated soil materials, which are ephemeral or have limited extent, are briefly described.

3.2 Previous Surveys

There have been numerous soil surveys undertaken of various regions within the Kiama 1:100 000 sheet. An early survey by Walker (1960*b*), which included part of the mapped region at the scale 1:500 000, described the relationship of soil and land use of part of the south coast of NSW. Studies of specific areas have been undertaken by the Soil Conservation Service of NSW by Morse and Atkinson (1979) and Atkinson (1980), and by the University of NSW by Burrough, Brown and Morris (1977). Urban capability studies have been undertaken by Hird, Quilty and Houghton (1977), Hicks and Davies (1978) and Hughes, Davies and Hicks (1985). A land capability study of Wingecarribee and Fitzroy Falls was carried out by the Soil Conservation Service of NSW in 1976 and a land resources survey of the Kiama area by Hird and Dolman in 1983.

3.3 Mapping

Provisional soil landscapes were established, based firstly on the dominant geomorphic processes responsible for the formation of the landscape and secondly on the geological parent material. The boundaries of these provisional soil landscapes were mapped using stereoscopic interpretation of 1:40 000 black and white aerial photographs (1984). Boundaries were transferred onto 1:25 000 topographic maps. After boundary checking in the field and detailed investigation of the soils, the provisional landscapes were confirmed, amalgamated or subdivided. The resulting soil landscapes are presented on the map in groups based on their dominant geomorphic processes. A colour has been allocated to each

group.

Soils were examined and described in detail at over 150 sites and inspected at many hundreds more over the 28 landscapes. At each described site, soil morphological data and site information were recorded on Soil Data Cards (Morse *et al.* 1982). The correct landscape classification was confirmed at each inspection site. Soil descriptions were made from available exposures at building sites, road batters and trenches and from hand-augured holes. Over 140 soil samples were collected for laboratory analysis. Sufficient field sampling was undertaken within each soil landscape to identify and describe the range of soil materials present to enable individual description of their occurrence and relationships.

Soil profile data, site data, and laboratory data may be obtained through the NSW Soil Data System on application to the Department of Conservation and Land Management.

3.4 Reliability

Soil landscape map unit boundaries were delineated at 1:25 000 scale for publication at 1:100 000. Soil landscape units of <40 ha were generally not mapped unless they were considered to be locally significant. Boundaries between soil landscapes are drawn as solid lines where they could be delineated reliably and as broken lines where they were more diffuse or difficult to identify.

The information in this report and the accompanying map should be used at the scale at which it is published. Enlarging the map will produce distortions whereby map boundaries will no longer correspond to boundaries on the ground. If more detailed information is required, specific purpose surveys should be conducted or professional advice sought.

3.5 Land Disturbance

Some areas within the Kiama region have been extensively disturbed or developed, making the original soil landscape difficult to identify. Two degrees of soil disturbance have been depicted on the map to indicate the extent to which the original soil material has been disturbed.

Where the shape of the original land surface has been extensively altered and where soil material has been removed, disturbed or buried, the area has been mapped as Disturbed Terrain. These sites have been coded **"xx"** and include reclaimed alluvial flats, quarries, rubbish dumps and major commercial and industrial areas.

Where the original soil landscape can still be recognised but there is significant disturbance of the soils, the area is mapped as Developed Terrain. It is depicted on the map with a diagonal hatch over the original landscape. Developed Terrain includes medium to high density development, usually with extensive paving, terracing or landscaping.

3.6 Laboratory Testing

The following soil tests were undertaken at Wellington Research Service Centre and Scone Research Service Centre for at least one representative sample of each soil material.

Table 3.1. Soil Laboratory Tests

Laboratory Test	Symbol	Units	Laboratory Code	References
Bray Phosphate	(Bray P)	ppm	C8A/2	(Abbott 1985)
Phosphate Sorption	(P Sorp)	ppm	C8B/1	(Abbott 1985)
Cation Exchange Capacity	(CEC)	me/100 g	C5A/2	(Pleysier & Juo 1980)
Exchangeable Cations		me/100 g	C5A/2	(Pleysier & Juo 1980)
Dispersion Percentage	(D)	%	P8A/2	(Ritchie 1963)
Electrical Conductivity	(EC) (1:5 soil:H_2O)	dS/m	C2A/3	(Abbott 1985)
Emerson's Aggregate Test	(EAT)	class	P9B/2	(Charman 1978)
Organic Carbon	(OC)	%	C6A/2	(Black 1965)
Particle Size Analysis	(PSA)	%	P7B/1	(SCS lab procedures)
pH (1:5 Soil:H_2O)	(pH)		C1A/2	(US Sal Lab Staff 1954)
USCS Classification	(USCS)	class	P13A/3	(US Bureau Recln. 1960)
Volume Expansion	(VE)	%	C5A/1	(Wickham *et al.* 1973)
Available Water-holding Capacity	(AWC)	%	P18B/1	(McIntyre 1974)

4 LIMITATIONS AND CAPABILITY

4.1 Soil Limitations

Soil limitations are soil properties which may restrict urban or rural development. The degree of severity of soil limitations will vary with site conditions and the proposed land use. The following limitations are listed for each soil material in Table 4.1.

Low Wet Bearing Strength. Soils with low wet bearing strength are usually fine-grained soils which are pliable and deform easily under pressure when wet. They are unsuitable for foundations and make site access difficult. Low wet bearing strength soils often suffer severe structural damage if cultivated or mechanically disturbed when wet.

Shrink-Swell Potential. Expansive soils shrink and swell with changes in moisture content. They can damage structures such as buildings, roads, dams, walls and underground services. The shrink-swell potential of most soils can be reduced by compaction, the addition of lime or gypsum, or burial with a stable material. Soil movement can be reduced by keeping soil moisture constant through drainage, slow irrigation or covering soils with impermeable materials (see Appendix 7.3).

Organic Soils. Soils with large amounts of organic matter such as peats and sandy peats are generally unsuitable for use as engineering materials because they have low wet bearing strength and their physical properties may be subject to change through decay. They are generally well structured for plant growth and have high available water-holding capacities. However, they are often very acid and may require large quantities of lime and nitrogen, as well as other nutrients and trace elements, for optimum plant growth. Most topsoils contain sufficient organic matter to be unsuitable for engineering purposes.

Stoniness. Stones and rocks increase the cost and difficulty of excavation for underground services. Stones and rocks make the soil difficult to work and occupy soil volume, reducing plant exploitable moisture and nutrients.

Sodicity. Sodic soils are often highly erodible, are generally expansive and have low wet bearing strength. They set extremely hard when dry and often form surface crusts. They are prone to severe structural degradation and require very careful management. Sodic soils may be treated with additions of lime, dolomite or gypsum.

High Erodibility. Soil erodibility is the susceptibility of a soil to erosion. It is based solely on soil properties. Landscape properties such as slope gradient, slope length, landform element and rainfall characteristics are not included in the assessment. Disturbance should be minimised on erodible soils, and disturbed areas should be protected by ground cover as soon as possible. Further details are presented in Appendix 7.5.

Hardsetting Surfaces. Hardsetting soils become hard and compact when dry. They do not readily absorb rainwater and cause high runoff with consequent soil erosion. They do not offer favourable environments for seed germination and require careful water management. Regular cultivation should be avoided, although some cultivation may be necessary to break up the hard layer for successful germination. Mulches are recommended to help retain soil moisture.

Permeability. Soils which drain water quickly are highly permeable. They usually have coarse textures (sands) and many interconnected pores. They are not suitable for absorbing effluent from septic systems because liquid drains rapidly into the ground water where it can cause pollution and possible health problems elsewhere. Soils with high permeability often have low water-holding capacities. Seedlings and newly established plants require regular, light irrigation.

Soils of low permeability usually have very slow drainage and are likely to pond water for long periods. They usually have clayey textures and mottled or greyish colours. They are not suitable for absorbing effluent. Special drainage may be required. They may also be sodic and have low wet bearing strengths.

Acidity. Extremely and strongly acid soils with laboratory measured pH values <5.5 often give rise to acid soil infertility. The more common problems are toxic levels of aluminium and/or manganese and deficiencies of calcium and molybdenum. Whilst many endemic native species are tolerant of acid conditions, susceptible species may require heavy applications of lime or dolomite, and often fertiliser, to raise the pH and nutrient supply to a satisfactory level. Acid soils may corrode untreated underground metal pipes, structures and concretes.

Alkalinity. Alkaline soils have laboratory measured pH values >8.5. Alkalinity may inhibit the growth of plants. High levels of carbonate or bicarbonate may impair the uptake of iron,

Table 4.1 General Urban and Rural Capability for Each Soil Landscape.

SOIL LANDSCAPE	URBAN LAND CAPABILITY			RURAL LAND CAPABILITY			
	Low Limitations for Urban Development	Moderate Limitations for Urban Development	High to Severe Limitations for Urban Development	Low to Moderate Limitations for Regular Cultivation	High to Severe Limitations for Regular Cultivation	Low to Moderate Limitations for Grazing	High to Severe Limitations for Grazing
Albion Park		●	○		●	●	
Barrengarry	●		○		●		●
Barren Grounds		○	●		●	●	○
Bombo		●	○		●	●	○
Cambewarra			●		●	●	
Coolangatta		●	○		●	●	
Ellerslie		○	●	●		●	
Fairy Meadow		○	●	●		●	
Fountaindale	●		○	●	○	●	○
Greenwell Point	●			●		●	
Hawkesbury			●		●		●
Illawarra Escarpment			●		●		●
Jamberoo		●	○	○	○	●	
Kiama	●	○			●	●	
Killalea			●	○	○	●	○
Mangrove Creek			●		●		●
Nowra	●			●		●	
Pulpit Rock			●		●		●
Robertson	●		○	●	○	●	
Seven Mile			●		●		●
Shellharbour	●			●		●	
Shoalhaven			●	●		●	
Wattamolla Road		●	○		●	●	
Wildes Meadow			●		●	●	
Wingecarribee			●	○	○	○	○
Wollongong				●		●	●

● : General occurrence (widespread)
○ : Localised occurrence

Table 4.2 Landscape Limitations for Each Soil Landscape.

SOIL LANDSCAPE	SLOPE STABILITY			DRAINAGE				EROSION			SOILS			OTHER	
	Steep Slopes	Mass Movement Hazard	Rock Fall Hazard	Flood Hazard	Waterlogging	Permanently High Watertables	Seasonal Waterlogging	Water Erosion Hazard	Wind Erosion Hazard	Wave Erosion Hazard	Shallow Soil	Non-cohesive Soil	Surface Movement Potential	Rock Outcrop	Run-on
Albion Park	○				○		●	●			○			○	○
Barrengarry				○	●	●	●	○						●	
Barren Grounds	○	○						●							○
Bombo	○	○	●					●						●	○
Cambewarra	●	●	●					●			●			●	
Coolangatta	○	○						●			○		○	○	
Ellerslie				●	●	●		●						○	●
Fairy Meadow					○	○	●								●
Fountaindale		○						○						○	●
Greenwell Point									○	○	○			○	
Hawkesbury	○	○	○						●		○				○
Illawarra Escarpment	●	●	●					●			●			●	
Jamberoo	○	○												○	●
Kiama	○		○					○						○	●
Killalea				●	●	●									
Mangrove Creek				●	●	●				●					
Nowra												○			○
Pulpit Rock	●	●	●					●			●			●	
Robertson	○														
Seven Mile					○	○			○			●			
Shellharbour	○	○						○		○	○			○	
Shoalhaven				●	○	●	●								
Wattamolla Road	○	○						○						○	●
Wildes Meadow	○	○					○	○					●		○
Wingecarribee					●	●									●
Wollongong					○					●	●				

● : General occurrence (widespread)
○ : Local occurrence

manganese, copper and zinc. These soils are also frequently sodic or saline.

Two different classes have been used to distinguish between field and laboratory measurements.

- Field pH measurements are given for all soil materials under soil landscape descriptions, and the following ranges have been used:
  - extremely acid <3.5
  - strongly acid 3.5 – 4.5
  - moderately acid 4.5 – 5.5
  - slightly acid 5.5 – 6.5
  - neutral 6.5 – 7.5
  - slightly alkaline 7.5 – 8.5
  - moderately alkaline 8.5 – 9.5
  - strongly alkaline 9.5 – 10.5
  - extremely alkaline >10.5
- Laboratory pH values are categorised after Bruce and Rayment (1982) and are described in Appendix 7.6 and listed in Appendix 7.7. Only laboratory measured pH values have been used in the soil limitations section of each soil landscape description.

Salinity. Excessive salt is toxic to most plants. Saline surface soils are usually bare or have sparse plant cover. These soils have a high erosion hazard and are often poorly drained. Treatment of saline soils often involves removal of saline water by drainage and deep ripping, as well as establishment of salt-tolerant species. Cover crops, mulches and large applications of nitrogenous fertilisers as well as gypsum are often required for successful vegetation establishment. Measures which further reduce concentration of salts within the plant root zone, such as tree or lucerne plantings in recharge areas, may be required to ensure long-term rehabilitation. Saline soils may be corrosive to untreated underground services.

Aluminium Toxicity Potential. High levels of soluble aluminium are often toxic to plants. High levels occur most frequently in strongly acid soils.

Fertility. Soils with poor chemical fertility usually require the application of chemical fertilisers, seasoned manure or compost to achieve permanent plant cover. Some soils do not respond well to normal applications of fertiliser. For example, soils with high aluminium or iron oxide contents readily "lock up" phosphate, making it unavailable to plants.

Available Water-holding Capacity. Soils with low available water-holding capacity can store only limited amounts of water which can be extracted by plants. Plants growing in these soils require small and frequent applications of water for optimum growth. Further details on the procedures used to rank available water-holding capacity for each soil material are presented in Appendix 7.6. The interpreted values for each soil material are presented in Appendix 7.7.

4.2 Landscape Limitations

Landscape limitations are landform properties which may restrict urban or rural development. The degree of severity of landscape limitations will vary with site conditions and the proposed land use. These are listed for each soil landscape in Table 4.2. Methods of controlling and ameliorating these limitations are described in Quilty *et al.* (1978). Categories of limitations are explained briefly below.

Steep Slopes. A number of landscape hazards increase with slope. Soil erosion is more severe, rock outcrop is more common, soils are generally shallower and mass movement is more likely with increasing slope. Therefore, slope is an important controlling parameter for both urban and rural capability.

Mass Movement Hazard. Mass movement is a general term for a number of forms of slope failure. It includes rock falls and earth slumps, slips and flows on steep, and often wet, slopes. It may lead to severe damage to buildings, roads and services or may result in recurrent problems such as shifting foundations.

Rock Fall Hazard. Areas immediately below cliffs and unstable scarps are at risk of serious damage from rock falls and other mass movement debris.

Flood Hazard. Areas subject to periodic flooding by stormwater runoff and overland flow by rivers and streams should be retained as drainage reserves.

Waterlogging. Waterlogged soils have permanent watertables at or near the surface. They may also be non-cohesive, organic, saline, acidic, infertile and have low wet bearing strength. They are unsuitable for septic effluent disposal.

Permanently High Watertables. Problems often occur where watertables are permanently within 2 m of the surface. The surface soil materials may dry out, but subsurface soils are often saturated. In these soils septic effluent disposal often results in ground water pollution.

Seasonal Waterlogging. Seasonally high watertables result in similar problems to permanently waterlogged soils. Soils in landscapes with this limitation can become extremely dry for long periods.

Water Erosion Hazard. Erosion hazard is the susceptibility of an area of land to prevailing agents of erosion. It is determined by factors such as climate, topography, soil erodibility and land use. Areas subject to erosion require special protective measures (Quilty *et al*. 1978). Water erosion hazard for sheet and rill erosion is estimated using a modified Universal Soil Loss Equation (see Appendix 7.2 for details). Erosion hazard for concentrated waterflow has also been assessed.

Wind Erosion Hazard. Areas subject to wind erosion typically are exposed and have easily transported, unconsolidated, loose sandy and often dry topsoils. Vegetative cover should be maintained to prevent erosion.

Shallow Soils. Shallow soils are <50 cm deep. This increases the difficulty of installing underground services and restricts plant growth.

Non-cohesive Soils. Loose sandy soils can be subject to severe wind erosion, gully erosion and batter failure. Batters steeper than 25% should be supported with retaining walls. Batters with slopes less than 25% should be revegetated quickly.

Surface Movement Potential. Surface movement potential is an estimate of potential soil shrink and swell movements which may occur with changes in soil moisture content. Surface movement can cause expensive damage to inappropriately designed buildings, roads and underground services. These soils are known in the building industry as reactive soils. Soils have been classified using the Builders Licensing Board's five class reactivity classification. (For further details, see Appendix 7.3. Laboratory results used to assist in determining surface movement potential are presented in Appendix 7.4.)

Rock Outcrop. Rock outcrop restricts excavation and the installation of underground services. Garden establishment is often difficult where there is rock outcrop.

Run-on. Run-on is surface water flowing onto an area as a result of runoff occurring higher up the slope. It is often used in an urban context as a contributing factor to increased erosion hazard.

4.3 Urban Capability

Urban capability is the ability of a parcel of land to support a particular intensity of urban development without serious erosion and sedimentation occurring during construction, as well as possible instability and drainage problems in the long term (Houghton and Charman 1986). Urban capability is ranked on the basis of the severity of the limitations which are likely to affect urban land uses (Hannam and Hicks 1980).

It is recognised that some parts of the Kiama mapped area classified as "high limitations—i.e., not capable of urban development" have been extensively urbanised. Soil and landscape limitations identified above have caused cracking of roads and buildings, sedimentation of streams, blocked drains and localised flooding. These are all expensive problems to overcome. If limitations to urban development are taken into account during planning, design and construction phases, these unnecessary long-term costs can be reduced or avoided.

Capability statements in this report are intended for regional planning purposes only. For detailed planning at the local level, more intensive capability assessments, dependent on additional information, are necessary. Additional factors such as slope angle, position on slope, terrain element and specific soil conditions need to be examined and, where necessary, geotechnical reports obtained. General urban capability rankings are given for each soil landscape and are presented in Table 4.3.

4.4 Rural Capability

Rural capability is the ability of an area of land to sustain permanent agricultural or pastoral production without permanent damage. Land which is used beyond its rural capability will deteriorate rapidly, resulting in loss of production and a permanent loss of soil resources (Emery 1985).

General rural land capability classifications are provided for those soil landscapes where most of the land has not been urbanised or reserved as National Park or nature reserve (see "Soil Landscape Descriptions" and Table 4.3).

Table 4.3 Soil Limitations for Each Soil Material.

SOIL MATERIAL	PHYSICAL LIMITATIONS				EROSION			PERME-ABILITY		TOXICITIES					FER-TILITY	
	Low wet bearing strength	Srink-swell	Organic matter	Stoniness	Sodicity	Erodibility	Hardseting surface	High permeability	Low permeability	Acid sulphate potential	Acidity	Alkalinity	Salinity	Aluminium toxicity	Low fertility	Low available water
Albion Park																
ap1		●			●	●										
ap2							●							●		
ap3		●			●				●							
ap4					●									●		
ap5		●			●				●							
Barrengarry																
bg1		●	●	■												●
bg2		●	●													●
bg3											■					
bg4											■					
bg5	●			●					●		■					
Barren Grounds																
ba1	■	●	■		■						■					
ba2	■	●	■		●						■					
ba3	●		■		●						■				●	●
ba4	●		■		●						■				●	●
ba5	●				●						■				●	●
ba6	●				●						■					
ba7									●		■				●	
Bombo																
bo1	●	■	■		●											
bo2			●	●		●		●								
bo3					●						○					
bo4					●											
bo5					●						■			■		

■ : Severe limitation with widespread occurrence
● : High limitation with widespread occurrence
○ : Localised occurrence

Table 4.3 Soil Limitations for Each Soil Material (Continued).

SOIL MATERIAL	PHYSICAL LIMITATIONS				EROSION			PERME-ABILITY		TOXICITIES					FER-TILITY	
	Low wet bearing strength	Srink-swell	Organic matter	Stoniness	Sodicity	Erodibility	Hardseting surface	High permeability	Low permeability	Acid sulphate potential	Acidity	Alkalinity	Salinity	Aluminium toxicity	Low fertility	Low available water
Cambewarra																
ca1				●												
ca2				●	○											
ca3				●							■					
ca4	●			●					●		■					●
Coolongatta																
co1	●	○	■				■				■					
co2	●	○	●	●							■					
co3	●			●					●		■					
co4				●							■					
Ellerslie																
el1	●	●	●				●							■		
el2	●	●	●		●		●							■		
el3	●								●							
el4	●								●					■		
el5	●								●							
el6	●								●							
Fairy Meadow																
fa1								●								●
fa2									●						●	●
fa3				●					●						●	
fa4				●					●				●		●	

■ : Severe limitation with widespread occurrence
● : High limitation with widespread occurrence
○ : Localised occurrence

Table 4.3 Soil Limitations for Each Soil Material (Continued).

SOIL MATERIAL	PHYSICAL LIMITATIONS				EROSION			PERMEABILITY		TOXICITIES					FERTILITY	
	Low wet bearing strength	Srink-swell	Organic matter	Stoniness	Sodicity	Erodibility	Hardseting surface	High permeability	Low permeability	Acid sulphate potential	Acidity	Alkalinity	Salinity	Aluminium toxicity	Low fertility	Low available water
Fountaindale																
fo1	●	○	●				●									
fo2				●												
fo3		○		●							●					
fo4	●				●				●							
Greenwell Point																
gp1	●	●	●	●	●		●									
gp2				●	●		●									●
gp3		●			●		●				●					●
gp4	●	●							●		●					
Hawkesbury																
ha1						●		●			●			●	●	●
ha2				○		●		○						●	■	
ha3						●					●				■	
Illawarra Escarpment																
il1				●				●			●					●
il2				●				●			●					●
il3				●					●		●					●
Jamberoo																
ja1	●	○	●													●
ja2					●						●					●
ja3																●
Kiama																
ka1				●	●						●					
ka2					●						●				●	
ka3				●					●		●					
ka4	●	●							●							

■ : Severe limitation with widespread occurrence
● : High limitation with widespread occurrence
○ : Localised occurrence

Table 4.3 Soil Limitations for Each Soil Material (Continued).

SOIL MATERIAL	PHYSICAL LIMITATIONS				EROSION			PERME-ABILITY		TOXICITIES					FER-TILITY	
	Low wet bearing strength	Srink-swell	Organic matter	Stoniness	Sodicity	Erodibility	Hardseting surface	High permeability	Low permeability	Acid sulphate potential	Acidity	Alkalinity	Salinity	Aluminium toxicity	Low fertility	Low available water
Killalea																
ki1	●	■	■													
ki2	●	■	■		●				●		●					●
ki3	●				●				●		●					●
ki4					●			●			●					●
ki5	●	●			●				●		●					
Mangrove Creek																
mg1	●		●		■				●	●			■		■	
mg2	●		●	■					●	■		■	●	■		
mg3	●		●		■					●	■		■		■	
mg4	●				■				●	●		●	■		●	●
Nowra																
no1			●		●			●								●
no2				●	●		●		●							●
no3	●				●		●		●		■					●
no4	●				●				●		■			●		●
no5	●			●	●				●		○					●
no6	●		●	●				●		○			●			
no7	●				●				●					■		
Pulpit Rock																
pr1							●									
pr2				●	●			●						●		●
pr3			■	●											●	
pr4								●			●					●
pr5	●									●					●	

■ : Severe limitation with widespread occurrence
● : High limitation with widespread occurrence
○ : Localised occurrence

Table 4.3 Soil Limitations for Each Soil Material (Continued).

SOIL MATERIAL	PHYSICAL LIMITATIONS				EROSION			PERME-ABILITY		TOXICITIES					FER-TILITY	
	Low wet bearing strength	Srink-swell	Organic matter	Stoniness	Sodicity	Erodibility	Hardseting surface	High permeability	Low permeability	Acid sulphate potential	Acidity	Alkalinity	Salinity	Aluminium toxicity	Low fertility	Low available water
Robertson																
ro1			●		●			●								●
ro2					●		●									
ro3					●		●									●
ro4							●									○
Seven Mile																
sm1			●								■					●
sm2					■											
sm3					●									●	●	
sm4							●							■	■	●
sm5							●		●		●			■	■	●
sm6														■	●	
Shellharbour																
sh1																
sh2				●	●		●									
sh3	●			●	●				●							
sh4	●				●				●							
sh5	●								●							
Shoalhaven																
sf1		●	■				●				■					●
sf2										●	■					
sf3	●								●		■					●
sf4											■					●

■ : Severe limitation with widespread occurrence
● : High limitation with widespread occurrence
○ : Localised occurrence

Table 4.3 Soil Limitations for Each Soil Material (Continued).

SOIL MATERIAL	PHYSICAL LIMITATIONS				EROSION			PERMEABILITY		TOXICITIES					FERTILITY	
	Low wet bearing strength	Srink-swell	Organic matter	Stoniness	Sodicity	Erodibility	Hardseting surface	High permeability	Low permeability	Acid sulphate potential	Acidity	Alkalinity	Salinity	Aluminium toxicity	Low fertility	Low available water
Warragamba																
wb1				●				●			■				●	●
wb2				●		○		●			■			●	●	●
wb3				●		○					■				●	
Wattamolla Road																
wt1			●			●					●					
wt2	●		●								●					
wt3	●				●						●					
wt4					●			●			●					●
wt5					●				●		●					
Wildes Meadow																
wm1																
wm2											●					
wm3	●							●	●							
wm4	●				●				●		●					
Wingecarribee																
wi1																
wi2	●		●		●											
wi3	●								●							
Wollongong																
wg1																
wg2								●							●	●
wg3														○	■	●

■ : Severe limitation with widespread occurrence
● : High limitation with widespread occurrence
○ : Localised occurrence

5 SOIL LANDSCAPE DESCRIPTIONS

Each of the soil landscapes is described in detail in the following pages. Terminology used follows McDonald *et al.* (1984) and Morse *et al.* (1982).

5.1 Residual Landscapes

- **Barren Grounds (ba)**
- **Jamberoo (ja)**
- **Robertson (ro)**

ba BARREN GROUNDS Residual

Landscape—gently undulating to undulating rises with poorly drained depressions on Hawkesbury Sandstone plateau surface. Local relief is low (<30 m) with slopes <10%. Scattered benched rock outcrop and moderately incised drainage channels. Uncleared heath with scattered stands of low woodland.

Soils—moderately deep (50–150 cm) Sands (Uc4.14) occur on crests and upper slopes and Leached Sands (Uc2.12) on midslopes. Gleyed Podzolic Soils (Dg4.31) and Acid Peats (0) occur in drainage depressions.

Limitations—waterlogging, permanently high watertable, high organic matter, sodicity, high shrink-swell (topsoil), low fertility, high available water-holding capacity (topsoil).

LOCATION

Undulating rises on sandstone plateau surface with scattered poorly drained depressions on Moss Vale Tableland adjoining the Illawarra Escarpment. Examples include Barren Grounds, Buderoo and Brogers Creek.

LANDSCAPE

Geology

Hawkesbury Sandstone—medium- to coarse-grained quartzose sandstone with occasional lenticular mudstone interbeds.

Topography

Gently undulating to undulating rises with scattered poorly drained depressions (swamps). Local relief is <30 m with slopes <10%. Crests are broad, slopes are long and gently inclined with wide concave footslopes and moderately incised drainage lines. Localised sandstone outcrops occur on ridges and in drainage lines.

Vegetation

Predominately uncleared closed-heath with isolated stands of low woodland.

Common heath species include swamp heath (*Epacris paludosa*), prickly broom-heath (*Monotoca scoparia*), coral heath (*Epacris microphylla*), paroo lily (*Dianella caerulea*), christmas bell (*Blandfordia nobilis*), necklace fern (*Asplenium flabellifolium*), button grass (*Gymnoschoenus sphaerocephalus*), spear grass (*Stipa rudis*), wire grass (*Aristida vagans*), scrub she-oak (*Allocasuarina distyla*), marsh banksia (*Banksia paludosa*), dagger hakea (*Hakea teretifolia*), screw fern (*Lindsaea linearis*), common sundew (*Drosera spathulata*), slender rice flower (*Pimelea linifolia*), heath banksia

(*Banksia ericifolia*), pine-leaf geebung (*Persoonia pinifolia*), drumsticks (*Isopogen* spp.) and dog rose (*Bauera rubioides*).Common woodland species include silvertop ash (*Eucalyptus sieberi*) and red bloodwood (*Eucalyptus gummifera*) with understorey species—for example, broad-leaved geebung (*Persoonia levis*), flaky-barked tea-tree (*Leptospermum attenuatum*), hill banksia (*Banksia spinnulosa* var. *collina*), mountain devil (*Lambertia formosa*), waratah (*Telopea speciosissima*), old man banksia (*Banksia serrata*) and native holly (*Oxylobium ilicifolium*).

Further vegetation information is available in Jordan and Jordan (1987).

Land Use

Predominately nature reserves (Barren Grounds Nature Reserve) and Crown Lands Reserve, with some areas cleared for grazing.

Existing Erosion

Moderately incised drainage channels to bedrock (1 m).

SOILS

Dominant Soil Materials

ba1—Black sticky massive peaty sand (topsoil)

Colour	black (2.5YR 2/1)
Texture	sand
Structure	apedal massive
Fabric	sandy
pH	5.5
Stones	nil
Roots	abundant

ba2—Friable spongy waterlogged organic peat (topsoil)

Colour	brownish black (10YR 2/2) to black (10YR 2/1)
Texture	peat
Structure	apedal massive
Fabric	sandy
pH	4.0–5.0
Stones	nil
Roots	common to abundant

ba3—Brownish black humic coarse sand (subsoil)

Colour	black (2.5Y 2/1) to brownish black (10YR 3/1)
Texture	sand
Structure	apedal, single-grained
Fabric	sandy
pH	4.5
Stones	nil
Roots	nil

ba4—Dull yellowish brown sand (subsoil)

Colour	brown (10YR 5/3)
Texture	sand
Structure	apedal, single-grained
Fabric	sandy
pH	5.0
Stones	nil
Roots	common

ba5—Waterlogged gleyed clayey sand (subsoil)

Colour	light grey (10YR 8/1) to dull yellow orange (10YR 7/2) with pale yellow, light grey and orange mottles at depth
Texture	clayey sand to sandy clay loam
Structure	apedal massive
Fabric	earthy
pH	3.0–4.5
Stones	nil
Roots	few

Associated Soil Material

Up to 5 cm of leaf litter overlies some profiles especially midslope. Up to 30 cm bleached greyish yellow brown sand.

Occurrence and Relationships

Crests and upper slopes. Up to 30 cm of black sticky massive peaty sand **(ba1)** overlies <30 cm loose brownish black humic sand **(ba3)**. Boundary is gradual [Sands (Uc4.14)]. Total depth is approximately 100 cm.

Midslopes. Up to 5 cm of leaf litter overlies <30 cm of dull yellowish brown sand **(ba4)** which overlies <10 cm bleached greyish yellow brown sand. Boundaries are gradual [Leached Sands (Uc2.12)]. Total depth is <50 cm.

Drainage depressions. Up to 150 cm of friable spongy waterlogged organic peat **(ba2)** overlies <30 cm of bleached greyish yellow brown sand which overlies <200 cm waterlogged gleyed clayey sand **(ba5)**. The boundaries are sharp [Gleyed Podzolic Soils (Dg4.31)]. Occasionally **ba2** lies over bedrock [Acid Peats (0)]. Total soil depth varies between 150 cm and 300 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ba1 Very high organic matter
Strongly acid

Low wet bearing strength
Sodicity

ba2 Very high organic matter
Very strongly acid
Low wet bearing strength
Very high available water-holding capacity

ba3 High organic matter
Low available water-holding capacity
Very strongly acid
Low fertility
Sodicity

ba4 High organic matter
Low available water-holding capacity
Strongly acid
Low fertility
Sodicity

ba5 Low permeability
Extremely acid
Low fertility
Sodicity

Fertility

General fertility is very low. The peat topsoil **(ba2)** is strongly acid with high organic matter. The subsoil materials have a low CEC, are often very strongly acid and are permanently waterlogged.

Erodibility

All of the soil materials have low erodibility as they consist of well-drained coarse sands.

Erosion Hazard

Erosion hazard for this soil landscape for non-concentrated flows is slight to very high. The calculated soil loss for the first 12 months of urban development ranges up to 70 t/ha for topsoils and 85 t/ha for exposed subsoils. The erosion hazard for concentrated flows is very high.

Surface Movement Potential

Except for **ba1** and **ba2** all materials are sufficiently coarse to be considered stable.

Landscape Limitations

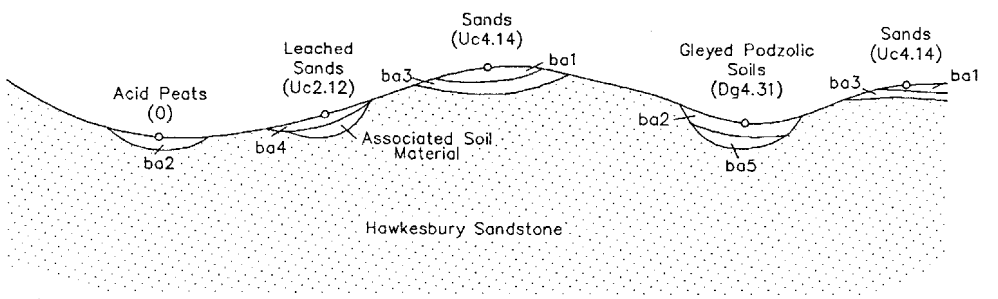
Flood hazard (localised)
Waterlogging
Permanently high watertable
Seasonal waterlogging
Water erosion hazard (localised)

Urban Capability

Generally low limitations for urban development. Localised high to severe limitations for urban development in poorly drained areas.

Rural Capability

Generally high to severe limitations for regular cultivation and for grazing.



■ ***Schematic cross-section of Barren Grounds soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

ja JAMBEROO Residual

Landscape—rolling hills with broad crests and ridges. Relief 100–200 m on Saddleback Latite. Slopes <25%. Extensively cleared with scattered stands of closed-forest.

Soils—deep (>150 cm) Krasnozems (Gn4.11) occur throughout this landscape with Structured Loams (Um6) localised on Saddleback Mountain Agglomerate.

Limitations—run-on, low wet bearing strength (topsoil), strongly acid.

LOCATION

Rolling hills with broad crests and ridges on latite in the Jamberoo Valley on the upper reaches of the Illawarra Escarpment. Examples include upper reaches of Saddleback Road and Fountaindale Road.

LANDSCAPE

Geology

Saddleback Latite Member—black porphyritic mafic latite with localised outcrops of Bong Bong Basalt.

Associated Geology

Saddleback Mountain Agglomerate—yellowish green to grey volcanic agglomerate.

Topography

Rolling hills. Relief 100–200 m. Slope gradients generally <25%. Broad crests and ridges with steep (>30%) upper and midslopes associated with edge of basalt flows. Scattered rock outcrops of latite boulders and minor sandstone outcrops on upper slopes. Narrow drainage lines. Mass movement is confined to steep slopes.

Vegetation

Extensively cleared with scattered stands of closed-forest throughout the landscape. Common species include cabbage tree palm (*Livistona australis*), red cedar (*Toona australis*), illawarra flame tree (*Brachychiton acerifolium*), sassafras (*Doryphora sassafras*), brush cherry (*Syzygium australe*), bastard rosewood (*Synoum glandulosum*), wilkiea (*Wilkiea huegeliana*), brush muttonwood (*Rapanea howittiana*), muttonwood (*Rapanea variabilis*), flintwood (*Scolopia braunii*), moreton bay fig (*Ficus macrophylla*), deciduous fig (*Ficus superba*), yellowwood (*Sarcomelicope simplicifolia*). Decorative paperbark (*Melaleuca decora*) and forest red gum (*Eucalyptus tereticornis*) occur in poorly drained areas.

Land Use

Dairying, cattle grazing, horse farms and hobby farms on improved pasture.

Existing Erosion

Evidence of mass movement and localised stream bank erosion on steeper slopes.

Included Soil Landscapes

Small areas of Fountaindale **(fo)** and Bombo **(bo)** have been included throughout.

SOILS

Dominant Soil Materials

ja1—Friable reddish brown sandy clay loam (topsoil)

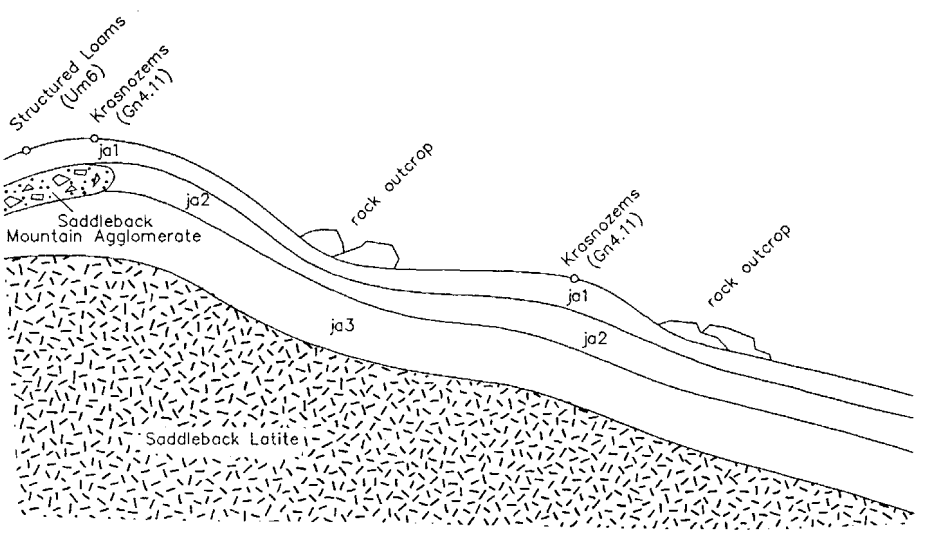
Colour	reddish brown (5YR 4/6, 5YR 4/8)
Texture	sandy clay loam
Structure	weak to moderately pedal, <2 mm crumb peds
Fabric	sandy to rough-faced, porous
pH	4.5–5.5
Stones	nil
Roots	abundant, ex-ped

ja2—Reddish brown sandy clay (subsoil)

Colour	reddish brown (2.5YR 4/6) to bright reddish brown (5YR 5/8)
Texture	sandy clay
Structure	moderately pedal, 5–10 mm granular to polyhedral peds
Fabric	rough-faced, porous
pH	4.0–5.0
Stones	nil
Roots	many, ex-ped

ja3—Reddish brown light clay (subsoil)

Colour	reddish brown (2.5YR 4/8) to brown (7.5YR 4/6)
Texture	light clay to light medium clay
Structure	moderately pedal, 5–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	4.0
Stones	nil
Roots	few, ex-ped



■ ***Schematic cross-section of Jamberoo soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

Occurrence and Relationships

The soils are generally uniform throughout the landscape.

Up to 50 cm **ja1** overlies <50 cm reddish brown sandy clay **(ja2)** which overlies <80 cm reddish brown light clay **(ja3)**. Boundaries are gradual [Krasnozems (Gn4.11)]. Total depth is <200 cm. On Saddleback Mountain Agglomerate <20 cm friable reddish brown sandy clay loam **(ja1)** overlies bedrock [Structured Loams (Um6)].

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ja1 High organic matter
Low wet bearing strength
Shrink-swell (localised)
Strongly acid

ja2 Sodicity
Strongly acid

ja3 Strongly acid

Fertility

General fertility is moderate to high. The topsoil **(ja1)** is friable. Soil materials are well structured, deep and freely draining with no impermeable clay horizons. They are strongly acid and have a moderate CEC.

Erodibility

Topsoil **(ja1)** has moderate erodibility rating because of high organic content. Subsoils **(ja2, ja3)** have low erodibility rating.

Erosion Hazard

Erosion hazard for non-concentrated flows is high. The calculated soil loss for the first 12 months of urban development ranges up to 750 t/ha for topsoils and 300 t/ha for exposed subsoils. The erosion hazard for concentrated flows is low to moderate.

Surface Movement Potential

These deep clayey soil materials are generally stable to very slightly reactive.

Landscape Limitations

Steep slopes (localised)
Mass movement (localised)
Rock outcrop (localised)
Run-on

Urban Capability

Generally moderate limitations for urban development. High to severe limitations for steep slopes on the edge of basalt flows.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing. High to severe limitations for regular cultivation on steeper slopes (localised).

ro	ROBERTSON	Residual

Landscape—undulating to rolling hills with flat-topped ridges on basalt and basanite. Relief 30–100 m. Slopes 5–15%. Remnant knolls and small rounded flat-topped crests. Extensively cleared with isolated stands of low woodland and closed-forest.

Soils—deep (>150 cm) red Krasnozems (Gn4.11) occur on upper slopes, brown Krasnozems (Gn4.31) and Red Earths (Gn2.11) occur on midslopes and Xanthozems (Gn4.31) occur on lower slopes.

Limitations—steep slopes (localised), high permeability, hardsetting and sodicity, low available water-holding capacity (topsoil).

LOCATION

Undulating to rolling low hills with flat-topped ridges on basalts and basanites on Moss Vale Tableland. Examples include Robertson, Bells Hill and Knapsack Hill.

LANDSCAPE

Geology

Robertson Basalt—tertiary alkaline olivine basalts and basanites.

Topography

Undulating to rolling low hills. Relief 30–100 m. Slopes 5–15%. Remnant knolls and small rounded flat-topped crests; short moderately inclined upper slopes (15–30%) grading into a complex of gently to moderately inclined mid and lower slopes with broad open valleys.

Vegetation

Extensively cleared with isolated remnants of low woodland with closed-forest. Common woodland species include coastal grey box (*Eucalyptus bosistoana*), cabbage gum (*Eucalyptus amplifolia*), thin-leaved stringybark (*Eucalyptus eugenioides*), ribbon gum (*Eucalyptus viminalis*), long-leaved box (*Eucalyptus goniocalyx*), small-leaved gum (*Eucalyptus panifolia*) and black sallee (*Eucalyptus stellulata*). Forest red gum (*Eucalyptus tereticornis*) grows in poorly drained areas. Small-leaved fig (*Ficus obliqua*) is the common closed-forest species.

Land Use

Dairying and beef production on improved pastures, vegetable growing (potatoes), isolated towns—for example, Robertson.

Existing Erosion

Local occurrences of sheet erosion occur on slopes >5% developing into extensive rilling unless well grassed. Minor gully erosion on upper drainage lines.

SOILS

Dominant Soil Materials

ro1—Friable reddish brown clay loam (topsoil)

Colour	reddish brown (5YR 4/6) to brown (7.5YR 4/4)
Texture	sandy clay loam to clay loam
Structure	moderately pedal, 10–20 mm polyhedral peds
Fabric	rough-faced, porous
pH	6.0
Stones	nil
Roots	few, in-ped

ro2—Hardsetting dark brown silty clay loam (topsoil)

Colour	dark brown (10YR 3/4)
Texture	clay loam to silty clay loam
Structure	weakly pedal, 2–5 mm crumb peds
Fabric	rough-faced, porous
pH	6.0
Stones	nil
Roots	abundant, ex-ped

ro3—Yellowish brown strongly pedal light clay (subsoil)

Colour	yellowish brown (10YR 4/3) to brown (7.5YR 4/3)
Texture	light clay to light medium clay
Structure	strongly pedal, 50–100 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	5.5
Stones	nil
Roots	few, ex-ped

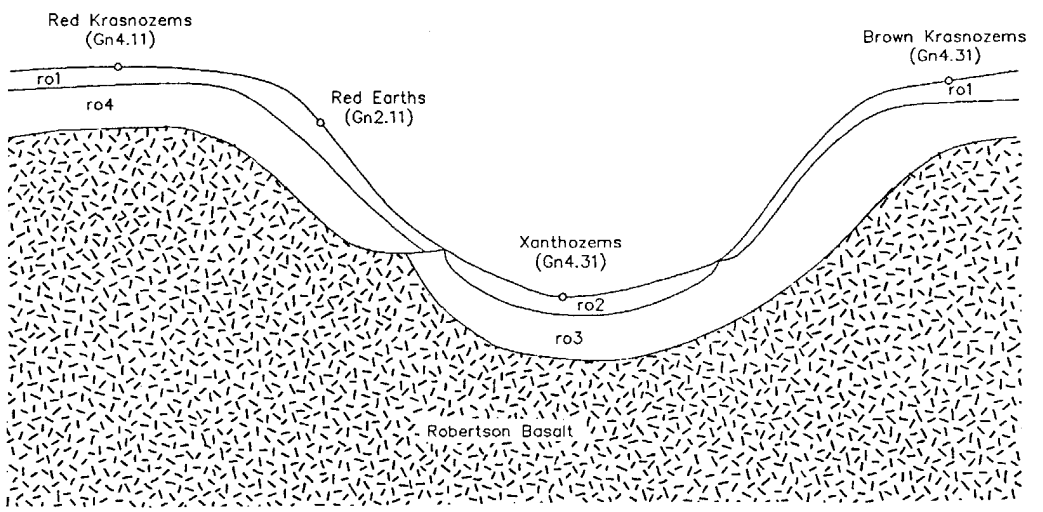
ro4—Dark reddish brown strongly pedal light medium clay (subsoil)

Colour	dark reddish brown (2.5YR 3/6, 2.5YR 3/4)
Texture	light medium clay to light clay
Structure	strongly pedal, 50–100 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	5.0
Stones	nil
Roots	nil

Occurrence and Relationships

Crests and upper slopes. Up to 5 cm reddish brown moderately pedal clay loam **(ro1)** overlies <200 cm of dark reddish brown clay **(ro4).** Boundary is gradual [red Krasnozems (Gn4.11)]. Total depth is >300 cm.

Midslopes. Up to 20 cm **ro1** overlies <150 cm yellowish brown strongly pedal light clay **(ro3)**. Boundary is gradual [brown Krasnozems



■ *Schematic cross-section of Robertson soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

(Gn4.31)]. Occasionally >50 cm friable reddish brown sandy clay loam **(ro1)** overlies <150 cm **ro4**. Boundary is gradual [Red Earths (Gn2.11)]. Total depth is >150 cm.

Lower slopes. Up to 20 cm of dark brown silty clay loam **(ro2)** overlies <80 cm **ro3**. Boundary is gradual [Xanthozems (Gn4.31)]. Total depth is approximately 100 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ro1 High organic matter
High permeability
Low available water-holding capacity
Sodicity (localised)

ro2 Sodicity (localised)
Hardsetting
High organic matter

ro3 High permeability
Sodicity (localised)

ro4 Acid

Fertility

General fertility is moderate to high. The soils are deep, well structured, freely draining with no impermeable clay layers. Soil materials have a moderate to high CEC and are moderately to strongly acid.

Erodibility

The topsoils **(ro1, ro2)** have low erodibility because of high organic matter. The subsoils **(ro3, ro4)** have moderate erodibility as they have relatively stable aggregates.

Erosion Hazard

Erosion hazard for non-concentrated flows is high. The calculated soil loss for the first 12 months of urban development ranges up to 100 t/ha for topsoils and 20 t/ha for exposed subsoils. The erosion hazard for concentrated flows is low.

Surface Movement Potential

Generally the well-drained soils are stable.

Landscape Limitations

Steep slopes (localised)

Urban Capability

Generally low limitations for urban development. High to severe limitations on steep slopes (localised).

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing with high to severe limitations on steep slopes (localised).

5.2 Colluvial Landscapes

- **Hawkesbury (ha)**
- **Illawarra Escarpment (ie)**

ha HAWKESBURY Colluvial

Landscape—rolling to very steep hills with slope gradients ranging from 25–70% on Hawkesbury Sandstone. Crests and ridges are convex and moderately narrow (<300 m). Valleys are narrow and incised. Rock outcrop occurs as horizontal benches and broken scarps up to 10 m high. Boulders and cobbles cover up to 50% of the ground surface. Local relief is up to 200 m. Mostly undisturbed open-woodland with pockets of tall open-forest and closed-forest.

Soils—shallow (<50 cm) Lithosols (Uc1.21) occur on crests and ridges. Yellow Podzolic Soils (Dy4.11) and Yellow Earths (Gn2.21) occur on sideslopes. Red Podzolic Soils (Dr4.41) and Yellow Podzolic Soils (Dy5.41) occur on minor shale lenses associated with high sides of some benches. Siliceous Sands (Uc1.21) occur in valley flats.

Limitations—extreme soil erosion hazard, mass movement (rock fall) hazard, steep slopes, rock outcrop, shallow, stoniness, highly permeable soil, low soil fertility, high aluminium toxicity.

LOCATION

Steep, rugged sandstone slopes and ridges of the Illawarra Escarpment. Examples include Browns Mountain, Tapitalee Mountain and Mannings Lookout.

LANDSCAPE

Geology

Hawkesbury Sandstone—medium- to coarse-grained quartz sandstone with minor shale and laminite lenses.

Topography

Rolling to very steep hills with slope gradients ranging from 25–70%. Crests and ridges are convex and moderately narrow (<300 m). Valleys are narrow and incised. Rock outcrop occurs as horizontal benches and broken scarps up to 10 m high. Boulders and cobbles cover up to 50% of the ground surface. Local relief is up to 200 m.

Vegetation

Mostly undisturbed open-woodland with pockets of tall open-forest and closed-forest in sheltered locations. Common species of open-woodland and tall open-forest include sydney peppermint (*Eucalyptus piperita*), silvertop ash (*Eucalyptus sieberi*), red bloodwood (*Eucalyptus gummifera*), white stringybark (*Eucalyptus globoidea*), budawang ash (*Eucalyptus dendromorpha*), mountain grey gum (*Eucalyptus cypellocarpa*), and old man banksia (*Banksia serrata*). Common closed-forest species include coachwood (*Ceratopetalum apetalum*), sassafras (*Doryphora sassafras*), lillypilly (*Acmena smithii*), featherwood (*Polyosma cunninghamii*) and scattered native laurel (*Cryptocarya glaucescens*).

Land Use

Mostly undisturbed bushland which is used for nature conservation, education and bushwalking.

Existing Erosion

Minor gully erosion, often to bedrock, occurs along unpaved tracks and fire trails.

SOILS

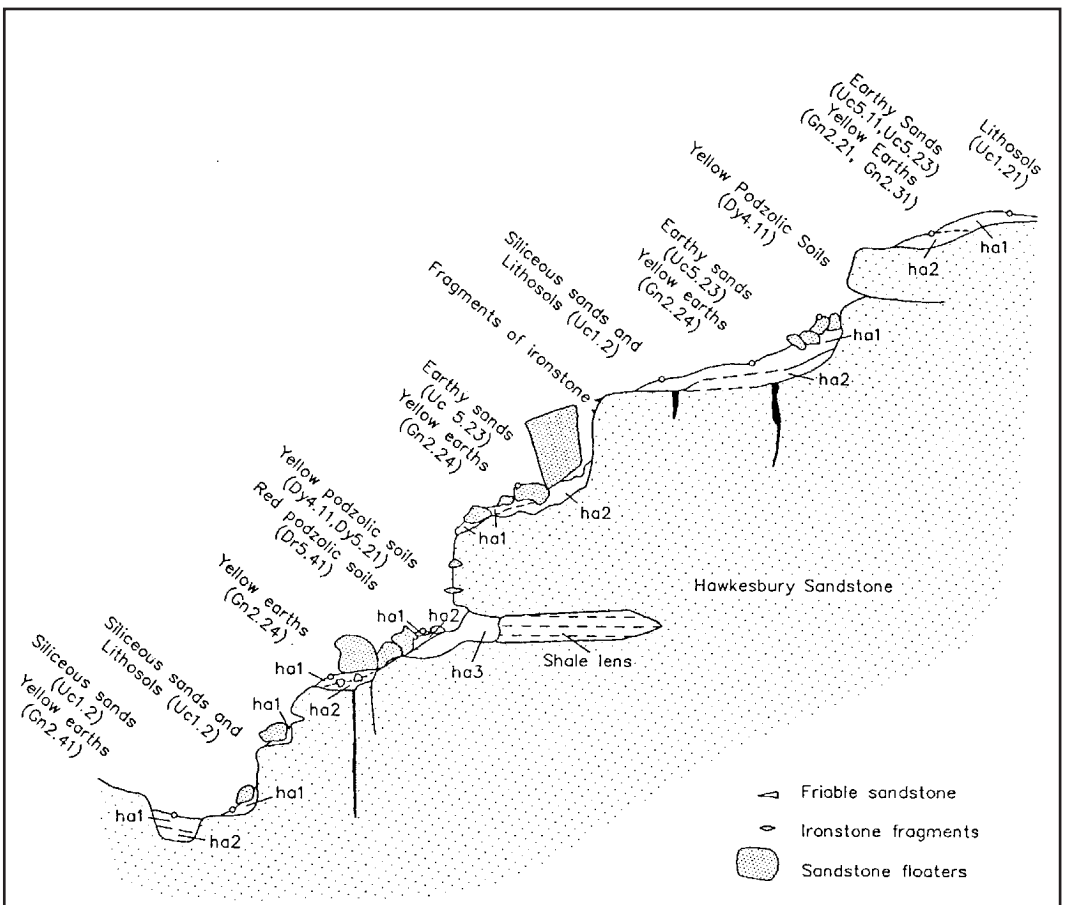
Dominant Soil Materials

ha1—Loose brownish black coarse quartz sand (topsoil)

Colour brownish black (10YR 3/1) to brownish grey (10YR 6/1)
Texture sand to sandy loam
Structure apedal single-grained to weakly pedal, <2 mm crumb peds
Fabric sandy to rough-faced, porous
pH 4.0
Stones <2% 2–6 mm sandstone fragments, dispersed
Roots abundant, in-ped

ha2—Earthy, yellowish brown sandy clay loam

Colour yellowish brown (10YR 5/6) to yellow orange (10YR 6/4)
Texture sandy clay loam
Structure weakly pedal, 20–50 mm sub-angular blocky peds
Fabric earthy to rough-faced, porous
pH 4.5–5.5
Stones gravels are common
Roots nil



■ *Schematic cross-section of Hawkesbury soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

ha3—Bright yellowish brown light clay

Colour	bright yellowish brown (10YR 6/6) to bright brown (5YR 5/6)
Texture	light clay to medium clay
Structure	strongly pedal, 20–50 mm sub-angular blocky to angular blocky peds
Fabric	rough-faced, porous
pH	4.5
Stones	gravels are common
Roots	nil

Associated Soil Materials

Litter and decomposing organic debris
White loose sand

Occurrence and Relationships

Crests and ridges. Up to 20 cm of loose sand **(ha1)** is commonly present directly over solid bedrock [Lithosols (Ucl.21)]. Where erosion rates are lower, <30 cm of yellowish brown sandy clay loam **(ha2)** is overlain by <20 cm of brownish black loamy sand topsoil **(ha1)**. Boundaries are clear [Yellow Earths (Gn2.21)]. Where higher rates prevail, bare rock or a few centimetres of **ha1** are often present. Total depth is <50 cm.

Sideslopes. Soil is discontinuous because of sandstone outcrop and surface fragments. Rock fragments occur throughout the soil. 10–30 cm of loose to weakly coherent sand topsoil **(ha1)** overlies bedrock [Lithosols (Ucl.21)]. Up to 30 cm **ha1** overlies 30 cm of **ha2.** Boundaries are either gradual or clear [Yellow Earths (Gn2.21), Yellow Podzolic Soils (Dy4.41)]. Total soil depth, although variable, is usually <70 cm.

Minor shale lenses associated with high sides of some benches. Up to 30 cm of loose to weakly coherent sand topsoil **(ha1)** overlies <50 cm of light to medium clay **(ha3)**. Boundaries are clear [Red Podzolic Soils (Dr4.41), Yellow Podzolic Soils (Dy5.41)]. Total soil depth is <50 cm.

Valley flats. Depositional sands **(ha1)** (usually deeper than 100 cm) occur [Siliceous Sands (Ucl.21)]. These are often swampy with a high organic matter content.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ha1 High permeability
Low available water-holding capacity
Low fertility
High erodibility
Strongly acid
High aluminium toxicity

ha2 Stoniness (localised)
High permeability (localised)
Very low fertility
High erodibility

ha3 Very low fertility
Strongly acid
High erodibility

Fertility

General fertility is very low. Soils are extremely to strongly acid with a low to very low nutrient status. They are severely deficient in nitrogen and phosphorus and have very low CEC. They are also shallow and stony with low available water-holding capacities and high aluminium toxicity.

Erodibility

The topsoil **(ha1)** has low erodibility for non-concentrated flows. It consists of highly permeable, loose, coarse sands and organic matter. **ha1** is highly susceptible to concentrated flow erosion, especially when the organic matter is removed by bushfires. **ha2** and **ha3** have moderate erodibility. They have low organic matter contents and weak fabrics.

Erosion Hazard

Erosion hazard for non-concentrated flows is generally very high and ranges from moderate to extreme. The calculated soil loss for the first 12 months of urban development ranges up to 100 t/ha for topsoil and 400 t/ha for subsoil. The soil erosion hazard for concentrated flows is extreme.

Surface Movement Potential

The shallow sandy soils are stable to slightly reactive.

Landscape Limitations

Steep slopes
Mass movement hazard
Rock fall
Seasonal waterlogging
Shallow soil
Rock outcrop

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

ie ILLAWARRA ESCARPMENT Colluvial

Landscape—steep to very steep slopes on Quaternary talus. Relief 100–500 m. Gradients 20–50%. Large landslips are common. Mostly uncleared tall open-forest and closed-forest.

Soils—deep colluvial Red Podzolic Soils (Dr5.21) and Brown Podzolic Soils (Db4.21) occur on slopes. Lithosols (Uc5.11) occur where the talus is recent.

Limitations—mass movement and rock fall hazard. Steep slopes and extreme water erosion hazard. Reactive, low wet bearing strength (subsoils), low soil fertility.

LOCATION

Steep slopes, benches and debris mantle of the Illawarra Escarpment. Examples include Minnamurra Falls Reserve and Macquarie Pass.

LANDSCAPE

Geology

Quaternary talus—blocks of sandstone, deep colluvial detritus and soil materials. These materials overlie benches and smaller scarps cut from the Narrabeen Group, the Illawarra Coal Measures and the Shoalhaven Group.

Topography

Debris mantle covering the upper slopes and benches of the Illawarra Range. Local relief is 100–500 m. Steep to very steep long slopes with gradients 20–50% with rock and colluvial benches. Large surface and subsurface sandstone boulders 2–25 m wide are commonplace. Drainage lines are parallel and incised. Below the escarpment bedrock outcrop is absent, and large landslips are very common.

Vegetation

Vegetation is a mixture of tall open-forest and closed-forest. The common species in the tall open-forest include brown barrel (*Eucalyptus fastigata*), gully gum (*Eucalyptus smithii*), red bloodwood (*Eucalyptus gummifera*), budawang ash (*Eucalyptus dendromorpha*), thin-leaved stringybark (*Eucalyptus eugenioides*) and bleeding heart (*Omalanthus populifolius*).

The common species in the closed-forest include sassafras (*Doryphora sassafras*), red cedar (*Toona australis*), coachwood (*Ceratopetalum apetalum*), black apple (*Planchonella australis*), native tamarind (*Dipolglottis cunninghamii*), cabbage gum (*Eucalyptus amplifolia*), brown beech (*Pennantia cunninghamii*), pigeonberry ash (*Elaeocarpus kirtonii*), native laurel (*Cryptocarya glaucescens*), rough tree-fern (*Cyathea australis*), prickly tree-fern (*Cyathea leichhardtiana*), moreton bay fig (*Ficus macrophylla*), small-leaved fig (*Ficus obliqua*) and sandpaper fig (*Ficus coronata*).

Land Use

Undisturbed forest, recreation areas such as Minnamurra Falls Reserve and access to Cambewarra Mountain Lookout and to Kangaroo Valley.

Existing Erosion

Mass movement including major rock fall slumping, landslips and batter failures are common occurrences. Minor gully erosion (<50 cm) and sheet erosion are widespread after heavy rain.

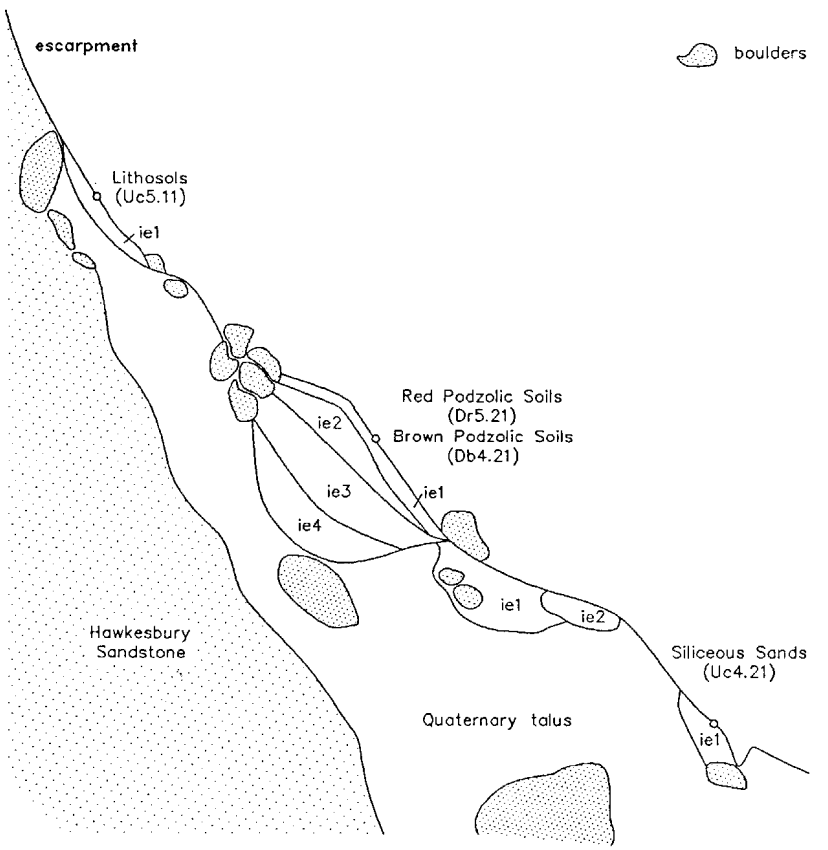
SOILS

The distribution of soils is very complex and reflects the variability of the parent material. Only the common soil materials and their occurrences have been described.

Dominant Soil Materials

ie1—Friable dark brown loamy sand (topsoil)

Colour dark brown (10YR 3/3) to brownish black (7.5YR 3/1) to greyish brown (7.5YR 4/2)



■ *Schematic cross-section of Illawarra Escarpment soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Texture	loamy sand to sand
Structure	weakly pedal, 20–50 mm crumb to polyhedral peds
Fabric	sandy to rough-faced, porous
pH	4.5–6.0
Stones	>10% 2–200 mm sub-angular and/or sub-rounded, dispersed
Roots	common, in-ped

ie2—Brown sandy loam (topsoil)

Colour	brown (7.5YR 4/4) to dull yellowish (10YR 4/3) to reddish brown (5YR 4/8)
Texture	sandy loam to fine sandy loam
Structure	weakly to moderately pedal, 20–50 mm polyhedral to sub-angular blocky peds
Fabric	rough-faced, porous
pH	4.5–5.5
Stones	>10% 2–200 mm sub-angular and/or sub-rounded, dispersed
Roots	few

ie3—Bright brown sandy clay loam (subsoil)

Colour	bright brown (7.5YR 5/8) to dull yellowish brown (10YR 4/3)
Texture	sandy clay loam
Structure	moderately pedal, 20–50 mm polyhedral to sub-angular blocky peds
Fabric	rough-faced, porous
pH	4.0–5.5
Stones	>10% 2–200 mm sub-angular and/or sub-rounded, dispersed
Roots	nil

ie4—Mottled dark reddish brown sandy clay (subsoil)

Colour	dark reddish brown (2.5YR 3/6) to dark brown (7.5YR 4/6) red, white and/or orange mottles (<30%)
Texture	sandy clay
Structure	moderately pedal, 20–50 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	4.5
Stones	>10% 2–200 mm sub-angular and/or sub-rounded, dispersed
Roots	nil

Occurrence and Relationships

Soils are highly variable. Soil materials in this landscape may include the following:

Recently deposited talus. Up to 50 cm friable dark brown loamy sand **(ie1)** overlies unconsolidated colluvium or bedrock [Lithosols (Uc5.11)]. This occurs directly below cliffs.

Slopes. Up to 30 cm of brown sandy loam **(ie2)** overlies <30 cm brown sandy clay loam **(ie3)**. Up to 60 cm mottled dark reddish brown sandy clay **(ie4)** is overlain by **ie3**. Boundaries are clear to diffuse [Red Podzolic Soils (Dr5.21), Brown Podzolic Soils (Db4.21)]. Total depth is <120 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ie1 High permeability
Low available water-holding capacity
Stoniness
Strongly acid

ie2 High permeability
Low available water-holding capacity
Stoniness
Strongly acid

ie3 Low permeability
Low available water-holding capacity
Stoniness
Strongly acid

ie4 Strongly acid
Stoniness
Low permeability

Fertility

Fertility of individual soil materials is low. General soil fertility is moderate. Soils are acid, have moderate CEC and low to moderate nutrient status with low to moderate available water capacities. Although the soils are stony, they are generally very deep and well structured, allowing large soil volumes to be available to roots.

Erodibility

ie1 has low erodibility consisting of highly permeable coarse sand grains. **ie2** and **ie3** have moderate erodibility especially when vegetation is removed by bushfires.

Erosion Hazard

The erosion hazard for non-concentrated flows is extreme. Calculated soil loss during the first 12 months of urban development ranges up to 1 415 t/ha for topsoil and 1 230 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows is high to extreme.

Surface Movement Potential

The topsoils **(ie1, ie2, ie3)** are stable, with **(ie4)** slightly reactive. Potential movements are offset by continuously poor drainage. Settlement and mass movement are a hazard to foundations.

Landscape Limitations

Steep slopes
Mass movement hazard
Rock fall hazard
Shallow soil (localised)
Rock outcrop
Extreme water erosion hazard

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

5.3 Erosional Landscapes

- **Albion Park (ap)**
- **Bombo (bo)**
- **Cambewarra (ca)**
- **Coolongatta (co)**
- **Kiama (ka)**
- **Pulpit Rock (pr)**
- **Shellharbour (sh)**
- **Wildes Meadow (wm)**

ap	ALBION PARK	Erosional

Landscape—short steep upper slopes with long gentle footslopes on Berry Formation. Relief 60–100 m. Footslopes 5–15%. Upper slopes 15–50%. Mostly cleared with stands of tall open-forest.

Soils—moderately deep (50–100 cm) Brown Podzolic Soils (Db4.11) occur on crests, Yellow Podzolic Soils (Dy3.21) on midslopes. Soloths (Dy3.41) occur on footslopes and drainage lines.

Limitations—waterlogging, seasonally high watertable, shrink-swell, hardsetting (topsoil), sodicity, low wet bearing strength (subsoil), high available water-holding capacity (topsoil and subsoil).

LOCATION

Short steep upper slopes grading into long gentle footslopes on Berry Formation on the Coastal Plain. Examples include Albion Park, Yallah, Oak Flats, Dapto and Broughton Creek.

LANDSCAPE

Geology

Berry Formation—mid grey to dark grey siltstone, mudstone and fine sandstone with localised outcrops of Budgong Sandstone (red brown and grey lithic volcanic sandstone) on mid to upper slopes. Localised outcrops of Bumbo Latite occasionally occur on crests.

Topography

Short steep upper slopes grading into long gently inclined footslopes. Relief 60–100 m. Upper slopes 15–50%, footslopes 5–15%. Drainage lines incised on upper slopes grading into broad drainage plains on lower slopes.

Vegetation

Extensively cleared with remnant stands of tall open-forest. Common species include thin-leaved stringybark (*Eucalyptus eugenioides*), cabbage gum (*Eucalyptus amplifolia*), northern boobialla (*Myoporum acuminatum*). Forest red gum (*Eucalyptus tereticornis*), woollybutt (*Eucalyptus longifolia*), decorative paperbark (*Melaleuca decora*) and prickly-leaved paperbark (*Melaleuca styphelioides*) grow on poorer drained areas.

Land Use

Urban areas include Albion Park, Oak Flats and Dapto. There is coalmining at Marshall Mount. Rural activities include dairying, cattle grazing and horse agistment on improved pastures.

Existing Erosion

There is localised minor gully erosion.

Included Soil Landscapes

Small areas of Shellharbour **(sh)**, Bombo **(bo)** and Fairy Meadow **(fa)** soil landscapes occur.

SOILS

Dominant Soil Materials

ap1—Friable brownish black sandy clay loam (topsoil)

Colour	brownish black (7.5YR 3/2)
Texture	sandy clay loam
Structure	strongly pedal, <2 mm crumb peds
Fabric	rough-faced, porous
pH	6.5
Stones	nil
Roots	common, ex-ped

ap2—Hardsetting weakly pedal dark brown loam (topsoil)

Colour	dark brown (10YR 3/3)
Texture	loam to fine sandy loam
Structure	weakly pedal, <2 mm crumb peds
Fabric	rough-faced, porous
pH	6.5
Stones	nil
Roots	few

ap3—Mottled moderately pedal greyish brown light clay (subsoil)

Colour	greyish brown (5YR 4/2) red and brown mottles (50%) or brown (10YR 4/4) without mottles
Texture	light clay
Structure	moderately pedal, 50–100 mm angular blocky peds
Fabric	rough-faced, porous
pH	6.0
Stones	nil
Roots	nil

ap4—Weakly pedal bright yellowish brown sandy loam (subsoil)

Colour	bright yellowish brown (10YR 7/6) to dull yellow orange (10YR 7/3)
Texture	sandy loam to loamy sand
Structure	weakly pedal, <2 mm crumb peds
Fabric	rough-faced, porous
pH	6.0
Stones	nil
Roots	nil

ap5—Mottled moderately pedal yellow orange heavy clay (subsoil)

Colour	yellow orange (10YR 7/8) yellow and grey mottles (40%)
Texture	heavy clay
Structure	moderately pedal, 20–50 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	5.5
Stones	nil
Roots	nil

Associated Soil Materials

Dark reddish brown (2.5YR 3/4) heavy clay with grey mottles occurs occasionally on midslopes.

Occurrence and Relationships

Crests and upper slopes. Up to 30 cm friable brownish black sandy clay loam **ap1** overlies latite [Structured Loams (Um6.41)]. Where deeper weathering occurs, <20 cm **ap1** overlies <80 cm mottled moderately pedal greyish brown light clay **(ap3).** Boundary is clear [Brown Podzolic Soils (Db4.11)]. Total soil depth is <100 cm.

Midslopes. Up to 40 cm hardsetting weakly pedal dark brown loam **(ap2)** overlies <10 cm weakly pedal bright yellowish brown sandy loam **(ap4)** which in turn overlies <50 cm mottled moderately pedal yellow orange heavy clay **(ap5).** Boundaries are clear to sharp [Yellow Podzolic Soils (Dy3.21)]. Total soil depth is <100 cm. Up to 20 cm **ap1** overlies associated soil material. Boundary is clear [Red Podzolic Soils (Dr5.11)]. Total depth is >100 cm.

Footslopes and drainage lines. Up to 20 cm of **ap2** overlies <20 cm of **ap4** which overlies <120 cm of **ap3**. Boundaries are clear [Soloths (Dy3.41)]. Total soil depth is <150 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ap1 Shrink-swell potential
High erodibility
Sodicity
Strongly acid
High available water-holding capacity

ap2 Hardsetting
Very high aluminium toxicity
High available water-holding capacity

ap3 Low permeability
Shrink-swell potential
Low wet bearing strength
Sodicity
Strongly acid
High available water-holding capacity

ap4 High aluminium toxicity
Sodicity
Strongly acid
High available water-holding capacity

ap5 Low permeability
Shrink-swell potential
Low wet bearing strength
Sodicity
Strongly acid
Very high available water-holding capacity

Fertility

Moderate to high fertility. **ap2** is hardsetting. **ap1, ap3, ap4** and **ap5** are moderately structured with moderate to high CEC and very high base saturation.

Erodibility

ap1 has a low erodibility rating. **ap2,** which is hardsetting, has high erodibility. The subsoils **(ap3, ap4** and **ap5)** have moderate erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is moderate to high. The calculated soil loss for the first 12 months of urban development ranges up to 60–300 t/ha for topsoils and 300 t/ha for exposed subsoils. The erosion hazard for concentrated flows is high.

Surface Movement Potential

The moderately deep clay soils are moderately reactive.

Landscape Limitations

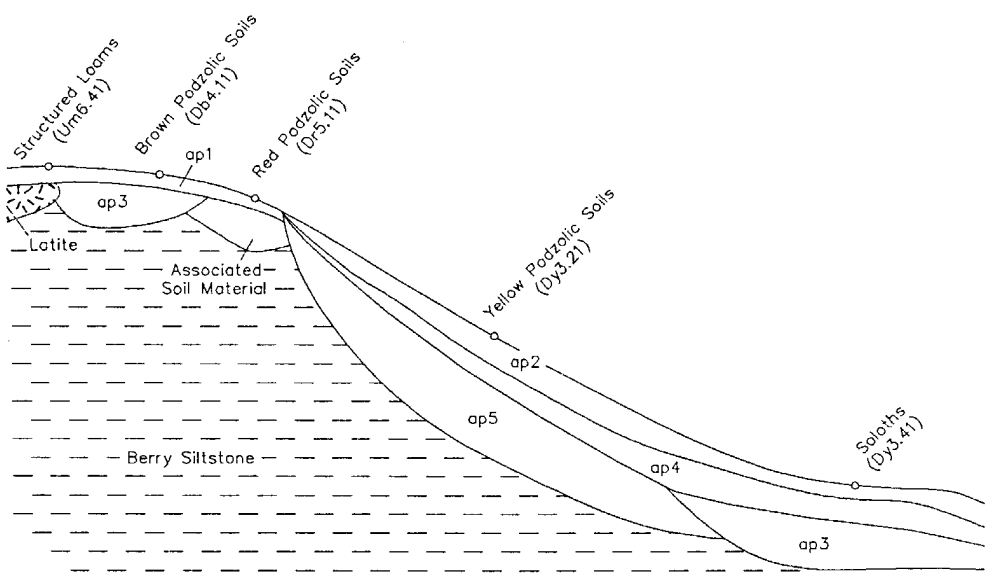
Waterlogging (localised)
Seasonal waterlogging
Water erosion hazard
Steep slopes (localised)
Shallow soil (localised)
Run-on (localised)
Rock outcrop (localised)

Urban Capability

Generally moderate limitations for urban development, but localised high to severe limitations on slopes greater than 20%.

Rural Capability

Generally high to severe limitations for regular cultivation. Low to moderate limitations for grazing.



■ ***Schematic cross-section of Albion Park soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

bo	BOMBO	Erosional

Landscape—rolling low hills with benched slopes and sea cliffs with extensive rock platforms on Bumbo Latite. Relief 40–100 m. Slope gradients 15–25%. Extensively cleared with stands of closed-forest and tall open-forest.

Soils—shallow (<50 cm) Structured Loams (Um6) occur on crests, moderately deep (50–100 cm) Krasnozems (Gn4.11) on upper slopes and benches. Brown Podzolic Soils (Db1.11, Db1.21) and Red Podzolic Soils (Dr2.21) occur on mid and lower slopes.

Limitations—rock fall hazard, wave erosion hazard, rock outcrop, hardsetting, low wet bearing strength, sodicity.

LOCATION

Rolling low hills with benched slopes and sea cliffs with extensive rock platforms on latite and basalt on the Coastal Plain. Examples include Bombo, Dunmore and extensive areas within Jamberoo Valley.

LANDSCAPE

Geology

Bumbo Latite Member—alphanitic to porphoryitic latite.

Topography

Rolling low hills. Relief 40–100 m. Slope gradients 15–25%. Crests are narrow. Convex ridges are long and gently inclined. Moderately inclined slopes with isolated steep (25–40%) slopes. Scattered benches and terracettes on upper slopes. Narrow incised drainage lines. Coastal headlands with cliffs and extensive rock platforms. Springs may occur on the mid and footslopes—for example, Rose Valley.

Vegetation

Extensively cleared with remnant stands of closed-forest and tall open-forest. Common closed-forest species include cabbage tree palm (*Livistona australis*), bastard rosewood (*Synoum glandulosum*), red cedar (*Toona australis*), brush cherry (*Syzygium australe*), bolly gum (*Litsea reticulata*), white cedar (*Melia azedarach* var. *australasica*), northern boobialla (*Myoporum acuminatum*), smooth mock olive (*Notelaea venosa*), snow-wood (*Parachidendron pruinsom*), celery wood (*Polyscias elegans*), black apple (*Planchonella australis*), plum pine (*Polocarpus elatus*), yellowwood, moreton bay fig (*Ficus macrophylla*), port jackson fig (*Ficus rubiginosa*) and flintwood (*Scolopia braunii*).

Common tall open-forest species include turpentine (*Syncarpia glomulifera*), grey ironbark (*Eucalyptus paniculata*), pittosporum (*Pittosporum* spp.) and sydney blue gum /bangalay (*Eucalyptus saligna/botryoides*). Forest red gum (*Eucalyptus tereticornis*) and prickly-leaved paperbark (*Melaleuca styphelioides*) are found in poorly drained areas.

The vegetation on the associated soil material includes coastal tea-tree (*Leptospermum laevigatum*), coastal banksia (*Banksia integrifolia*), swamp oak (*Casuarina glauca*), bracelet honey-myrtle (*Melaleuca armillaris*) and drooping she-oak (*Allocasuarina verticillata*).

Land Use

Dairying, grazing and hobby farms on improved pasture, recreation areas including Jamberoo Recreation Park and quarrying of latite at Bombo and Dunmore.

Existing Erosion

Evidence of minor mass movement (terracettes) on moderately steep lower slopes. Moderate rill erosion on batters of footslopes where soils have been disturbed.

Included Soil Landscapes

Small areas of Fountaindale **(fo)** and Jamberoo **(ja)** soil landscapes occur.

SOILS

Dominant Soil Materials

bo1—Friable reddish brown sandy clay loam (topsoil)

Colour	reddish brown (5YR 4/6)
Texture	sandy clay loam
Structure	apedal massive to weakly pedal, <2 mm crumb peds
Fabric	earthy and rough-faced, porous
pH	5.5
Stones	nil
Roots	abundant, ex-ped

bo2—Hardsetting brownish black sandy loam (topsoil)

Colour	brownish black (5YR 3/1) to dark reddish brown (5YR 3/3) occasionally at depth
Texture	sandy loam
Structure	weakly pedal, <2 mm crumb peds
Fabric	rough-faced, porous
pH	6.0
Stones	2–10% 2–6 mm angular, dispersed
Roots	abundant, ex-ped

bo3—Reddish brown light medium clay (subsoil)

Colour	reddish brown (2.5YR 4/8)
Texture	light medium clay
Structure	moderately pedal, 5–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	4.0
Stones	nil (but can be localised rounded basalt or latite stones 20–60 mm 2–10% dispersed)
Roots	few, ex-ped

bo4—Reddish brown sandy clay (subsoil)

Colour	reddish brown (2.5YR 4/6)
Texture	sandy clay
Structure	moderately pedal, 5–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	5.0
Stones	nil
Roots	many, ex-ped

bo5—Brown strongly pedal medium clay (subsoil)

Colour	brown (7.5YR 4/6)
Texture	medium clay
Structure	strongly pedal, 5–10 mm polyhedral and crumb peds
Fabric	rough-faced, porous
pH	4.0
Stones	nil
Roots	nil

Associated Soil Materials

Very shallow (<50 cm) indurated beach and fine grey Quaternary sands occur (Bass Point).

Occurrence and Relationships

Crests. Up to 15 cm friable reddish brown sandy clay loam **(bo1)** overlies bedrock [Structured Loams (Um6)].

Upper slopes and benches. Up to 15 cm **bo1** overlies <50 cm reddish brown sandy clay **(bo4)** which overlies <60 cm reddish brown light medium clay **(bo3)**. The boundaries are gradual [Krasnozems (Gn4.11)]. Total soil depth is <120 cm.

Midslopes and lower slopes. Up to 10 cm hardsetting brownish black sandy loam **(bo2)** overlies <15 cm **bo4**. Up to 40 cm brown strongly

pedal medium clay **(bo5)** is overlain by <35 cm **bo3**. The boundaries are clear to gradual [Brown Podzolic Soils (Db1.11, Db1.21), Red Podzolic Soils (Dr2.21)]. Total depth is <120 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

bo1 High organic matter
Low wet bearing strength
High shrink-swell
Sodicity
High aluminium toxicity

bo2 Stoniness
Hardsetting
Low permeability
Sodicity

bo3 Strongly acid
Sodicity

bo4 Sodicity

bo5 Strongly acid
Sodicity

Fertility

General fertility is moderate to low. The topsoil **(bo1)** is friable. The soils are deep, well structured, freely drained on crests and upper slopes. They are strongly acid with low to moderate CEC.

Erodibility

bo1 has high erodibility. **bo2** has moderate erodibility, and the strongly structured subsoils **(bo3, bo4** and **bo5)** have low erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 100 t/ha for topsoils and 100 t/ha for exposed subsoils. The erosion hazard for concentrated flows is moderate to high.

Surface Movement Potential

These soils are generally stable; however, there are localised occurrences of moderately reactive soils.

Landscape Limitations

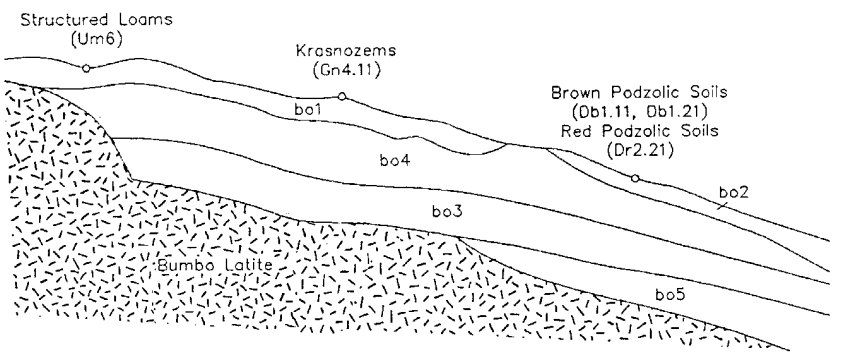
Steep slopes (localised)
Mass movement hazard (localised)
Rock fall hazard
Wave erosion hazard (coasts)
Rock outcrop
Run-on (localised)

Urban Capability

Generally moderate limitations for urban development. High to severe limitations on slopes greater than 20%.

Rural Capability

Generally high to severe limitations for regular cultivation. Generally low to moderate limitations for grazing but high to severe limitations for grazing on steep slopes.



■ ***Schematic cross-section of Bombo soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

ca	CAMBEWARRA	Erosional

Landscape—steep to very steep hills with broad colluvial benches on latite. Relief 100–200 m. Slope gradients >30%. Partially cleared to extensive stands of closed-forest.

Soils—deep (>150 cm) Red Solonetzic Soils (Dr5.31) or Krasnozems (Gn4.11) occur on upper slopes and benches. Lithosols (Um6.24) occur on basanite outcrops.

Limitations—steep slopes, mass movement hazard, rock fall hazard, extreme water erosion hazard, shallow soil, rock outcrop, stoniness, low available water-holding capacity (topsoil), low wet bearing strength (subsoil) and sodicity.

LOCATION

Steep to very steep hills with broad colluvial benches on latite and Illawarra Coal Measures on the Illawarra Escarpment. Examples include upper reaches of Cambewarra Range, the Kangaroo Valley and of Stockyard Mountain.

LANDSCAPE

Geology

Cambewarra Latite Member—felsic latite with scattered olivine basanite outcrops; Illawarra Coal Measures—interbedded quartz lithic sandstone, mudstones, carbonaceous claystones and coals.

Topography

Steep to very steep hills with broad (600 m) colluvial benches. Relief 100–300 m. Slope gradients >30%. Crests and ridges are convex and narrow. Isolated moderately wide plateaux occur—for example, Stockyard Mountain. Hillslopes are steep (>50%) with talus comprising latite boulders and scattered rock outcrops with occasional terracettes and landslips. Drainage lines are closely spaced and deeply incised.

Vegetation

Uncleared to partially cleared closed-forest. Common species include coachwood (*Ceratopetalum apetalum*), churnwood (*Citronella moorei*), white cedar (*Melia azedarach* var. *australasica*), red cedar (*Toona australis*), giant stinging tree (*Dendrocnide excelsa*), brittlewood (*Claoxylon australe*), bolly gum (*Litsea reticulata*), native laurel (*Cryptocarya glaucescens*), native tamarind (*Dipolglottis cunninghamii*), sassafras (*Doryphora sassafras*), hairy clerodendrum (*Clerodendrum tomentosum*), rough tree-fern (*Cyathea australis*), olivers sassafras (*Cinnamomum oliveri*) and bangalow palm (*Archontophoenix cunninghamiania*).

Land Use

Cattle grazing and hobby farms on improved pastures. Undisturbed rainforest and National Parks including Morton National Park.

Existing Erosion

Widespread rock falls and slumps along road batters especially after heavy rain. Minor gully erosion.

Included Soil Landscape

Small areas of Illawarra Escarpment **(ie)** soil landscape occur.

SOILS

Dominant Soil Materials

ca1—Friable very dark reddish brown sandy clay loam (topsoil)

Colour	very dark reddish brown (5YR 2/3) (with occasional bleach)
Texture	sandy clay loam to light sandy loam
Structure	moderately pedal, 10–20 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	5.5–6.0
Stones	2–10% 2–6 mm rounded and sub-rounded, dispersed
Roots	common, in-ped

ca2—Very dark reddish brown silty clay loam (topsoil)

Colour	very dark reddish brown (2.5YR 2/3)
Texture	silty clay loam
Structure	moderately pedal, 5–50 mm polyhedral to angular blocky peds
Fabric	rough-faced, porous
pH	5.5–6.0
Stones	50–90% 2–6 mm angular, dispersed
Roots	few, ex-ped

ca3—Bright brown strongly pedal light clay (subsoil)

Colour	bright brown (7.5YR 5/8) to reddish brown (2.5YR 4/8)
Texture	light clay to light medium clay
Structure	strongly pedal, 10–20 mm angular blocky peds
Fabric	rough-faced, porous
pH	4.5
Stones	2–10% 2–6 mm rounded and sub-rounded, dispersed
Roots	few, in-ped

ca4—Mottled bright reddish brown strongly pedal medium clay (subsoil)

Colour	bright reddish brown (5YR 5/8) with yellow (50%) and grey (40%) mottles
Texture	medium clay
Structure	strongly pedal, 10–20 mm angular blocky peds
Fabric	rough-faced, porous
pH	3.5–5.5
Stones	nil to localised 10–20% 6–60 mm angular and sub-angular, dispersed
Roots	nil

Occurrence and Relationships

Steep slopes and benches. Up to 50 cm friable very dark reddish brown sandy clay loam **(ca1)** overlies <70 cm bright brown light clay **(ca3)** which overlies <80 cm mottled bright reddish brown strongly pedal medium clay **(ca4)**. Boundaries are clear to gradual [Red Solonetzic Soils (Dr5.31)]. Total depth is <250 cm. Up to 50 cm **ca1** overlies <70 cm **ca3** which in turn overlies <150 cm **ca4**. Boundaries are gradual [Krasnozems (Gn4.11)]. Total depth is <200 cm.

Very steep slopes. Up to 30 cm very dark reddish brown silty clay loam **(ca2)** overlies bedrock [Lithosols (Um6.24)].

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ca1 Stoniness
Very low available water-holding capacity
Sodicity

ca2 Stoniness
Shallow
Slight sodicity

ca3 Strongly acid
Stoniness

ca4 Strongly acid
Stoniness
Low permeability
Low wet bearing strength

Fertility

General fertility is moderate. The soils are deep except on steep slopes, well structured and well drained. The topsoils have a moderate CEC and are moderately to slightly acid. Subsoils may be extremely acid.

Erodibility

The topsoils **(ca1** and **ca2)** are well structured but stony and have moderate erodibility. The subsoils **(ca3** and **ca4)** have low erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 1 200 t/ha for topsoils and 600 t/ha for exposed subsoils. The erosion hazard for concentrated flows is extreme.

Surface Movement Potential

These soils are stable.

Landscape Limitations

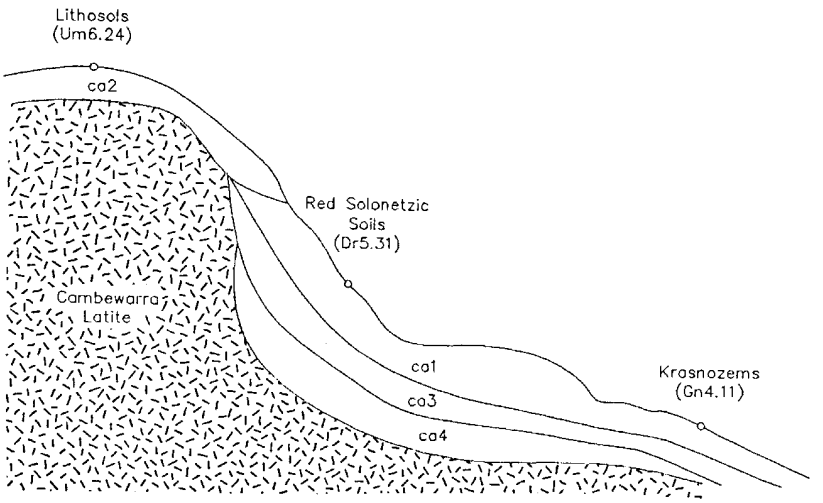
Steep slopes
Mass movement hazard
Rock fall hazard
Water erosion hazard
Shallow soil
Rock outcrop

Urban Capability

Generally high to severe limitations for urban development

Rural Capability

Generally high to severe limitations for cultivation and grazing.



■ ***Schematic cross-section of Cambewarra soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

co	COOLONGATTA	Erosional

Landscape—undulating to rolling low hills on Berry Formation. Relief 10–100 m. Slopes 5–20%. Extensively cleared with scattered open-woodland with occasional shrubs.

Soils—Lithosols (Um6.12) occur on crests and upper slopes. Moderately deep (50–100 cm) Brown Earths (Gn3.22) occur on midslopes. Deep (>150 cm) Red and/or Yellow Podzolic Soils (Dr3.31, Dy3.31) occur on lower slopes and in adjacent drainage lines.

Limitations—water erosion hazard, surface movement potential (localised), mass movement hazard (localised), hardsetting, stoniness, strongly acid, low wet bearing strength (topsoil), shrink-swell (subsoil).

LOCATION

Undulating to rolling low hills on Berry Formation on the Coastal Plain. Examples include lower slopes of Coolongatta Mountain and Parma Road, Nowra.

LANDSCAPE

Geology

Berry Formation—light grey to dark grey micaceous siltstone, mudstone and shale.

Topography

Undulating to rolling low hills. Relief 10–100 m. Slopes ranging from 5–20% with isolated steep slopes >25% and scattered rock outcrops. Broad crests and ridges to 200 m long, moderately inclined slopes with moderate to steeply incised drainage lines. Slumping at heads of drainage lines. On isolated steep slopes terracettes and landslips.

Vegetation

Extensively cleared with scattered open-woodland with occasional shrubs. Common species include spotted gum (*Eucalyptus maculata*), blackbutt (*Eucalyptus pilularis*), blue-leaved stringybark (*Eucalyptus agglomerata*), cabbage tree palm (*Livistona australis*), illawarra flame tree (*Brachychiton acerifolium*), wattle (*Acacia* sp.). Decorative paperbark (*Melaleuca decora*) occurs in the drainage lines.

Land Use

Cattle grazing on improved pastures, Albatross Naval Base, recreational walking trails.

Existing Erosion

Moderate to severe stream bank erosion. Localised moderate gully erosion. Slumping at heads of drainage lines. Moderate to severe rill erosion occurs on batters. There is evidence of terracettes and landslips on steep slopes.

SOILS

Dominant Soil Materials

co1—Hardsetting dull brown loam, fine sandy (topsoil)

Colour	dull brown (7/5YR 5/4)
Texture	loam, fine sandy
Structure	weakly to moderately pedal, 5–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	5.5
Stones	nil
Roots	common, in-ped

co2—Friable dark brown loam (topsoil)

Colour	dark brown (10YR 4/3)
Texture	loam
Structure	weakly pedal, 2–5 mm polyhedral to sub-angular blocky peds
Fabric	rough-faced, porous
pH	6.0
Stones	10–20% 8–12 mm angular, dispersed
Roots	abundant, in-ped

co3—Mottled dull reddish brown weakly pedal sandy clay (subsoil)

Colour	dull reddish brown (2.5YR 4/4) with grey red mottles (50%)
Texture	sandy clay to heavy clay
Structure	weakly pedal, 5–10 mm polyhedral peds
Fabric	smooth-faced, dense
pH	4.0
Stones	20–50% <2 mm
Roots	few

co4—Brown weakly pedal sandy clay loam (subsoil)

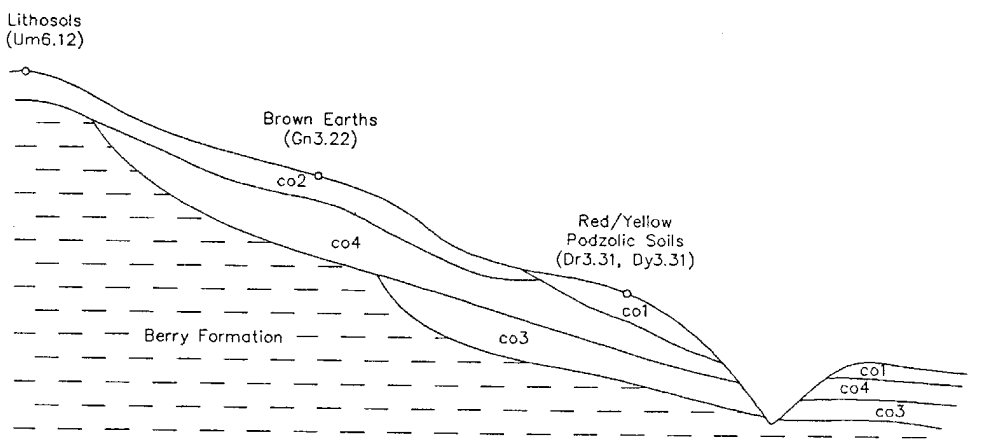
Colour	brown (7.5YR 4/4) to yellowish brown (10YR 5/6)
Texture	sandy clay loam
Structure	weakly pedal, 2–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	4.0
Stones	20–50% 5–10 mm
Roots	few

Occurrence and Relationships

Crests and upper slopes. Up to 20 cm friable dark brown loam **(co2)** overlies bedrock. Boundary is sharp [Lithosols (Um6.12)]. Total soil depth is <20 cm.

Midslopes. Up to 10 cm friable dark brown loam **(co2)** overlies <50 cm brown weakly pedal sandy clay loam **(co4).** Boundary is gradual [Brown Earths (Gn3.22)]. Total soil depth is <60 cm.

Lower slopes and drainage lines. Up to 10 cm hardsetting dull brown loam, fine sandy **(co1)** overlies <15 cm **co4** which overlies <150 cm mottled dull reddish brown weakly pedal sandy clay **(co3).** Boundaries are clear. [Red Podzolic Soils and Yellow Podzolic Soils (Dr3.31, Dy3.31)]. Total soil depth is <200 cm.



■ *Schematic cross-section of Coolongatta soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

LIMITATIONS TO DEVELOPMENT

When ground cover is removed, these soils can be highly dispersible, and dams will fail.

Soil Limitations

co1 Hardsetting
High organic matter
Low wet bearing strength
Shrink-swell potential (localised)
Strongly acid

co2 Stoniness
High organic matter
Low wet bearing strength
Shrink-swell potential (localised)
Strongly acid
Sodicity

co3 Low permeability
Stoniness
Low wet bearing strength
Strongly acid
Shrink-swell

co4 Stoniness
Strongly acid

Fertility

General fertility is moderate to low. The soils, with the exception of localised friable outcrops, are generally very hardsetting, weakly structured, strongly acid with low to moderate CEC.

Erodibility

The topsoils **(co1** and **co2)** are highly to moderately erodible (respectively). The subsoils **(co3** and **co4)** have low erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 900 t/ha for topsoils and 600 t/ha for exposed subsoils. The erosion hazard for concentrated flows is extreme.

Surface Movement Potential

The deep soils are slightly to moderately reactive. Reactivity of these soils may vary widely over short distances. Shallow soils are slightly reactive.

Landscape Limitations

Steep slopes (localised)
Mass movement hazard (localised)
Shallow soil (localised)
Rock outcrop (localised)
Water erosion hazard
Surface movement potential (localised)

Urban Capability

Generally moderate limitations for urban development except on slopes greater than 20% and areas of mass movement hazard which have severe limitation hazard.

Rural Capability

Generally high to severe limitations for regular cultivation. Low to moderate limitations for grazing.

ka	KIAMA	Erosional

Landscape—rolling low hills with broad crests, long convex slopes and steep coastal headlands on Blow Hole Latite. Relief 40–60 m. Slopes <20%. Extensive rock outcrop. Extensively cleared with stands of closed-forest.

Soils—deep (>150 cm) Krasnozems (Gn4.11) on crests and upper slopes and Prairie Soils (Gn4.51, Gn4.81) on lower slopes.

Limitations—run-on, water erosion hazard (localised), mass movement hazard (localised), sodicity, low permeability, low wet bearing strength, moderate shrink-swell (subsoil).

LOCATION

Rolling low hills and steep coastal headlands on latite on the Coastal Plain. Examples include Kiama, Gerringong and Gerroa.

LANDSCAPE

Geology

Blow Hole Latite Member—mid grey latite, generally aphanitic.

Topography

Rolling low hills. Relief 40–60 m. Slopes <20%. Crests are broad with long moderately inclined convex slopes and gently inclined concave footslopes. Extensively scattered rock outcrops on upper slopes. Drainage plains <100 m wide. Steep coastal headlands with narrow rock platforms and occasional blow holes.

Vegetation

Extensively cleared with isolated stands of closed-forest. Common species include lillypilly (*Acmena smithii*), native quince (*Alectryon subcinereus*), brush bloodwood (*Baloghia lucida*), red-fruited olive plum (*Cassine australis*), brittlewood (*Claoxylon australe*), hairy clerodendrum (*Clerodendrum tomentosum*), murrogun (*Cryptocarya microneura*), giant stinging tree (*Dendrocnide excelsa*), black plum (*Diospyros australis*), sassafras (*Doryphora sassafras*), corkwood (*Duboisia myoporoides*), koda (*Ehretia acuminata*), bolwarra (*Eupomatia laurina*) (Gerroa only), moreton bay fig (*Ficus macrophylla*), deciduous fig (*Ficus superba*), cabbage tree palm (*Livistona australis*), northern boobialla (*Myoporum acuminatum*), large mock olive (*Notelaea longifolia*), snow-wood (*Parachidendron pruinosum*), pittosporum (*Pittosporum* spp.), black apple (*Planchonella australis*), plum pine (*Polocarpus elatus*), yellowwood (*Sarcomelicope simplicifolia*), flintwood (*Scolopia braunii*), wilkiea (*Wilkiea huegeliana*), whalebone tree (*Streblus brunonianus*),

bastard rosewood (*Synoum glandulosum*), buff hazelwood (*Symplocos thwaitesii*), scrub beefwood (*Stenocarpus salignus*), olivers sassafras (*Cinnamomum oliveri*), coast canthium (*Canthium coprosmoides*), bird lime tree (*Pisonia umbellifera*).

Land Use

Cattle grazing on improved pastures, urban development including service and tourist centres of Kiama, Gerringong and Gerroa.

Existing Erosion

Moderate sheet and gully erosion only where a poor vegetative cover exists.

Included Soil Landscape

Small areas of Fountaindale **(fo)** soil landscape occur.

SOILS

Dominant Soil Materials

ka1—Friable brownish black sandy clay loam (topsoil)

Colour	brownish black (5YR 2/2)
Texture	sandy clay loam to light sandy clay loam
Structure	moderately pedal, <2 mm crumbs to polyhedral peds
Fabric	rough-faced, porous
pH	4.5–6.0
Stones	10–20% 2–20 mm sub-rounded, dispersed
Roots	common, ex-ped

ka2—Brown weakly pedal light clay (subsoil)

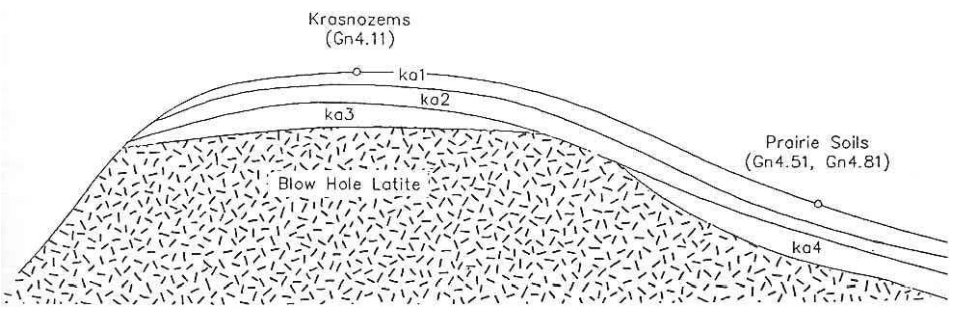
Colour	brown (10YR 4/4)
Texture	light clay to sandy clay
Structure	weakly pedal, 10–20 mm polyhedral peds
Fabric	rough-faced, porous
pH	4.5
Stones	nil
Roots	few, ex-ped

ka3—Dark red weakly pedal heavy clay (subsoil)

Colour	dark red (10R 3/6) to dark reddish brown (10R 3/3)
Texture	heavy clay
Structure	weakly to moderately pedal, 2–5 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	4.5–5.5
Stones	2–10%, 6–20 mm angular, dispersed
Roots	common, ex-ped

ka4—Bright yellowish brown moderately pedal light medium clay (subsoil)

Colour	bright yellowish brown (10YR 6/6) to dull yellow orange (10YR 6/4) with localised brown and grey (<50%) mottling
Texture	light medium clay to sandy clay
Structure	moderately pedal, 10–20 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	5.0–5.5
Stones	nil
Roots	nil



■ ***Schematic cross-section of Kiama soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

Occurrence and Relationships

Crests and upper slopes. Up to 50 cm friable brownish black clay loam **(ka1)** overlies <20 cm brown weakly pedal light clay **(ka2)**. Up to 150 cm dark red weakly pedal heavy clay **(ka3)** is overlain by <20 cm **ka2**. Boundaries are gradual [Krasnozems (Gn4.11)]. Total depth is 100–200 cm.

Lower slopes and drainage plains. Up to 50 cm **ka1** overlies <20 cm **ka2** which overlies <150 cm bright yellowish brown light medium clay **(ka4)**. Boundaries are clear to gradual [Prairie Soils (Gn4.51, Gn4.81)]. Total depth is 100–200 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ka1 Stoniness
Sodicity
Low available water-holding capacity
High organic matter

ka2 Low fertility
Sodicity
Strongly acid

ka3 Stoniness
Low permeability
Sodicity
Strongly acid
Low available water-holding capacity

ka4 Shrink-swell potential
Low permeability
Low wet bearing strength
Strongly acid

Fertility

General fertility is moderate to low. The topsoil **(ka1)** is friable. The subsoils are deep, well structured, freely drained on crests and upper slopes. They are strongly acid with low to moderate CEC.

Erodibility

The topsoil **(ka1)** has moderate erodibility. The subsoils **(ka2, ka3** and **ka4)** have high erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 1 300 t/ha for topsoils and 900 t/ha for exposed subsoils. The erosion hazard for concentrated flows is moderate.

Surface Movement Potential

These moderate to deep clay soils **(ka1, ka2, ka3)** are slightly reactive. The subsoil **ka4** is moderately reactive.

Landscape Limitations

Rock fall hazard (localised)
Rock outcrop (localised)
Steep slopes (localised)
Run-on
Water erosion hazard (localised)

Urban Capability

Generally low limitations for urban development. Moderate limitations on steeper slopes.

Rural Capability

Generally high to severe limitations for regular cultivation. Low to moderate limitations for grazing.

pr	PULPIT ROCK	Erosional

Landscape—convex weathered rugged sandstone cliffs on Nowra Sandstone with talus slopes. Relief <80 m. Slopes >30%. Extensive caves and concave weathered pinnacles. Partially uncleared with low open-woodland.

Soils—soil is often discontinuous. Lithosols (Uc1.21) occur on crests, midslopes and lower slopes. Moderate to deep (100–>150 cm) Yellow Podzolic Soils (Dy2.31 and Dy3.11) occur on midslopes and lower slopes.

Limitations—steep slopes, mass movement hazard, rock fall hazard, rock outcrop, water erosion hazard, shallow soils, stoniness, hardsetting, and low available water-holding capacity.

LOCATION

Convex weathered sandstone cliffs and concave weathered pinnacles with talus slopes on sandstone on the Coastal Plain. Examples include Yalwal and Hanging Rock.

LANDSCAPE

Geology

Nowra Sandstone—medium- to coarse-grained quartzose sandstones containing rounded pebbles of scattered quartz throughout the beds.

Topography

Convex weathered rugged sandstone cliffs with steep to very steep talus slopes. Relief <80 m. Slopes >30%. Crests are broad (500 m), slopes are steep with benches, drainage lines are narrow and incised. Extensive caves and concave weathered pinnacles associated with block gliding (Young 1983)—for example, Chimney Stack Rock near Yalwal. Scattered large rocks and boulders are common.

Vegetation

Uncleared low open-woodland. Common species include grey gum (*Eucalyptus punctata*), scribbly gum (*Eucalyptus haemostoma*), red bloodwood (*Eucalyptus gummifera*), blackbutt (*Eucalyptus pilularis*), sydney peppermint (*Eucalyptus piperita*), grey ironbark (*Eucalyptus paniculata*), hairpin banksia (*Banksia spinulosa*), black wattle (*Acacia mearnsii*), lillypilly (*Acmena smithii*), coastal tea-tree (*Leptospermum laevigatum*), dagger hakea (*Hakea teretifolia*), burrawang (*Macrozamia communis*), turpentine (*Syncarpia glomulifera*) and spotted gum (*Eucalyptus maculata*).

Land Use

Recreational areas, walking trails and undisturbed bushland.

Existing Erosion

Rock falls are common on scree slopes. There is evidence of minor rill erosion and moderate slumping on batters.

SOIL

Dominant Soil Materials

pr1—Hardsetting moderately pedal brown fine sandy loam (topsoil)

Colour	brown (10YR 4/4) to dull yellowish brown (10YR 4/3)
Texture	fine sandy loam
Structure	moderately pedal, 50–100 mm polyhedral to sub-angular blocky peds
Fabric	rough-faced, porous
pH	5.0
Stones	20–50% 60–200 mm angular, dispersed
Roots	common, in-ped

pr2—Loose brownish grey sand (topsoil)

Colour	brownish grey (5YR 4/1)
Texture	sand to loamy sand
Structure	apedal single-grained
Fabric	sandy
pH	5.0
Stones	2–10% 2–6 mm rounded, dispersed
Roots	common

pr3—Bright brown strongly pedal medium clay (subsoil)

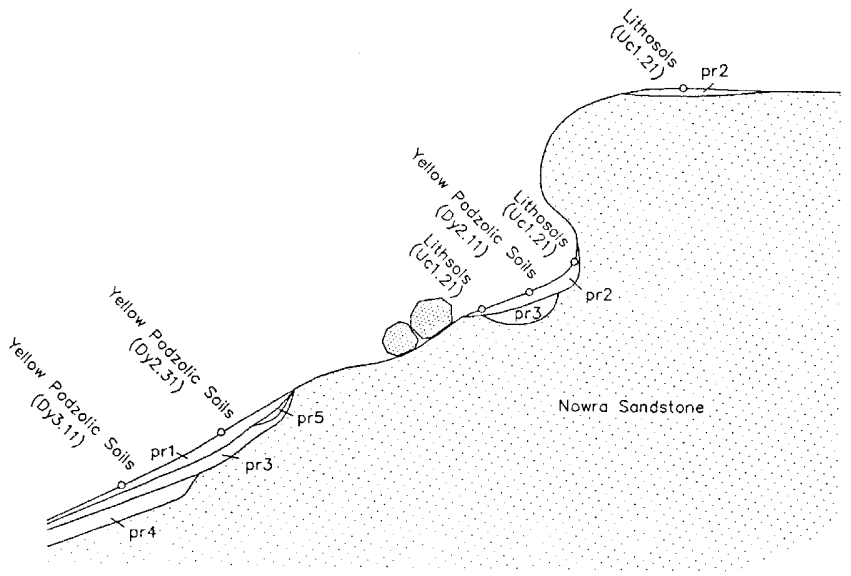
Colour	bright brown (7.5YR 5/8)
Texture	sandy clay
Structure	strongly pedal, 10–20 mm angular blocky peds
Fabric	rough-faced, porous
pH	4.5
Stones	20–50% 20–60 mm rounded, dispersed
Roots	nil

pr4—Mottled bright brown massive medium clay (subsoil)

Colour	bright brown (7.5YR 5/8) with yellow and grey mottles (50%)
Texture	medium clay
Structure	apedal massive
Fabric	dense
pH	3.5
Stones	nil
Roots	nil

pr5—Bright yellowish brown sandy clay loam (subsoil)

Colour	bright yellowish brown (10YR 5/3) with sporadic bleach
Texture	sandy clay loam



■ *Schematic cross-section of Pulpit Rock soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Structure	apedal massive to weakly pedal, 10–20 mm polyhedral peds
Fabric	earthy to rough-faced, porous
pH	5.0
Stones	nil
Roots	few, ex-ped

Occurrence and Relationships

Soils are often shallow and discontinuous.

Crests. Up to 20 cm of loose brownish grey sand **(pr2)** overlies bedrock [Lithosols (Uc1.21)].

Midslopes. Up to 15 cm **pr2** overlies bedrock [Lithosols (Uc1.21)]. Otherwise, <15 cm **pr2** overlies <50 cm bright brown strongly pedal medium clay **(pr3)**. Boundary is sharp [Yellow Podzolic Soils (Dy2.11)]. Total depth is >100 cm.

Lower Slopes. Up to 20 cm fine sandy loam **(pr1)** overlies <20 cm bright yellowish brown sandy clay loam **(pr5)** which overlies <70 cm **pr3**. Boundaries are sharp to clear [Yellow Podzolic Soils (Dy2.31)]. Total depth is <150 cm. Up to 20 cm of **pr1** overlies <70 cm **pr3**. Up to 40 cm mottled bright massive medium clay **(pr4)** is overlain by <70 cm **pr3.** Boundaries are sharp to clear [Yellow Podzolic Soils (Dy3.11)]. Total depth is <250 cm. Occasionally <20 cm of loose brownish grey sand **(pr2)** overlies bedrock [Lithosols (Uc1.21)].

LIMITATIONS TO DEVELOPMENT

Soil Limitations

pr1 Hardsetting
Stoniness
Low available water-holding capacity

pr2 Stoniness
Sodicity
High permeability
Very low available water-holding capacity
High aluminium toxicity

pr3 Stoniness
Very low organic matter
Low fertility
Low available water-holding capacity
High aluminium toxicity

pr4 Strongly acid
High permeability
Low available water-holding capacity

pr5 Low permeability
Low wet bearing strength
Low fertility
Low available water-holding capacity

Fertility

General fertility is low. The topsoil **(pr1)** is hardsetting. The subsoils are often shallow and stony, strongly to moderately acid with a low CEC.

Erodibility

All the soil materials have very low erodibility ratings.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 500 t/ha for topsoils and 750 t/ha for exposed subsoils. The erosion hazard for concentrated flows is low to moderate.

Surface Movement Potential

These soil materials are generally stable.

Landscape Limitations

Steep slopes
Mass movement hazard
Rock fall hazard
Shallow soil
Rock outcrop
Water erosion hazard

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

sh	SHELLHARBOUR	Erosional

Landscape—rolling low hills with long sideslopes and broad drainage plains on Budgong Sandstone. Relief 30–50 m. Slopes <20%. Extensively cleared with stands of tall open-forest and closed-forest.

Soils—deep (>150 cm) Prairie Soils (Gn3.21) occur on crests and upper slopes. Brown Krasnozems (Gn3.14) occur on midslopes. Red Podzolic Soils (Dr4.41) and Prairie Soils (Dy4.11) occur on lower slopes and drainage plains.

Limitations—mass movement (localised), shallow soil (localised), water erosion hazard (localised), sodicity, hardsetting, low permeability, low wet bearing strength (subsoil), high shrink-swell (subsoil).

LOCATION

Rolling low hills with long sideslopes and broad drainage plains which occur on Budgong Sandstone on the Coastal Plain—for example, Dunmore, Blackbutt Reserve and Shellharbour.

LANDSCAPE

Geology

Budgong Sandstone—red brown and grey volcanic sandstones.

Topography

Rolling low hills. Relief 20–50 m. Slope gradient <20%. Broad convex crests with long ridges. Long moderately inclined sideslopes with concave footslopes grading into broad drainage plains. Scattered occasional rock outcrops.

Vegetation

Extensively cleared with stands of tall open-forest and closed-forest in sheltered locations. Common species of tall open-forest include blackbutt (*Eucalyptus pilularis*), sydney blue gum (*Eucalyptus saligna*), bangalay (*Eucalyptus botryoides*), sydney blue gum/bangalay (*Eucalyptus saligna/botryoides*), and kangaroo grass (*Themeda australis*). Forest red gum (*Eucalyptus tereticornis*) and white stringybark (*Eucalyptus globoidea*) grow in poorly drained areas. A remnant stand of closed-forest grows on the sea cliffs at Gerroa. The common species include yellowwood (*Sarcomelicope simplicifolia*), bird lime tree (*Pisonia umbellifera*) and plum pine (*Polocarpus elatus*).

Land Use

Dairying and horse agistment on improved pastures and urban subdivisions—for example, Lakeview Estate.

Existing Erosion

Moderate gullying along drainage lines to bedrock (1 m).

SOILS

Dominant Soil Materials

sh1—Friable brownish black sandy loam (topsoil)

Colour	brownish black (7.5YR 2/2)
Texture	sandy loam
Structure	weakly pedal, 2–5 mm crumb peds
Fabric	rough-faced, porous
pH	6.0
Stones	nil
Roots	many, ex-ped

sh2—Hardsetting organic rich black light clay (topsoil)

Colour	black (7.5YR 2/1)
Texture	sandy clay to light clay
Structure	moderately pedal, 5–10 mm platy peds
Fabric	rough-faced, porous
pH	5.5
Stones	2–10% 2–6 mm sub-rounded, dispersed
Roots	abundant, in-ped

sh3—Mottled dull reddish brown, sandy clay (subsoil)–with characteristic stone line

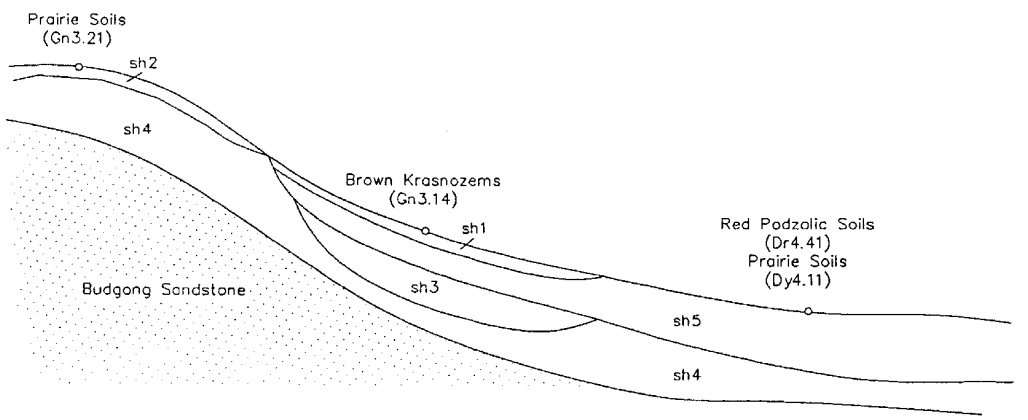
Colour	dull reddish brown (5YR 4/4) with red and grey mottles (50%) at depth
Texture	sandy clay to light clay
Structure	moderately pedal, 10–20 mm sub-angular blocky peds
Fabric	smooth-faced, dense
pH	6.0
Stones	20–50% 2–6 mm sub-angular, stratified
Roots	common, in-ped

sh4—Brown strongly pedal heavy clay (subsoil)

Colour	brown (7.5YR 4/6)
Texture	heavy clay
Structure	strongly pedal, 20–50 mm sub-angular to columnar peds
Fabric	smooth-faced, dense
pH	5.5–4.5
Stones	nil
Roots	few, in-ped

sh5—Very sticky strongly pedal dull reddish brown sandy clay loam (subsoil)

Colour	dull reddish brown (5YR 4/4)
Texture	sandy clay loam to sandy clay at depth
Structure	strongly pedal, 10–20 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	6.0
Stones	nil
Roots	many, in ped



■ *Schematic cross-section of Shellharbour soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Occurrence and Relationships

Crests and upper slopes. Up to 10 cm hardsetting organic rich black light clay **(sh2)** overlies <100 cm of brown strongly pedal heavy clay **(sh4).** Boundary is gradual [Prairie Soils (Gn3.21)]. Total depth is >120 cm.

Midslopes. Up to 20 cm friable brownish black sandy loam **(sh1)** overlies <50 cm very sticky strongly pedal dull reddish brown sandy clay loam **(sh5)**. Up to 50 cm mottled dull reddish brown sandy clay **(sh3)** overlies <50 cm **sh4.** Occasionally **sh1** is absent. The boundaries are sharp to gradual [brown Krasnozems (Gn3.14)]. Total depth is <200 cm.

Footslopes and drainage plains. Up to 40 cm of **sh5** overlies >50 cm of **sh4.** Boundary is clear [Red Podzolic Soils (Dr4.41) with localised Prairie Soils (Dy4.11) more frequently occurring on drainage plains]. Total depth is >100 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

sh1 Sodicity

sh2 Hardsetting
Stoniness
Sodicity

sh3 Low permeability
Low wet bearing bearing strength
Stoniness
Sodicity

sh4 Low permeability
Low wet bearing strength
Sodicity
Shrink-swell

sh5 Low permeability
Low wet bearing strength
Sodicity

Fertility

General fertility is moderate. The soils, with the exception of localised friable outcrops, are generally hardsetting. The soils have localised impeded drainage with a definite stone line but are often deep. Soil materials are slightly acid with a high CEC.

Erodibility

The erodibility ratings for both topsoils and subsoils is very high to high respectively.

Erosion Hazard

Erosion hazard for this soil landscape for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 1 300 t/ha for topsoils and 900 t/ha for exposed subsoils. The erosion hazard for concentrated flows is high.

Surface Movement Potential

These soils are generally stable. **sh4** is moderately reactive.

Landscape Limitations

Mass movement (localised)
Steep slopes (localised)
Water erosion hazard (localised)
Shallow soil (localised)
Rock outcrop (localised)

Urban Capability

Generally low limitations for urban development.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing.

wm	WILDES MEADOW	Erosional

Landscape—gently undulating rises grading to low hills on Wianamatta Group—Bringelly Shale. Local relief >40 m. Slopes 10–20%. Extensively cleared with stands of tall open-forest.

Soils—moderately deep (50–100 cm) Xanthozems (Gn3.71) occur on crests and upper slopes. Yellow Podzolic Soils (Dy5.11) and Yellow Earths (Gn2.81) occur on mid and lower slopes.

Limitations—surface movement potential, water erosion hazard, mass movement hazard (localised), seasonal waterlogging (localised), high available water-holding capacity (topsoil), strongly acid, sodicity, high organic matter (topsoil).

LOCATION

Gently undulating rises to low hills on mudstones and siltstones on the Moss Vale Tableland. Examples include Wildes Meadow, Glenquarry and Mount Murray.

LANDSCAPE

Geology

Wianamatta Group—Bringelly Shale—mid grey and dark grey mudstones with interbedded lithic sandstones.

Topography

Gently undulating rises grading to low hills. Local relief <40 m. Slopes ranging from 10–20% with localised steeper slopes 20–35%. Crests and ridges are broad and convex. The slopes are moderately inclined with steep narrow concave drainage lines. Minor terracetting occurs on steeper slopes.

Vegetation

Extensively cleared with remnant stands of tall open-forest. Common species include white stringybark (*Eucalyptus globoidea*), red bloodwood (*Eucalyptus gummifera*), scribbly gum (*Eucalyptus racemosa/haemastoma*)(hybrid), narrow-leaved peppermint (*Eucalyptus radiata*) and mountain spotted gum (*Eucalyptus mannifera*).

Land Use

Beef and dairy cattle grazing on improved pastures are the principal agricultural industries. Villages include Wildes Meadow and Mount Murray.

Existing Erosion

Moderate to severe rill erosion is common on cleared slopes and batters. Minor terracetting occurs on steeper slopes.

Included Soil Landscapes

Small areas of Robertson **(ro)** and Maddens Plains **(md)** soil landscapes occur.

SOILS

Dominant Soil Materials

wm1—Loose dark brown loam fine sandy (topsoil)

Colour	dark brown (10YR 3/3)
Texture	loam fine sandy
Structure	apedal single-grained to weakly pedal <5 mm crumb peds
Fabric	sandy
pH	4.0
Stones	nil
Roots	common

wm2—Brown silt loam (topsoil)

Colour	brown (7.5YR 3/3)
Texture	silt loam
Structure	apedal massive
Fabric	earthy
pH	4.5
Stones	nil
Roots	common

wm3—Brown sandy clay (subsoil)

Colour	brown (7.5YR 4/6) to dull yellowish brown (10YR 5/4)
Texture	sandy clay to light clay
Structure	weak to moderately pedal, 10–20 mm crumb to polyhedral peds
Fabric	smooth-faced, dense
pH	4.5–5.5
Stones	nil
Roots	few, ex-ped

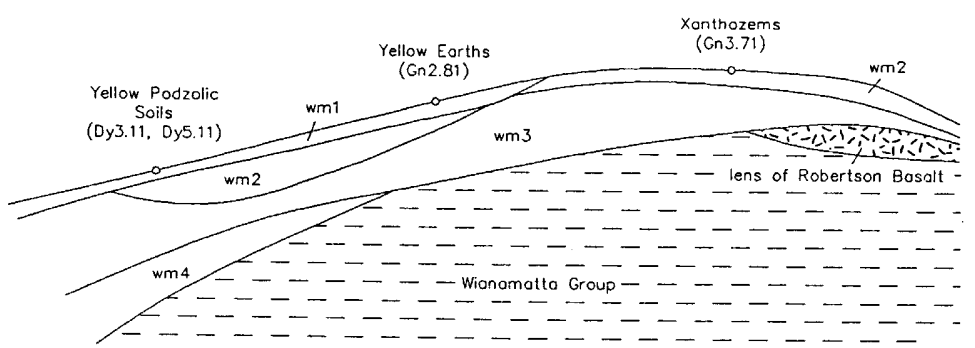
wm4—Mottled orange medium clay (subsoil)

Colour	orange (7.5YR 6/8) to bright yellowish brown (10YR 6/8) mottled grey, yellow and red (50%) at depth >100 cm
Texture	medium to heavy clay
Structure	strongly pedal, 10–20 mm sub-angular blocky
Fabric	rough-faced, porous
pH	3.5–4.5
Stones	nil
Roots	nil

Occurrence and Relationships

Crests and upper slopes. Up to 5 cm brown silt loam **(wm2)** overlies <40 cm brown sandy clay **(wm3).** Boundary is gradual [Xanthozems (Gn3.71)]. Total depth is <50 cm.

Midslopes and lower slopes. Up to 5 cm loose dark brown loamy sand **(wm1)** or <5 cm **wm2** overlies >100 cm mottled orange medium clay **(wm4).** Boundaries are sharp [Yellow Podzolic Soils (Dy3.11)]. Total depth is >100 cm. Occasionally there are localised occurrences of <5 cm **wm1** overlying <15 cm **wm3** which overlies >80 cm **wm4.** Boundaries are clear or gradual [Yellow Podzolic Soils (Dy5.11), Yellow Earths (Gn2.81)]. Total depth is >100 cm.



■ *Schematic cross-section of Wildes Meadow soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

LIMITATIONS TO DEVELOPMENT

Soil Limitations

wm1 Very high available water-holding capacity
Strongly acid
High organic matter

wm2 Strongly acid
Sodicity

wm3 Low permeability
Low wet bearing strength
Strongly acid
Sodicity

wm4 Low permeability
Strongly acid
Low wet bearing strength
Sodicity

Fertility

General fertility is low. The topsoils **(wm1** and **wm2)** are loose and well drained on upper and midslopes but have poorly drained subsoils **(wm3** and **wm4).** The soils are strongly acid and have low CEC.

Erodibility

Erodibility of the topsoils **wm1** and **wm2** is low, especially **wm1** which is composed of coarse sand grains. The erodibility of the subsoils **wm3** and **wm4** is high, especially **wm3** which is highly dispersible.

Erosion Hazard

Erosion hazard for this soil landscape for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 300 t/ha for topsoils and 270 t/ha for exposed subsoils. The erosion hazard for concentrated flows is high.

Surface Movement Potential

Slightly reactive in areas of deep clayey soils. There are isolated areas of moderately reactive soils throughout the landscape.

Landscape Limitations

Steep slopes (localised)
Mass movement hazard (localised)
Seasonal waterlogging (localised)
Surface movement potential
Run-on (localised)
Water erosion hazard

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing

5.4 Fluvial Landscapes

- **Ellerslie (el)**
- **Shoalhaven (sf)**

el ELLERSLIE Fluvial

Landscape—undulating narrow floodplains and terrace surfaces with minor depressions and small intermittent swamps on Quaternary alluvium. Relief <10 m. Slopes <5%. Scattered volcanic sandstone boulders. Extensively cleared with isolated stands of tall open-forest.

Soils—deep (250 cm) Alluvial Soils on floodplain and in drainage lines. Gleyed Podzolic Soils (Dg2.41) and Soloths (Db2.41) occur on lower terraces and in depressions. Yellow Podzolic Soils (Dy3.11) and structured plastic clays (Uf6.33) occur on the upper terraces.

Limitations—flood hazard, permanently high watertable, hardsetting, high organic matter, low permeability, low wet bearing strength and slight shrink-swell potential (topsoil).

LOCATION

Undulating floodplain and terrace surfaces with minor depressions and drainage lines on Quaternary alluvium and Budgong Sandstone in the Kangaroo Valley.

LANDSCAPE

Geology

Quaternary alluvium and gravel. Budgong Sandstone—red brown and grey volcanic lithic sandstone.

Topography

Gently undulating floodplain and terrace surfaces with scattered minor depressions and small intermittent swamps. Relief <10 m. Slopes <5%. Narrow floodplain grading into lower terraces with swampy depressions and well-drained upper terraces. Scattered boulders on upper and lower terraces.

Vegetation

Extensively cleared with stands of tall open-forest. Common species include forest red gum (*Eucalyptus tereticornis*), rough-barked apple (*Angophora floribunda*), river oak (*Casuarina cunninghamiana*), prickly-leaved paperbark (*Melaleuca styphelioides*), scattered white cedar (*Melia azedarach* var. *australasica*), bangalay (*Eucalyptus botryoides*) and river peppermint (*Eucalyptus elata*).

Land Use

Cattle grazing and dairy farming on improved pastures, caravan park, tennis courts, recreation reserves and the village of Kangaroo Valley.

Existing Erosion

Widespread moderate to severe stream bank erosion.

SOILS

Dominant Soil Materials

el1—Hardsetting strongly pedal brownish black loam fine sandy (topsoil)

Colour	brownish black (5YR 2/2)
Texture	loam, fine sandy
Structure	strongly pedal, 2–5 mm polyhedral peds
Fabric	rough-faced, porous
pH	6.0
Stones	nil
Roots	abundant, in-ped

el2—Hardsetting massive brownish black light sandy clay loam (topsoil and subsoil)

Colour	brownish black (10YR 3/2) to dull yellowish brown (10YR 5/3)
Texture	light sandy clay loam
Structure	apedal massive
Fabric	sandy
pH	6.0
Stones	nil
Roots	abundant

el3—Waterlogged sticky light grey sandy clay loam (subsoil)

Colour	light grey (10YR 7/1)
Texture	sandy clay loam
Structure	apedal massive (wet)
Fabric	dense
pH	6.0
Stones	nil
Roots	nil

el4—Dark brown clayey sand (subsoil)

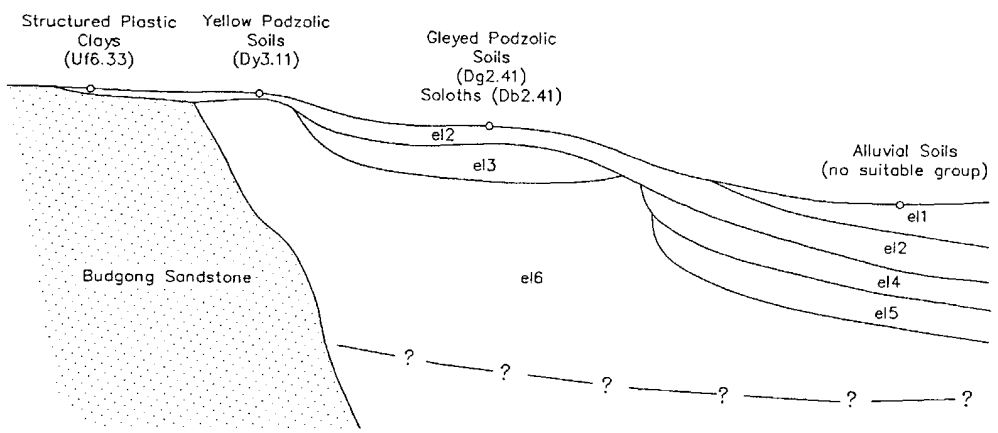
Colour	dark brown (10YR 3/3)
Texture	clayey sand
Structure	apedal massive
Fabric	sandy
pH	6.0
Stones	nil
Roots	nil

el5—Dull yellowish brown sandy loam (subsoil)

Colour	dull yellowish brown (10YR 4/3)
Texture	sandy loam
Structure	apedal massive
Fabric	sandy
pH	6.0
Stones	nil
Roots	nil

el6—Mottled greyish yellow brown heavy clay (subsoil)

Colour	greyish yellow brown (10YR 6/2) yellow/red mottles (75%)
Texture	heavy clay with coarse sand grains
Structure	apedal massive
Fabric	dense



■ *Schematic cross-section of Ellerslie soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

pH 6.0
Stones nil
Roots nil

Occurrence and Relationships

Floodplain and drainage lines. Up to 50 cm hardsetting strongly pedal brownish black loam fine sandy **(el1)** overlies <50 cm massive brownish black sandy clay loam **(el2)**. Up to 50 cm dark brown clayey sand **(el4)** overlies <20 cm dull yellowish brown sandy loam **(el5)** which overlies >30 cm mottled greyish yellow brown heavy clay **(el6).** Boundaries are clear to diffuse. Alluvial Soils—no suitable group. Total depth is >200 cm.

Lower terraces and depressions. Up to 20 cm **el2** overlies <10 cm waterlogged sticky light grey sandy clay loam **(el3)** which overlies >60 cm **el6** [Gleyed Podzolic Soils (Dg2.41), Soloths (Db2.41)]. Boundaries are clear. Total depth is >100 cm.

Upper terraces. Up to 5 cm **el2** overlies >50 cm **el6** [Yellow Podzolic Soils (Dy3.11)]. Boundary is clear. Total depth is >60 cm. These terraces have been cultivated for approximately 100 years, and **el2** has been in many instances completely removed leaving <30 cm **el6** overlying large boulders [structured plastic clays (Uf6.33)]. Boundary is sharp. Total depth is <30 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

el1 Hardsetting
High organic matter
Low wet bearing strength
Shrink-swell
Very high aluminium toxicity

el2 Hardsetting
High organic matter
Low wet bearing strength
Shrink-swell
Sodicity
Very high aluminium toxicity
Low available water-holding capacity

el3 Waterlogged
Low permeability
Low wet bearing strength

el4 Low permeability
Low wet bearing strength
Very high aluminium toxicity
Very high available water-holding capacity

el5 Low permeability
Low wet bearing strength

el6 Low permeability
Low wet bearing strength

Fertility

General soil fertility is moderate. These soils have a high base saturation but are poorly structured and are often waterlogged.

Erodibility

Erodibility of the topsoils **(el1, el2)** is moderate, and that of the subsoils **(el3, el4, el5, el6)** is high.

Erosion Hazard

Erosion hazard for non-concentrated flows is moderate. The calculated soil loss for the first 12 months of urban development ranges up to 15 t/ha for topsoils and 30 t/ha for exposed subsoils. The erosion hazard for concentrated flows is moderate to high.

Surface Movement Potential

Topsoils **(el1, el2)** are slightly reactive, but subsoils **(el3, el4, el5, el6)** are deep and mostly stable.

Landscape Limitations

Flood hazard
Permanently high watertable
Waterlogging
Water erosion hazard (stream bank erosion)
Rock outcrop (localised)
Run-on

Urban Capability

Generally high to severe limitations on lower terraces. Moderate limitations for urban development on upper terraces.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing.

sf SHOALHAVEN Fluvial

Landscape—level to gently undulating present river bed and banks, active floodplain with levees and backwater swamps on alluvium. Flat to gently undulating terrace surfaces of the Shoalhaven River. Relief <5 m and slopes <3%. Completely cleared.

Soils—moderately deep (50–100 cm) Prairie Soils (Gn4.31) occur on levees. Red Earths (Gn2.11) and Yellow and Red Podzolic Soils (Dy.2.51, Dr2.21) occur on terraces. Alluvial Soils (Uc1.22, Uc1.23) and Gleyed Podzolic (potential Acid Sulphate) Soils (Dg1.41) occur on the floodplain.

Limitations—flood hazard, seasonal waterlogging, permanently high watertable, hardsetting, acid sulphate potential (subsoil), strongly acid, sodicity.

LOCATION

Level to gently undulating active floodplain with small levees, minor depressions and backwater swamps on the Coastal Plain. Flat to gently undulating terrace surfaces of the Shoalhaven River.

LANDSCAPE

Geology

Alluvium—gravel, sand, silt and clay derived mainly from sandstone and shale overlying buried estuarine sediments.

Topography

Level to gently undulating floodplains. Relief <5 m and slopes <3%. Broad active floodplains 6–10 km wide with minor levees <1 m and occasional back plain swamps. Scattered flat to gently undulating narrow terraces with relief <2 m.

Vegetation

Completely cleared except for scattered decorative paperbark (*Melaleuca decora*), swamp oak (*Casuarina glauca*), illawarra flame tree (*Brachychiton acerifolium*) on terraces and various reeds in swamps.

Land Use

Predominantly grazing on improved pastures. Recreation areas include Nowra Golf Course.

Existing Erosion

The floodplain is subject to scour or sheet and rill erosion during floods and may be covered by varying depths of alluvial materials as the water recedes. Minor stream bank erosion is widespread.

SOILS

Dominant Soil Materials

sf1—Hardsetting brownish black fine sandy loam (topsoil)

Colour	brownish black (10YR 2/2) to brown (10YR 4/4)
Texture	fine sandy loam to sandy loam
Structure	apedal massive to weakly pedal, <2 mm crumb peds
Fabric	sandy to rough-faced, porous
pH	4.0
Stones	nil
Roots	few

sf2—Brown weakly pedal light sandy clay loam (subsoil)

Colour	brown (10YR 4/4) to yellowish brown (10YR 5/6)
Texture	light sandy clay loam to sandy clay loam
Structure	weakly pedal, <2 mm crumb peds
Fabric	sandy to rough-faced, porous
pH	4.5–5.5
Stones	nil
Roots	nil

sf3—Dull yellowish brown massive sandy clay (subsoil)

Colour	dull yellowish brown (10YR 5/4)
Texture	sandy clay
Structure	apedal massive
Fabric	dense
pH	5.0
Stones	nil
Roots	nil

sf4—Dull reddish brown moderately pedal light medium clay

Colour	dull reddish brown (5YR 4/4)
Texture	light medium clay to heavy clay
Structure	moderately pedal, 5–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	4.5–5.0
Stones	nil
Roots	nil

Associated Soil Materials

Dark grey (10YR 4/1) apedal massive cat-clay with yellow streaks (5Y 8/4) pH 3.0 (after drainage) occurs near channels but is also scattered throughout the floodplain, probably in prior channels.

Dull reddish brown (5YR 4/4) earthy sandy clay loam occurs on the upper terraces.

Light grey (5Y 8/1) apedal massive silty clay loam to fine sandy clay loam occurs beneath Prairie Soils on levees in a small section north of the Shoalhaven River.[1]

Peats in swamps (localised).

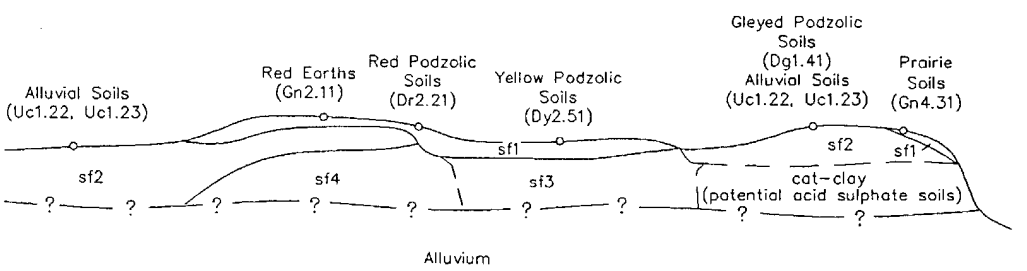
Occurrence and Relationships

A very complex soil pattern occurs on the floodplain. The following soil materials sequences have been described.

Levees. Up to 20 cm hardsetting brownish black fine sandy loam **(sf1)** overlies >50 cm brown weakly pedal sandy clay loam **(sf2)**. Boundary is gradual [Prairie Soils (Gn4.31)]. Total depth is >100 cm.

Lower terraces. Up to 20 cm **sf1** overlies >80 cm dull yellowish brown massive sandy clay **(sf3)**. Boundary is clear [Yellow Podzolic Soils (Dy2.51)]. Total depth is >100 cm.

Upper terraces. Up to 20 cm **sf1** overlies <20 cm **sf2** which overlies 80 cm dull reddish brown moderately pedal light medium clay **(sf4).** Boundaries are clear [Red Podzolic Soils (Dr.2.21)]. Total depth is >150 cm.



■ *Schematic cross-section of Shoalhaven soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

[1] This soil material is probably the buried topsoil of a relict. It forms a hard layer which appears to disperse very slowly.

On higher elevations <20 cm **sf1** overlies >80 cm dull reddish brown sandy clay loam. Boundary is gradual [Red Earths (Gn2.11)]. Total depth is >150 cm.

Floodplain. Up to 100 cm **sf2** has been deposited as point bars [Alluvial Soils (Uc1.22, Uc1.23)]. Up to 30 cm **sf2** is associated with >30 cm dark grey cat-clay with yellow streaks. Boundary is abrupt [Gleyed Podzolic—potential Acid Sulphate—Soils (Dg1.41)]. Total depth is >100 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

sf1 Hardsetting
Very high organic matter
Strongly acid
Sodicity
Low available water-holding capacity

sf2 In combination with associated soil material, acid sulphate potential
Sodicity
Strongly acid

sf3 Low permeability
Low wet bearing strength
Low available water-holding capacity

sf4 Strongly acid
Low available water-holding capacity
Sodicity

Fertility

General fertility is moderate to low. The soils on the upper terraces **(sf1, sf2, sf4)** are moderately structured and better drained than those of the lower terraces **(sf1, sf3).** Soil materials **sf1, sf2, sf4** are strongly acid with moderate CEC. The presence of acid sulphate soils when exposed would prevent plant growth.

Erodibility

Erodibility of the topsoil is low. The erodibility of the subsoils **(sf2, sf3** and **sf4)** is high.

Erosion Hazard

Erosion hazard for non-concentrated flows is slight. The calculated soil loss for the first 12 months of urban development ranges up to 10 t/ha for topsoils and 10 t/ha for exposed subsoils. The erosion hazard for concentrated flows is low.

Surface Movement Potential

Moderately reactive topsoil **(sf1).** Non-reactive subsoils **(sf2, sf3, sf4).**

Landscape Limitations

Flood hazard
Permanent waterlogging (localised)
Permanently high watertable
Seasonal waterlogging

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing. High to severe limitations for cultivation and grazing in flood-prone areas. Drainage may result in highly acid soils.

5.5 Depositional Landscapes

- **Barrengarry (bg)**
- **Fountaindale (fo)**
- **Greenwell Point (gp)**
- **Nowra (no)**
- **Wattamolla Road (wt)**

bg BARRENGARRY Depositional

Landscape—moderately inclined to steep 10–30% slopes with broad (100 m) benches on Berry Formation. Relief <300 m. Scattered rock outcrops similar to tors. Extensively cleared with scattered stands of tall open-forest.

Soils—deep (>150 cm) Krasnozems (Gn4.11) occur on benches and midslopes and Xanthozems (Gn3.71) occur on lower slopes. Lithosols (Um2.64) occur on steeper slopes.

Limitations—water erosion hazard, mass movement hazard (localised), run-on (localised), stoniness, high organic matter, high water-holding capacity, strongly acid.

LOCATION

Moderately inclined to steep slopes with broad benches on siltstone in the Kangaroo Valley. Examples occur at Barrengarry and along the Upper Kangaroo Valley Road.

LANDSCAPE

Geology

Berry Formation—light grey to dark grey micaceous siltstones, mudstones and shales with basaltic dykes.

Topography

Moderately inclined to steep slopes with hummocky sideslopes. Relief to 300 m. Slopes 10–30% locally ranging to 45%. Scattered broad colluvial benches up to 100 m wide with hummocky sideslopes that have occasional slumps and terracettes. Occasional gently inclined footslopes and narrow deeply incised drainage lines. Scattered rock outcrops resembling tors.

Vegetation

Extensively cleared with scattered stands of tall open-forest. Common tree species include sydney peppermint (*Eucalyptus piperita*), lemon-scented gum (*Eucalyptus citriodora*), rough-barked apple (*Angophora floribunda*), blue-veined stringybark (*Eucalyptus agglomerata*) and bangalay (*Eucalyptus botryoides*).

Land Use

Mostly cattle grazing on improved pastures.

Existing Erosion

Stable except for minor terracettes on the benches (localised) and rock fall from the benches after heavy rainfall. Occasional minor gullying along drainage lines.

Included Soil Landscape

Small areas of Wattamolla Road **(wt)** soil landscape occur.

SOILS

Dominant Soil Materials

bg1—Moderately pedal dull reddish brown sandy clay loam (topsoil)

Colour	dull reddish brown (5YR 4/3)
Texture	sandy clay loam
Structure	moderately pedal, 2–5 mm granular peds
Fabric	rough-faced, porous
pH	5.0
Stones	<2% 2–6 mm angular, dispersed
Roots	common, ex-ped

bg2—Dark reddish brown silty clay loam (subsoil)

Colour	dark reddish brown (5YR 3/3)
Texture	silty clay loam
Structure	weakly to moderately pedal, 2–5 mm crumb to polyhedral peds
Fabric	rough-faced, porous
pH	5.0
Stones	nil
Roots	common, ex-ped

bg3—Reddish brown silty clay (subsoil)

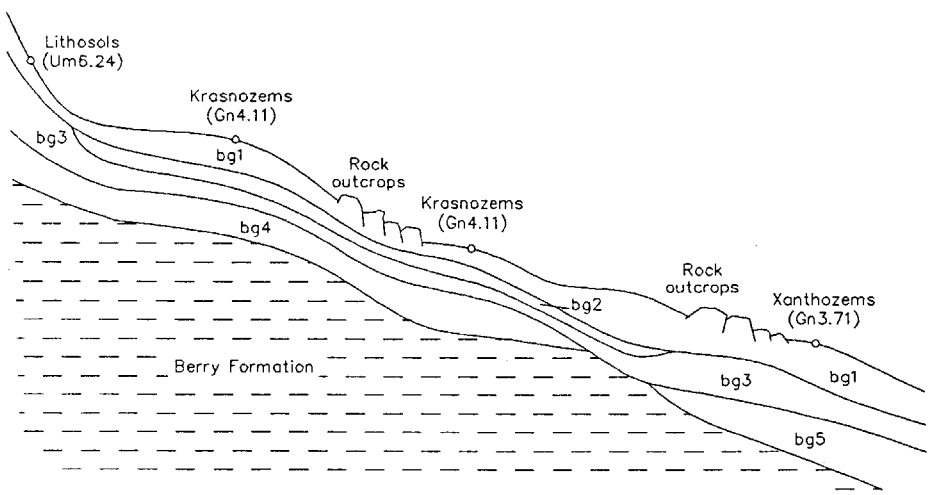
Colour	reddish brown (2.5YR 4/6)
Texture	silty clay to light clay
Structure	moderately pedal, 5–10 mm sub-angular blocky to angular blocky peds
Fabric	rough-faced, porous
pH	4.5
Stones	nil
Roots	few

bg4—Reddish brown medium clay (subsoil)

Colour	reddish brown (2.5YR 4/6)
Texture	medium clay
Structure	strongly pedal, 10–20 mm angular blocky peds
Fabric	rough-faced, porous
pH	4.0
Stones	nil
Roots	nil

bg5—Mottled bright brown medium clay (subsoil)

Colour	bright brown (5YR 5/8) yellowish brown (10YR 5/6) red yellow and grey mottles (25%)
Texture	medium to heavy clay
Structure	strongly pedal, 10–20 mm angular blocky peds
Fabric	rough-faced, porous
pH	3.5
Stones	10–20% 6–60 mm sub-angular to angular, dispersed
Roots	nil



■ *Schematic cross-section of Barrengarry soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Occurrence and Relationships

A very complex geology pattern occurs within this landscape. The following soils materials sequences have been described.*

Benches. Up to 10 cm moderately pedal sandy clay loam **(bg1)** overlies <40 cm dark reddish brown silty clay loam **(bg2).** Up to 40 cm reddish brown silty clay **(bg3)** overlies <40 cm reddish brown medium clay **(bg4).** Boundaries are gradual [Krasnozems (Gn4.11)]. Total depth is <150 cm.

Steep slopes. Up to 40 cm **bg1** overlies bedrock [Lithosols (Um6.24)].

Midslopes. Up to 50 cm **bg1** overlies <70 cm **bg2** which overlies <50 cm **bg3.** Boundaries are clear to gradual [Krasnozems (Gn4.11)]. Total depth is 170–200 cm.

Lower slopes. Up to 50 cm **bg1** overlies <100 cm **bg3** which overlies <30 cm mottled bright brown medium clay **(bg5).** Boundaries are gradual [Xanthozems (Gn3.71)]. Total depth is >180 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

bg1 Stoniness
High organic matter
High available water-holding capacity
Shrink-swell

bg2 High organic matter
High available water-holding capacity
Shrink-swell

bg3 Strongly acid

bg4 Strongly acid

bg5 Low permeability
Low wet bearing strength
Strongly acid
Stoniness

Fertility

General fertility is moderate to high. The soils are deep except on steep slopes, well structured and well drained. The soils have a moderate CEC and are moderately to strongly acid.

Erodibility

The erodibility of the topsoil **(bg1)** is low and for the subsoils **(bg2** to **bg5)** is moderate.

Erosion Hazard

Erosion hazard for non-concentrated flows is ex-treme. The calculated soil loss for the first 12 months of urban development ranges up to 350t/ha for topsoils and 500 t/ha for exposed subsoils. The erosion hazard for concentrated flows is high.

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Surface Movement Potential

bg1 and **bg2** are moderately reactive. **bg3** and **bg5** are slightly reactive.

Landscape Limitations

Steep slopes (localised)
Mass movement hazard (localised)
Water erosion hazard
Run-on (localised)

Urban Capability

Generally high to severe limitations for urban development with moderate limitations on benches.

Rural Capability

Generally high to severe limitations for regular cultivation. Low to moderate limitations for grazing but high to severe on steep slopes.

* Where the parent material is entirely shale and siltstone, highly dispersible Red and Brown Podzolics often occur.

fo FOUNTAINDALE Depositional

Landscape—rolling low hills with long sideslopes on Budgong Sandstone in the Jamberoo Valley. Relief 40–80 m. Slopes <20%. Extensively cleared with scattered stands of tall open-forest and closed-forest.

Soils—moderately deep (50–100 cm) Brown Podzolic Soils (Db3.21, Db2.11) and Yellow Podzolic Soils (Dy3.21, Dy2.11) occur.

Limitations—run-on, water erosion hazard (localised), mass movement hazard (localised), hardsetting, stoniness, sodicity, moderate shrink-swell potential (subsoil).

LOCATION

Rolling low hills with long moderately inclined slopes on volcanic sandstone in Jamberoo Valley on the lower slopes of the Illawarra Escarpment. Examples include lower reaches along Fountaindale Road, Jerrara Creek Road and Swamp Road.

LANDSCAPE

Geology

Budgong Sandstone—red brown and grey volcanic lithic sandstone.

Topography

Rolling low hills. Relief 40–80 m. Slopes <20%. Broad convex crests with long moderately inclined slopes. Narrow to moderately incised drainage lines opening into broad drainage plains <150 m wide. Terracettes and slumping occur on steeper slopes. Scattered rock outcrops are evident, especially in drainage lines.

Vegetation

Extensively cleared with scattered remant stands of tall open-forest and closed-forest. Common species in tall open-forest include blackbutt (*Eucalyptus pilularis*) and turpentine (*Syncarpia glomulifera*). Forest red gum (*Eucalyptus tereticornis*) grows in poorly drained areas. Common species in closed-forest include cabbage tree palm (*Livistona australis*), red ash (*Alphitonia excelsa*), port jackson fig (*Ficus rubiginosa*), cheese tree (*Glochidion ferdinandi*), moreton bay fig (*Ficus macrophylla*), native cherry (*Exocarpos cupressiformis*), ribbonwood (*Euroschinus falcata*) and white euodia (*Euodia micrococca*).

Land Use

Grazing of cattle on improved pastures and hobby farms.

Existing Erosion

Terracettes on steeper slopes. Moderate to severe stream bank erosion. Subject to sheet and gully erosion where not well grassed.

Included Soil Landscape

Small areas of Bombo **(bo)** soil landscape occur.

SOILS

Dominant Soil Materials

fo1—Hardsetting weakly pedal brownish black sandy loam (topsoil)

Colour	brownish black (5YR 3/1)
Texture	sandy loam
Structure	weakly pedal, <2 mm crumb peds
Fabric	rough-faced, porous
pH	6.0
Stones	2–10% 2–6 mm angular, dispersed
Roots	abundant, ex-ped

fo2—Weakly pedal greyish brown sandy clay loam (subsoil)

Colour	greyish brown (7.5YR 3/2)
Texture	sandy clay loam
Structure	weakly pedal, <2 mm crumb peds
Fabric	rough-faced, porous
pH	5.5
Stones	2–10% 2–6 mm angular, dispersed
Roots	few, ex-ped

fo3—Brown light medium clay (subsoil)

Colour	brown (7.5YR 4/3) to dull orange (7.5YR 7/3)
Texture	light medium clay
Structure	weakly to moderately pedal, 2–5 mm crumb to polyhedral peds
Fabric	rough-faced, porous
pH	4.0
Stones	<2% 2–6 mm angular, dispersed
Roots	few, ex-ped

fo4—Mottled brown medium clay (subsoil)

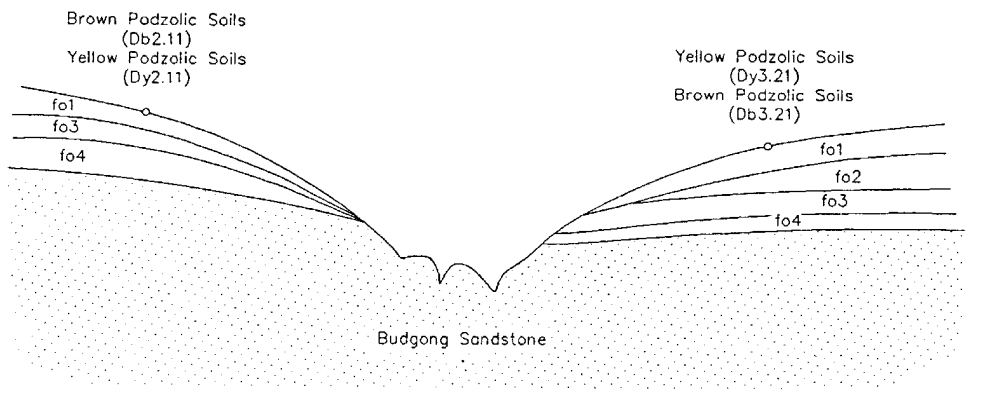
Colour	brown (7.5YR 4/6) with orange and red mottles (50%)
Texture	medium clay
Structure	moderately to strongly pedal, 5–10 mm crumb to polyhedral peds
Fabric	rough-faced, porous
pH	4.0
Stones	nil
Roots	nil

Occurrence and Relationships

The soils of this landscape are generally uniform with minor variations in total soil depth.

Up to 10 cm hardsetting brownish black sandy loam **(fo1)** overlies <15 cm greyish brown sandy clay **(fo2)**, which overlies either <40 cm brown light medium clay **(fo3)** or <40 cm brown medium clay with mottles **(fo4).** Boundaries are clear to gradual [Brown Podzolic Soils (Db3.21), Yellow Podzolic Soils (Dy3.21)]. Total depth is <100 cm.

Occasionally **fo2** is absent [Brown Podzolic Soils (Db2.11), Yellow Podzolic Soils (Dy2.11)]. Total depth is <100 cm.



■ *Schematic cross-section of Fountaindale soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

LIMITATIONS TO DEVELOPMENT

Soil Limitations

fo1 Hardsetting
High organic matter
Shrink-swell potential (localised)
Low wet bearing strength

fo2 Stoniness

fo3 Stoniness
Strongly acid
Shrink-swell potential (localised)
Low available water-holding capacity

fo4 Low permeability
Low wet bearing strength
Sodicity
Strongly acid
Low available water-holding capacity
Shrink-swell potential

Fertility

General fertility is moderate to high. The soils are generally deep, well structured and freely drained with permeable clay subsoils. Soil materials are moderately to slightly acid with high CEC.

Erodibility

The erodibility of the topsoil **(fo1)** is high and for the subsoils **(fo2** to **fo4)** is moderate.

Erosion Hazard

Erosion hazard for this soil landscape for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 1 000 t/ha for topsoils and 1 000 t/ha for exposed subsoils. The erosion hazard for concentrated flows is moderate.

Surface Movement Potential

The topsoil **(fo1)** is slightly reactive and the subsoils **fo3** and **fo4** are moderately to highly reactive. **fo2** is non-reactive.

Landscape Limitations

Mass movement hazard (localised)
Water erosion hazard (localised)
Rock outcrop (localised)
Run-on

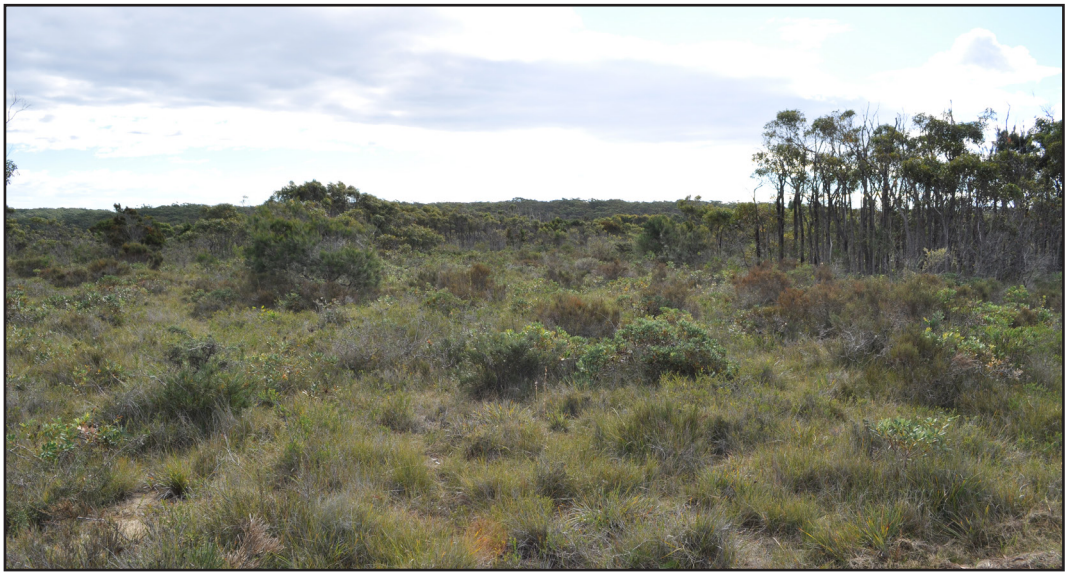
Urban Capability

Generally low limitations for urban development. High to severe limitations on steep slopes.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing. High to severe limitations for cultivation (localised) on steep slopes.

gp GREENWELL POINT Depositional



Landscape—gently undulating rises on siltstone with small coastal cliffs. Relief >20 m. Slopes >3%. Mostly cleared with stands of low open-forest. Undisturbed areas of tall open-forest.

Soils—shallow (<50 cm) Structured Loams (Uc6.14) or moderately deep (50–100 cm) Yellow Podzolic Soils (Dy2.11) on coastal cliffs. Red Solodic Soils (Dr3.31) occur on simple slopes and in drainage lines.

Limitations—shallow soil (localised), rock outcrop (localised), sodicity, hardsetting, high organic matter, moderate shrink-swell potential (subsoil).

LOCATION

Gently undulating rises on siltstone with small coastal cliffs on the Coastal Plain. Examples include Culburra, Orient Point, Greenwell Point and Callala Bay.

LANDSCAPE

Geology

Wandrawandian Siltstone—mid grey to dark grey pebbly siltstone to poorly sorted pebbly lithic sandstone.

Topography

Gently undulating rises. Relief <20 m. Slopes <3%. Scattered rock outcrops near crests and small coastal cliffs at Crookhaven Lighthouse. Moderately incised drainage lines (depth <3 m).

Vegetation

Extensively cleared to uncleared tall open-forest. The common species are scribbly gum (*Eucalyptus sclerophylla*), spotted gum (*Eucalyptus maculata*), red bloodwood (*Eucalyptus gummifera*), blackbutt (*Eucalyptus pilularis*), grey ironbark (*Eucalyptus paniculata*), forest oak (*Allocasuarina torulosa*), turpentine (*Syncarpia glomulifera*), grey gum (*Eucalyptus punctata*) and coastal tea-tree (*Leptospermum laevigatum*). Swamp oak (*Casuarina glauca*) or river oak (*Casuarina cunninghamiana*) grows along drainage lines.

Land Use

On the coast are the villages of Orient Point, Greenwell Point, Culburra and Callala Bay. The remaining area is undisturbed bushland including sections of Currambene State Forest.

Existing Erosion

Moderate rill erosion on batters and moderate stream bank erosion (localised).

Included Soil Landscape

Small areas of Nowra **(no)** soil landscape occur.

SOILS

Dominant Soil Materials

gp1—Hardsetting brownish black silt loam (topsoil)

Colour	brownish black (7.5YR 3/2) to dark brown (7.5YR 3/4) with occasional bleach
Texture	silt loam to loam, fine sandy
Structure	moderately pedal, 2–5 mm round peds
Fabric	rough-faced, porous
pH	6.5
Stones	<2% 6–20 mm angular, dispersed
Roots	few, ex-ped

gp2—Yellowish brown strongly pedal sandy clay (subsoil)

Colour	yellowish brown (10YR 5/6)
Texture	sandy clay
Structure	strongly pedal 10–20 mm angular blocky peds
Fabric	rough-faced, porous
pH	7.0–5.5
Stones	10–20% 20–60 mm angular, dispersed
Roots	few, in-ped

gp3—Brown strongly pedal medium clay (subsoil)

Colour	brown (10YR 4/4)
Texture	medium clay
Structure	strongly pedal 20–50 mm columnar peds
Fabric	rough-faced, porous
pH	3.5–4.5
Stones	<2% 6–20 mm angular, dispersed
Roots	nil

gp4—Mottled massive bright reddish brown heavy clay (subsoil)

Colour	bright reddish brown (5YR 5/6) with orange and grey mottles (50%)
Texture	heavy clay (with coarse sand)
Structure	apedal massive
Fabric	dense
pH	4.0–4.5
Stones	nil
Roots	nil

Occurrence and Relationships

Coastal cliffs and headlands. Near coastal cliffs <50 cm hardsetting brownish black silt loam **(gp1)** overlies bedrock [Structured Loams (Uc6.14)]. On headlands **gp1** overlies <40 cm yellowish brown strongly pedal sandy clay **(gp2).** Boundaries are clear [Yellow Podzolic Soils (Dy2.11)]. Total depth is <100 cm.

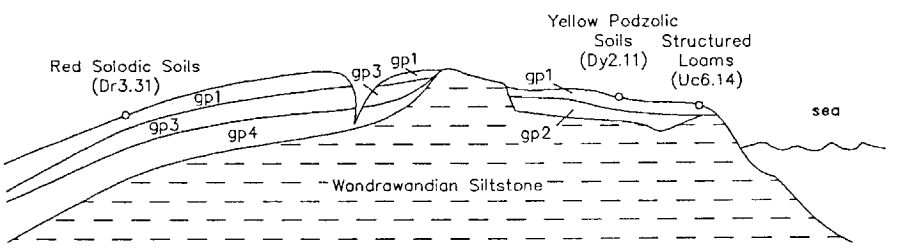
Slopes and drainage lines. Up to 10 cm **(gp1)** overlies <50 cm brown strongly pedal medium clay **(gp3)** which overlies <50 cm mottled massive bright reddish brown heavy clay **(gp4).** Boundaries are clear [Red Solodic Soils (Dr3.31)]. Total depth is <150 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

gp1 Hardsetting
Stoniness
High organic matter
Low wet bearing strength
Sodicity
Shrink-swell

gp2 Stoniness
High permeability
Low available water-holding capacity
Sodicity



■ *Schematic cross-section of Greenwell Point soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

gp3 Strongly acid
High permeability
Low available water-holding capacity
Shrink-swell

gp4 Low permeability
Strongly acid
Low wet bearing strength
Shrink-swell

Fertility

General fertility is low. The topsoil **(gp1)** is generally hardsetting. The soil materials are stony, moderately to strongly acid with a low CEC.

Erodibility

All soil materials have a high erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is moderate. The calculated soil loss for the first 12 months of urban development ranges up to 20 t/ha for topsoils and 20 t/ha for exposed subsoils. The erosion hazard for concentrated flows is low.

Surface Movement Potential

gp1, **gp3** and **gp4** are slightly reactive.

Landscape Limitations

Shallow soil (localised)
Wave erosion hazard (localised)
Wind erosion hazard (localised)
Rock outcrop (localised)

Urban Capability

Generally low limitations for urban development.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing.

no	NOWRA	Depositional

Landscape—moderately to gently undulating rises to low hills on Nowra Sandstone. Relief >40 m. Slopes >5%. Broad ridges and crests. Benched sandstone outcrops adjacent to drainage lines. Extensive to moderately cleared tall open-forest.

Soils—moderately deep (50–100 cm) Brown Podzolic Soils (Db1.11) occur on crests and upper slopes. Soloths (Dy3.21) and/or Yellow Earths (Gn2.61) occur midslope. Yellow Podzolic Soils (Dy5.11) occur on lower slopes and drainage lines.

Limitations—run-on, rock outcrop (localised), shallow soil (localised), stoniness, hardsetting, sodicity, low permeability, low wet bearing strength (subsoil).

LOCATION

Moderately to gently undulating rises to undulating low hills on sandstone on the Coastal Plain. Examples include Bomaderry and Falls Creek areas extending south and east of the township of Nowra.

LANDSCAPE

Geology

Nowra Sandstone—medium- to coarse-grained quartz sandstones which contain rounded pebbles scattered throughout the beds. Localised laterisation west of the village of Kangaroo Valley.

Topography

Moderately to gently undulating rises to undulating low hills. Relief >40 m. Slopes >5%. Broad ridges and crests with long, very gently inclined slopes, broad drainage areas with deeply incised channels. Benched sandstone outcrops adjacent to drainage lines.

Vegetation

Extensively to moderately cleared with stands of tall open-forest. Common species include turpentine (*Syncarpia glomulifera*), grey gum (*Eucalyptus punctata*), scribbly gum (*Eucalyptus sclerophylla*), sydney peppermint (*Eucalyptus piperita*), thin-leaved stringybark (*Eucalyptus eugenioides*), red bloodwood (*Eucalyptus gummifera*), forest oak (*Allocasuarina torulosa*) and blackbutt (*Eucalyptus pilularis*) with an understorey of flaky-barked

tea-tree (*Leptospermum attenuatum*). Mountain devil (*Lambertia formosa*), hairpin banksia (*Banksia spinulosa*), pine-leaf geebung (*Persoonia pinifolia*) and burrawang (*Macrozamia communis*) grow on sandier soils.

Spotted gum (*Eucalyptus maculata*) and grey ironbark (*Eucalyptus paniculata*) grow on heavy soils. Decorative paperbark (*Melaleuca decora*) grows in drainage lines.

Land Use

Cattle grazing on improved pastures. State Forests including Nowra, Shoalhaven, Colymea, and Currambene. Urban—for example, Nowra—with small areas set aside as parks or undisturbed bushland.

Existing Erosion

Moderate rill erosion on batters.

Included Soil Landscape

Small areas of Greenwell Point **(gp)** soil landscape occur.

SOILS

Dominant Soil Materials

no1—Loose yellowish brown single-grained sand (topsoil)

Colour	greyish yellow brown (10YR 5/4) to yellowish brown (10YR 4/6)
Texture	sand to loamy sand
Structure	apedal, single-grained
Fabric	sandy
pH	4.0–6.5
Stones	nil
Roots	common

no2—Hardsetting gravelly massive yellowish brown clayey sand (topsoil and subsoil)

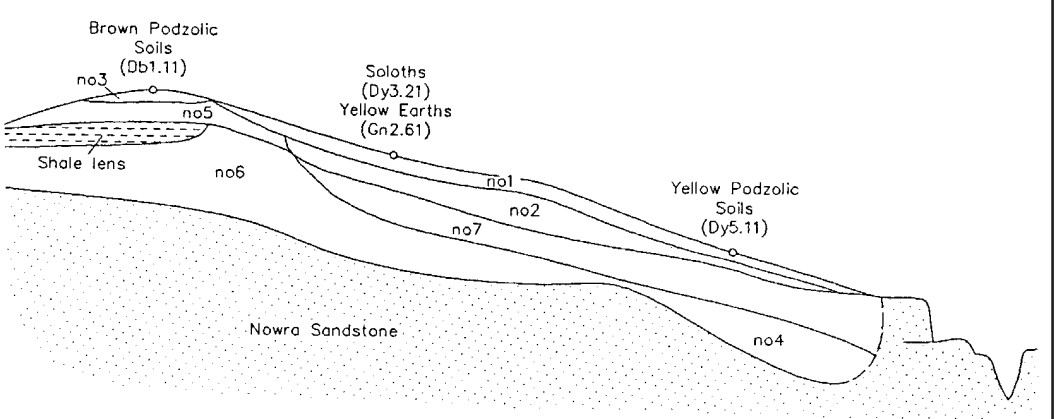
Colour	yellowish brown (10YR 5/6)
Texture	clayey sand to sandy loam
Structure	apedal massive
Fabric	sandy
pH	5.5
Stones	50–90% 6–20 mm sub-angular, stratified
Roots	common, in-ped

no3—Hardsetting dark reddish brown loam fine sandy (topsoil)

Colour	dark reddish brown (5YR 3/3)
Texture	loam fine sandy to silt loam
Structure	apedal massive
Fabric	earthy
pH	4.5
Stones	nil
Roots	common

no4—Mottled light clay (subsoil)

Colour	dull yellow orange (10YR 7/3) red and grey mottles (50%)
Texture	light clay with coarse sand
Structure	weak to moderate, 10–20 mm sub-angular blocky peds
Fabric	rough-faced, peds
pH	3.5
Stones	nil
Roots	nil



■ *Schematic cross-section of Nowra soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

no5—Dark olive sandy clay (subsoil)

Colour	dark olive (5Y 4/4) to brown (10YR 4/6)
Texture	sandy clay
Structure	weak to moderately pedal, 2–20 mm round to sub-angular blocky peds
Fabric	smooth-faced, dense
pH	3.5–6.0
Stones	20–50% 6–20 mm rounded and sub-angular, dispersed
Roots	nil

no6—Bright brown moderately pedal light medium clay (subsoil)

Colour	bright brown (7.5YR 5/8) to dark olive (5Y 4/4)
Texture	light medium clay to medium clay
Structure	moderately pedal, 2–20 mm round to sub-angular blocky peds
Fabric	smooth-faced, dense
pH	3.5–5.0
Stones	10–20% 6–20 mm sub-rounded and sub-angular, dispersed
Roots	nil

no7—Brown sandy clay loam (subsoil)

Colour	brown (7.5YR 4/6)
Texture	light sandy clay loam to sandy clay
Structure	apedal massive
Fabric	earthy
pH	6.5
Stones	nil
Roots	few

Occurrence and Relationships

Crests and upper slopes. Up to 40 cm hardsetting dark reddish brown loam fine sandy **(no3)** overlies <30 cm dark olive sandy clay **(no5)** which overlies <30 cm bright brown moderately pedal light medium clay **(no6).** Boundaries are clear [Brown Podzolic Soils (Db1.11)]. Total depth is <120 cm.

Midslopes. Up to 10 cm loose yellowish brown sand **(no1)** or hardsetting gravelly massive yellowish brown clayey sand **(no2)** overlies <20 cm brown sandy clay loam **(no7)** which overlies <100 cm **no6**. Boundaries are clear [Soloths (Dy3.21)] to gradual [Yellow Earths (Gn2.61)]. Occasionally **no1** does not occur. Total depth is <150 cm.

Lower slopes and drainage lines. Up to 15 cm **no1** overlies <15 cm **no7** which overlies <70 cm light clay with mottles **(no4)**. Boundaries are gradual to clear [Yellow Podzolic Soils (Dy5.11)]. Total depth is <120 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

no1 High organic matter
High permeability
Low available water-holding capacity
Sodicity

no2 Hardsetting
Stoniness
Low permeability
Sodicity
Low available water-holding capacity

no3 Hardsetting
Low permeability
Low wet bearing strength
Sodicity
Strongly acid
Low available water-holding capacity

no4 Low permeability
Strongly acid
Low wet bearing strength
Very high aluminium toxicity
Low available water-holding capacity

no5 Stoniness
Low permeability
Strongly acid (localised)
Sodicity
Low wet bearing strength
Low available water-holding capacity

no6 Stoniness
Strongly acid (localised)
Low permeability
Low wet bearing strength
Aluminium toxicity

no7 Low permeability
Low wet bearing strength
Very high aluminium toxicity

Fertility

General fertility is low to moderate. Topsoils **(no1, no2, no3)** are generally hardsetting. The soils are often moderately deep but are stony, strongly to moderately acid with generally low CEC.

Erodibility

Erodibility for the topsoil is generally low, but for the subsoils **(no4, no5, no6** and **no7)** the erodibility is high.

Erosion Hazard

Erosion hazard for non-concentrated flows is moderate to high. The calculated soil loss for the first 12 months of urban development ranges up to 20 t/ha for topsoils and 60 t/ha for exposed subsoils. The erosion hazard for concentrated flows is low to moderate.

Surface Movement Potential

These soil materials are generally stable.

Landscape Limitations

Shallow soil (localised)
Rock outcrop (localised)
Run-on

Urban Capability

Generally low limitations for urban development.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing.

wt WATTAMOLLA ROAD Depositional

Landscape—long gently to moderately inclined sideslopes and undulating to rolling hills with broad benches on Budgong Sandstone. Relief <200 m. Slopes 5–15%. Extensively cleared with stands of tall open-forest.

Soils—moderately deep (50–100 cm) Red Podzolic Soils (Dr2.31) on upper slopes and benches. Yellow Podzolic Soils (Dy5.31) on mid and lower slopes.

Limitations—rock outcrop, run-on, mass movement (localised), hardsetting, high organic matter, low wet bearing strength, strongly acid, sodicity.

LOCATION

Long, gently to moderately inclined sideslopes and undulating to rolling hills on sandstone in the Kangaroo Valley. Examples include along the lower reaches of Wattamolla Road, Woodhill/Berry Road and the crest and midslopes of Coolongatta Mountain.

LANDSCAPE

Geology

Budgong Sandstone—red brown and grey volcanic lithic sandstone.

Topography

Long, gently to moderately inclined sideslopes and undulating to rolling hills. Relief <200 m. Slope gradients generally 5–15% with isolated steep slopes >40%. Broad flat benches and crests <400 m wide recur throughout the landscape. Drainage lines are incised with rock outcrop. Terracettes and slumping and scattered boulders occur on steeper slopes.

Vegetation

Extensively cleared with scattered stands of tall open-forest. Common species include rough-barked apple (*Angophora floribunda*), cabbage gum (*Eucalyptus amplifolia*), brown barrel (*Eucalyptus fastigata*), mountain grey gum (*Eucalyptus cypellocarpa*), forest red gum (*Eucalyptus tereticornis*), isolated stands of scribbly gum (*Eucalyptus racemosa*) and bangalay (*Eucalyptus botryoides*).

Existing Erosion

On steeper slopes minimal terracettes, slumping and minor gullying occur.

Included Soil Landscapes

Small areas of Barrengarry **(bg)** soil landscape and Cambewarra **(ca)** soil landscape occur.

SOILS

Dominant Soil Materials

wt1—Hardsetting brownish black fine sandy loam (topsoil)

Colour brownish black (5YR 3/1) to greyish brown (7.5YR 4/2) with occasional bleaching at depth
Texture fine sandy loam
Structure moderately pedal, 2–5 mm polyhedral peds
Fabric rough-faced, porous
pH 6.0
Stones <2% 2–6 mm
Roots abundant, ex-ped

wt2—Friable brown silt loam (topsoil)

Colour brown (7.5YR 4/3) to dull brown (7.5YR 4/6) with occasional bleach
Texture silt loam
Structure weakly pedal <2 mm polyhedral peds
Fabric rough-faced, porous
pH 5.5
Stones nil
Roots common, ex-ped

wt3—Mottled brown light clay (subsoil)

Colour brown (7.5YR 4/3) yellowish brown (10YR 5/4) red mottles (50%)
Texture light clay
Structure weakly to moderately pedal, 10–20 mm polyhedral to sub-angular blocky peds
Fabric smooth-faced, dense
pH 5.5
Stones nil
Roots few, in-ped

wt4—Dark reddish brown strongly pedal light clay (subsoil)

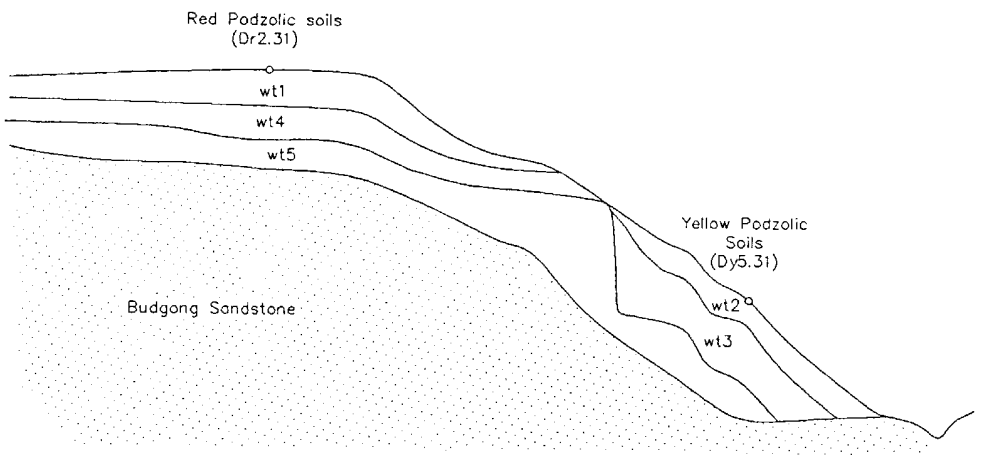
Colour dark reddish brown (5YR 3/4)
Texture light clay
Structure strongly pedal, 10–20 mm sub-angular blocky peds
Fabric rough-faced, porous
ph 5.5
Stones nil
Roots common, ex-ped

wt5—Mottled brown strongly pedal medium clay (subsoil)

Colour brown (7.5YR 4/6) to yellowish brown (10YR 5/8) with red and grey mottles (50%) at depth
Texture medium clay
Structure strongly pedal, 20–50 mm polyhedral to sub-angular blocky peds
Fabric rough-faced, porous
pH 4.5
Stones nil
Roots few, in-ped

Occurrence and Relationships

Upper slopes and benches. Up to 10 cm hardsetting brownish black fine sandy loam **(wt1)** overlies <25 cm dark reddish brown strongly pedal light clay **(wt4)** which overlies <60 cm mottled brown strongly pedal medium clay **(wt5).**



■ *Schematic cross-section of Wattamolla Road soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Boundaries are clear [Red Podzolic Soils (Dr2.31)]. Total depth is <100 cm.

Mid and lower slopes. Up to 5 cm friable brown silt loam **(wt2)** overlies <20 cm mottled brown light clay **(wt3)** which overlies <80 cm **wt5.** Boundaries are clear [Yellow Podzolic Soils (Dy5.31)]. Total depth is <120 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

wt1 Hardsetting
Strongly acid
High organic matter

wt2 High organic matter
Low wet bearing strength
Sodicity
Strongly acid

wt3 Low wet bearing strength
Sodicity
Strongly acid

wt4 High permeability
Sodicity
Strongly acid

wt5 Low permeability
Low wet bearing strength
Sodicity

Fertility

Moderate to high fertility. Moderately pedal with moderate CEC. Very high to moderate base saturation **(wt1, wt2, wt3).** High organic matter **(wt1, wt2).**

Erodibility

The erodibility of the topsoils **(wt1, wt2)** is moderate. The erodibility of the subsoils **(wt3, wt4, wt5)** is high.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 150 t/ha for topsoils and 200 t/ha for exposed subsoils. The erosion hazard for concentrated flows is high.

Surface Movement Potential

The soil materials are generally stable.

Landscape Limitations

Steep slopes (localised)
Mass movement (localised)
Shallow soil (localised)
Rock outcrop
Water erosion hazard (localised)
Run-on

Urban Capability

Generally moderate limitations for urban development. High to severe limitations for urban development on steep slopes.

Rural Capability

Generally high to severe limitations for regular cultivation. Low to moderate limitations for grazing.

5.6 Marine Landscapes

- **Wollongong (wg)**

wg WOLLONGONG Marine

Landscape—beaches and coastal foredunes on marine and aeolian sands. Beach plains with relief <10 m, slopes <3%; foredunes with relief <15 m and slope gradients <35%. Spinifex grassland/herbland to closed-scrub on foredunes.

Soils—deep (>200 cm) Calcareous Sands (Uc1.11) on beaches, Siliceous Sands (Uc1.21) on foredunes, localised Humus Podzol/Podzol intergrades (Uc2.21) in low lying areas.

Limitations—extreme wind erosion hazard, non-cohesive, highly permeable soils, very low soil fertility, localised flooding and permanently high watertables.

LOCATION

Mainland beaches exposed to ocean swell and associated windblown foredunes on the Coastal Plain. Examples include Warilla, Kendalls and Easts Beaches.

LANDSCAPE

Geology

Quaternary (Holocene) well-sorted marine, predominantly coarse quartz sands with well-sorted, coarse sand sized, abraded shell fragments.

Topography

Beaches. Gently inclined to gently undulating plains from <50 m up to several kilometres long. As beaches are geomorphically active, the topography is subject to continuous alteration in response to changes in wave energy and tidal dynamics (Short 1984).

Foredunes and minor swales. Moderately inclined to steep rises from <150 m wide up to several kilometres in length. Relief ranges 2–15 m. Slope may be 10–35% on blowout edges and seaward erosion scarps but is more commonly <10%.

Vegetation

The beach has no vegetation. The original herbland/grassland of the foredunes has been extensively disturbed, but many of the foredunes are currently being revegetated to stabilise the sand with community plantings of marram grass (*Ammophila arenaria*), hairy spinifex (*Spinifex sericeus*) and native dune shrubs.

Colonising vegetation on foredunes includes hairy spinifex (*Spinifex sericeus*), knobby club-rush (*Isolepsis nodosus*) and beach pennywort (*Hydrocotyle bonariensis*). In relatively sheltered areas on dunes, coastal heath (*Monotca eliptica*) and scrub occur. In disturbed areas bitou bush (*Chrysanthemoides monifilera*) often dominates.

Land Use

Beaches are used for recreation. Foredunes have been developed for residential purposes, caravan parks and golf courses—for example, at Windang Peninsula.

Existing Erosion

Wind erosion can be extreme on foredunes, especially where stabilising vegetation cover is absent or disturbed. Wind erosion on foredunes is characterised by blowouts.

Extreme wave erosion occurs during high seas. Many beaches in the mapped region—for example, Currarong and Shellharbour—are being eroded by wave action. This problem appears to have been increased by the construction of breakwaters.

SOILS

Dominant Soil Materials

wg1—Loose yellow shelly sand (topsoil and subsoil)

Colour	pale yellow (10YR 8/6)
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	7.0–9.0
Stones	nil (fragments of shell, pumice and organic matter)
Roots	nil

wg2—Loose pale brown siliceous sand (subsoil)

Colour	pale brown (10YR 7/4) to dark brown (10YR 5/3)
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	7.0–9.0
Stones	nil
Roots	nil

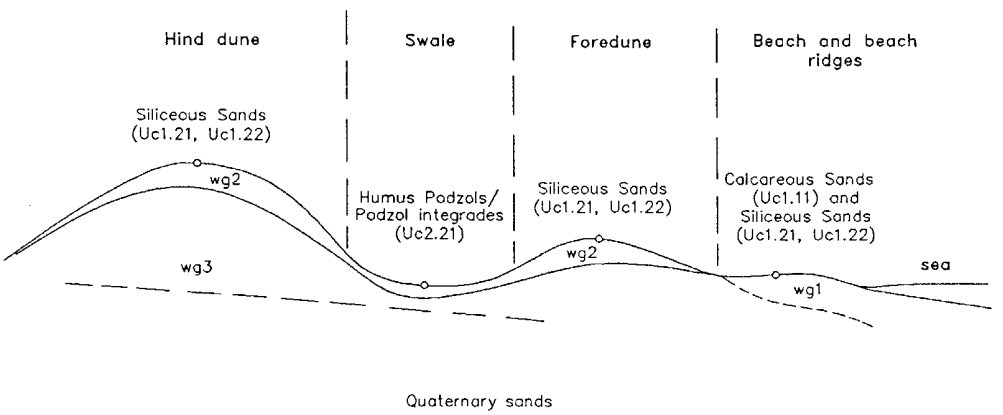
wg3—Yellowish brown mottled sand (subsoil)

Colour	yellowish brown (10YR 5/8) to dull yellowish brown (10YR 5/3) with faint orange mottles at depth (50%)
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	5.5–7.0
Stones	nil
Roots	nil

Occurrence and Relationships

Beach. Generally >200 cm of loose pale yellow shelly sand **(wg1)** occurs over the entire beach [Calcareous Sands (Uc1.11, Uc1.12)]. Some beaches contain fewer shell fragments [Siliceous Sands (Uc1.21, Uc1.22)].

Foredune. More than 200 cm of loose pale brown siliceous sand **(wg2)** occurs over all foredunes. In some sheltered situations where vegetation has not been disturbed, surface soil texture may approach that of loamy sand and have a slight accumulation of organic matter [Siliceous Sands



■ *Schematic cross-section of Wollongong soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

(Uc1.21, Uc1.22) and occasional Calcareous Sands (Uc1.11, Uc1.12)].

Minor Swales. Up to 30 cm **(wg1)** overlies >30 cm **(wg2). (wg3)** occurs below **(wg2)** usually at the level of the capillary fringe of the watertable. Boundary is gradual. Total soil depth exceeds 100 cm [Humus Podzol/Podzol intergrades (Uc2.21)][*].

LIMITATIONS TO DEVELOPMENT

Soil Limitations

wg1 [*]

wg2 High permeability
Low available water-holding capacity
Very low fertility

wg3 Low available water-holding capacity
Very low fertility
Salinity (localised)

Fertility

The general fertility is low. The soils are often strongly saline with low organic matter content, low available water-holding capacity, very low CEC and very low nutrient status.

Erodibility

The soil materials have very low erodibility. They consist of well-drained, loose, coarse sands. As loose material these soils are easily entrained by concentrated water flows.

Erosion Hazard

The erosion hazard for non-concentrated flows is slight to moderate. Calculated soil loss during the first 12 months of urban development ranges up to 15 t/ha for topsoil and 15 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows, wind erosion and wave erosion is extreme.

Surface Movement Potential

The sandy soil materials are stable.

Landscape Limitations

Wave erosion hazard
Wind erosion hazard
Waterlogging (beach)
Non-cohesive soil

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation or grazing.

[*] Beaches in this region have disturbed topography because of foredune reshaping following destruction of bitou bush (*Chrysanthemoides monilfiera*) and replanting with marram grass and spinifex.

5.7 Estuarine Landscapes

- **Seven Mile (sm)**

sm	SEVEN MILE	Estuarine

Landscape—series of dune ridges and swales, swamps or lagoons on Quaternary marine sands. Relief <5 m. Slopes <5%. Watertable at depth of <200 cm. Open-scrub, low open-forest grading to tall open-forest. Pockets of closed-forest in sheltered areas.

Soils—deep (>150 cm) Siliceous Sands (Uc1.21), Podzols (Uc2.21) occur on ridges. Acid Peats (0) occur in swamps and Humus Podzols (Uc4.21) occur in swales (localised).

Limitations—wind erosion hazard, non-cohesive soil, very low available water-holding capacity, sodicity, salinity, low fertility.

LOCATION

Series of dune ridges and swales, swamps and lagoons on Quaternary marine sands on the Coastal Plain. Examples include Seven Mile Beach, Warrain Beach, Coomonderry Swamp, Foys Swamp and Wollumboola Lake.

LANDSCAPE

Geology

Quaternary marine sands and peat; fine to medium marine quartz sands. Quaternary alluvium and peats in swamp.

Topography

Receding barrier (Thom 1974) with gently to moderately inclined dune ridges and swales, lagoons or swamps occurring landward of the barrier. Relief <5 m. Slopes <5%. Watertable at a depth of <200 cm.

Vegetation

The vegetation includes open-scrub on beach ridges to low open-forest to tall open-forest. Common species of open-scrub is coastal heath (*Monotoca eliptica*). Common species of low open-forest and tall open-forest include blackbutt (*Eucalyptus pilularis*) and bangalay (*Eucalyptus botryoides*) with an understorey of coastal banksia (*Banksia integrifolia*), old man banksia (*Banksia serrata*), sydney golden wattle (*Acacia longifolia*), and burrawang (*Macrozamia communis*). In poorly drained areas swamp mahogany (*Eucalyptus robusta*) and linear paperbark (*Melaleuca linariifolia*) grow. Pockets of closed-forest including lillypilly (*Acmena smithii*) and red-fruited olive plum (*Cassine australis*) occur in sheltered areas.

Land Use

Predominately National Park—for example, Seven Mile Beach National Park— with localised sandmining near Seven Mile Beach.

Existing Erosion

Wind and coastal erosion processes including blowouts are active on unconsolidated sands.

SOILS

Dominant Soil Materials

sm1—Loose dull yellow sand (topsoil)

Colour	dull yellow (2.5Y 6/3) to light grey (2.5Y 8/2)
Texture	sand
Structure	apedal, single-grained
Fabric	sandy
pH	4.5–6.0
Stones	nil
Roots	abundant

sm2—Friable organic peat (topsoil)

Colour	brownish black (10YR 2/2)
Texture	peat
Structure	apedal massive
Fabric	sandy
pH	5.5
Stones	nil
Roots	common

sm3—Bright yellowish brown clayey sand (subsoil)

Colour	bright yellowish brown (2.5Y 7/6)
Texture	clayey sand
Structure	apedal massive
Fabric	sandy
pH	7.0
Stones	nil
Roots	nil

sm4—Brownish black soft sandy organic pan (subsoil)

Colour	brownish black (10YR 3/1)
Texture	loamy sand
Structure	apedal massive
Fabric	sandy
pH	5.5–7.0
Stones	nil
Roots	nil

sm5—Bright yellowish brown sandy iron pan (subsoil)

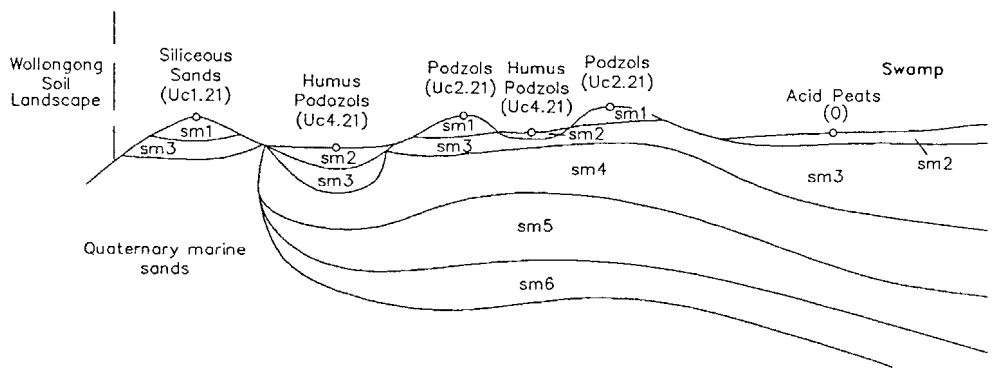
Colour	bright yellowish brown (10YR 7/6)
Texture	loamy sand
Structure	apedal massive
Fabric	sandy
pH	5.5–7.0
Stones	nil
Roots	nil

sm6—Mottled bright yellowish brown clayey sand (subsoil)

Colour	bright yellowish brown (10YR 7/6) with orange and red mottles
Texture	clayey sand
Structure	apedal massive
Fabric	sandy
pH	4.0
Stones	nil
Roots	nil

Occurrence and Relationships

Recent beach ridges. Up to 30 cm loose dull yellow sand **(sm1)** overlies <50 cm bright brownish yellow clayey sand **(sm3).** Boundary is clear. Total depth is <100 cm [Siliceous Sands (Uc1.21)].



■ *Schematic cross-section of Seven Mile soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Former beach ridges. Up to 30 cm loose dull yellow sand **(sm1)** overlies <20 cm bright yellowish brown clayey sand **(sm3).** Up to 20 cm brownish black soft sandy organic pan **(sm4)** overlies cm bright yellowish brown soft sandy iron pan **(sm5).** These soil materials overlie <200 cm mottled bright yellowish brown clayey sand **(sm6).** Boundaries are sharp to clear. Total depth is <300 cm [Podzols (Uc2.21)].

Swamps. Up to 30 cm friable organic peat **(sm2)** overlies >100 cm **sm3** [Acid Peats (0)].

Swales. Up to 20 cm **sm2** overlies <30 cm **sm3** which in turn overlies <10 cm **sm4** and **sm5**. These soil materials overlie <20 cm **sm6.** Boundaries are sharp to clear [Humus Podzols (Uc4.21)]. Total depth is >150 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

sm1 Very low available water-holding capacity
High organic matter
Strongly saline
Strongly sodic

sm2 Very low available water-holding capacity
Strongly sodic
Strongly saline

sm3 Low fertility
Sodicity
Aluminium toxicity

sm4 Hardsetting
Low available water-holding capacity
Very low fertility
Aluminium toxicity
Strongly acid
Sodicity

sm5 Low available water-holding capacity
Hardsetting
Very low fertility
Strongly acid
Aluminium toxicity

sm6 Low fertility
Low permeability
Strongly acid
Aluminium toxicity

Fertility

General fertility is low. The soils are often saline, low in organic matter and moderately to strongly acid. They have a low water-holding capacity and low CEC.

Erodibility

The erodibility of the topsoils **(sm1, sm2)** is very low. The erodibility of the subsoils **(sm3, sm4, sm5, sm6)** is high.

Erosion Hazard

Erosion hazard for this soil landscape for non-concentrated flows is slight. The calculated soil loss for the first 12 months of urban development ranges up to 10 t/ha for topsoils and 30 t/ha for exposed subsoils. The erosion hazard for concentrated flows, wind erosion and wave erosion is extreme.

Surface Movement Potential

The sandy soil materials are stable.

Landscape Limitations

Wind erosion hazard
Waterlogging (localised)
Permanently high watertable (localised)
Non-cohesive soil

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

5.8 Swamp Landscapes

- **Fairy Meadow (fa)**
- **Killalea (ki)**
- **Wingecarribee (wi)**

fa FAIRY MEADOW Swamp

Landscape—alluvial plains, floodplains, valley flats and terraces below the Illawarra Escarpment. Relief <10 m. Slopes <5%. Almost completely cleared low open-forest and woodland.

Soils—moderately deep (50–100 cm) Alluvial Loams (Um5.2) and Siliceous Sands (Uc1.21, Uc5.11) on terraces. Prairie Soils (Gn4.31) and Yellow Podzolic Soils (Dy5.41) occur on the drainage plains.

Limitations—flood hazard, low wet bearing strength, highly permeable topsoils, high watertables.

LOCATION

Gently undulating broad alluvial plains. Discontinuous distribution of alluvium on the Coastal Plain extending from the footslopes of the escarpment to Lake Illawarra. Examples include lowlands and floodplains associated with Solomons Creek, Duck Creek and Macquarie Rivulet.

LANDSCAPE

Geology

Quaternary sediments—quartz sand, lithic fluvial sand, silt and clay.

Topography

Gently undulating broad alluvial plains. Relief <10 m. Slopes <5%. Floodplains and valley flats with minor terraces and scattered swamps.

Vegetation

Almost completely cleared except for some isolated stands of low open-forest and woodland. Common species of poorly drained areas include woollybutt (*Eucalyptus longifolia*), cabbage gum (*Eucalyptus amplifolia*), forest red gum (*Eucalyptus tereticornis*), swamp oak (*Casuarina glauca*), river oak (*Casuarina cunninghamiana*), rough-barked apple (*Angophora floribunda*), forest oak (*Allocasuarina torulosa*), two-veined hickory (*Acacia binervata*), decorative paperbark (*Melaleuca decora*), prickly-leaved paperbark (*Melaleuca styphelioides*) and northern boobialla (*Myoporum acuminatum*). Blackbutt (*Eucalyptus pilularis*) and thin-leaved stringybark (*Eucalyptus eugenioides*) grow in more freely drained areas.

Land Use

Much of this landscape has been developed for commercial, industrial and residential use. Playing fields are often designed as drainage reserves. The floodplain is used for recreation reserves and horse training tracks. Albion Park Aerodrome is located in this landscape.

Existing Erosion

Minor sheet erosion, gully erosion, minor rill erosion on batters and stream bank erosion occur throughout this soil landscape.

Included Soil Landscape

Many small areas of Disturbed Terrain **(xx)** and developed terrain have been included.

SOILS

Dominant Soil Materials

fa1—Massive brownish black sandy loam (topsoil)

Colour	brownish black (10YR 2/2)
Texture	sandy loam to silty loam
Structure	apedal massive (wet)
Fabric	sandy
pH	7.0–7.5
Stones	10% of 2–20 mm sub-angular to angular, dispersed
Roots	common

fa2—Massive brown sand (topsoil and subsoil)

Colour	brown (7.5YR 4/4) to dull brown (7.5YR 6/3)
Texture	sand to sandy loam
Structure	apedal massive (wet)
Fabric	sandy
pH	6.0–7.0
Stones	nil
Roots	rare

fa3—Yellowish brown light clay (subsoil)

Colour	brown (7.5YR 4/3) to dull yellowish brown (10YR 4/3)
Texture	light clay to sandy clay loam
Structure	moderately pedal, 5–20 mm polyhedral peds
Fabric	rough-faced, porous
pH	6.0
Stones	small to medium rounded gravels <50%
Roots	rare

fa4—Olive brown heavy clay (subsoil)

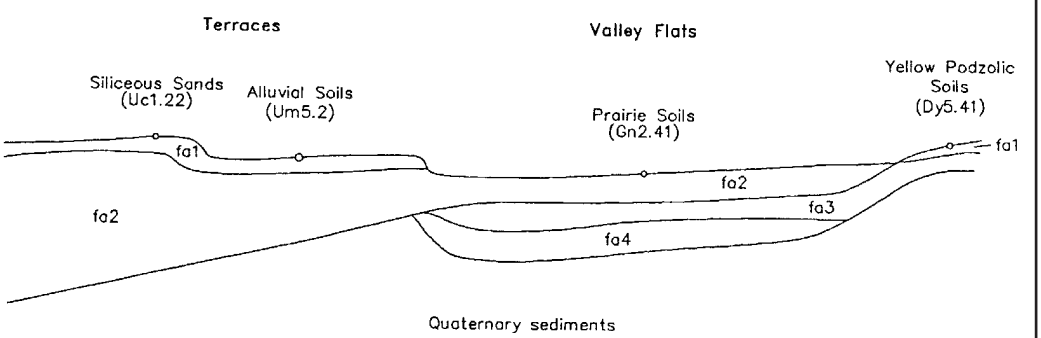
Colour	olive brown (2.5YR 4/3) to dull yellowish brown (10YR 4/3) with occasional orange red mottles (20%)
Texture	heavy clay to medium clay
Structure	weakly to moderately pedal, 2–20 mm crumb to polyhedral peds
Fabric	rough-faced, porous
pH	5.0–6.0
Stones	localised <50% fine to medium rounded gravels >20 mm
Roots	rare

Occurrence and Relationships

Terraces. Up to 20 cm of massive brownish black sandy loam **(fa1)** overlies >40 cm of massive brown sand **(fa2).** Boundary is clear [Siliceous Sands (Uc1.21, Uc5.11)] or gradual [Alluvial Loams (Um5.2)]. Total soil depth is <100 cm.

Drainage plains. Soils are highly variable. Soil materials in this landscape may include <40 cm **fa2** which overlies <50 cm of yellowish brown light clay **(fa3)** which overlies >80 cm of olive brown heavy clay **(fa4).** Boundaries are gradual [Prairie Soils (Gn4.31)]. Total soil depth is <150 cm.

Occasionally <20 cm of **fa1** overlies >80 cm of **fa3.** Boundary between soil materials is clear [Yellow Podzolic Soils (Dy5.41)]. Total soil depth is >120 cm.



■ *Schematic cross-section of Fairy Meadow soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

LIMITATIONS TO DEVELOPMENT

Soil Limitations

fa1 High permeability
Low available water-holding capacity

fa2 Low available water-holding capacity
Low fertility

fa3 Low permeability
Stoniness
Low fertility

fa4 Low permeability
Saline
Low fertility
Stoniness

Fertility

Fertility of all soil materials is low, except for **fa1** which is moderate. Nutrient storage potentials and nutrient status are low. General fertility is moderate. High watertables limit soil volumes available for root penetration.

Erodibility

The erodibility of the soil materials is low. **fa1** and **fa2** are readily entrained by concentrated flows.

Erosion Hazard

The erosion hazard for non-concentrated flows is slight. Calculated approximate soil loss during the first 12 months of urban development ranges up to 5 t/ha for topsoil and 5 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows is low to very high (localised).

Surface Movement Potential

These soils are generally stable.

Landscape Limitations

Flood hazard (localised)
Seasonal waterlogging
Permanently high watertables
Run-on

Urban Capability

Generally high to severe limitations for urban development in areas subject to waterlogging or flooding. Otherwise, moderate limitations for urban development.

Rural Capability

Generally low to moderate limitations for regular cultivation and grazing.

ki KILLALEA Swamp

Landscape—level to gently inclined wide alluvial plain with scattered swamps on Quaternary sediments. Relief <10 m. Slopes <3%. Extensively cleared with scattered trees.

Soils—moderate to deep (50–150 cm) Prairie Soils (Gn3.21) occur on drainage plains. Alluvial Soils (Uc1.21) occur on the alluvial plains. Humic Gleys (Uf6.61) occur in swamps and low lying areas.

Limitations—flood hazard, waterlogging, permanently high watertable, high organic content, low permeability, shrink-swell potential (topsoil and subsoil), strongly acid, sodicity.

LOCATION

Level to gently inclined wide alluvial plain and swamps on alluvium on the Coastal Plain. Examples include Shellharbour Swamp and Terragong Swamp and the floodplain between Killalea Lagoon and Rocklow Creek.

LANDSCAPE

Geology

Quaternary sediments—unconsolidated sediments, including alluvium, gravel, beach and dune sand.

Topography

Level to gently inclined wide alluvial plain. Relief <10 m. Slopes <3%. Occasional alluvial fans, very gently inclined drainage plains and scattered swamps. The low lying swamps are prone to periodic inundation.

Vegetation

Extensively cleared with scattered trees. The common species include decorative paperbark (*Melaleuca decora*), prickly-leaved paperbark (*Melaleuca styphelioides*), woollybutt (*Eucalyptus longifolia*), illawarra flame tree (*Brachychiton acerifolium*), weeping willow (*Salix babylonica*), tussock grass (*Poa* sp.) and kangaroo grass (*Themeda australis*).

Land Use

Grazing of dairy cattle and agistment on improved pasture when not inundated.

Existing Erosion

Sheet erosion if ungrassed because of flash flooding. High watertables.

Included Soil Landscape

Small areas of Disturbed Terrain **(xx)** occur.

SOILS

Dominant Soil Materials

ki1—Friable brown strongly pedal silty clay loam (topsoil)

Colour	brown (7.5YR 3/8)
Texture	silty clay loam
Structure	strongly pedal, 10–20 mm sub-angular blocky peds
Fabric	rough-faced and smooth-faced
pH	5.5
Stones	nil
Roots	common, ex-ped

ki2—Organic black massive sandy loam (topsoil)

Colour	black (10YR 2/1)
Texture	sandy loam
Structure	apedal massive
pH	4.0–5.0
Fabric	sandy
Stones	nil
Roots	abundant

ki3—Very dark strongly pedal brown medium clay (subsoil)

Colour	very dark brown (7.5YR 2/3)
Texture	medium clay
Structure	strongly pedal, 10–20 mm sub-angular blocky peds
Fabric	smooth-faced
pH	5.0
Stones	nil
Roots	few, ex-ped

ki4—Loose bleached light grey sand with iron staining (subsoil)

Colour	light grey (10YR 7/1)
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	4.5
Stones	nil
Roots	common

ki5—Mottled black massive clay (subsoil)

Colour	black (7.5YR 2/1) to dark brown (7.5YR 3/3) with dark brown orange mottles (50%)
Texture	silty clay to heavy clay
Structure	apedal massive
Fabric	sandy
pH	4.5
Stones	nil
Roots	nil

Occurrence and Relationships

Soils are very complex on alluvial plains. Common sequences of soil materials in this soil landscape may include the following.

Drainage plains. Up to 15 cm of friable brown strongly pedal silty clay loam **(ki1)** overlies >50 cm very dark brown strongly pedal medium clay **(ki3).** Boundary is gradual [Prairie Soils (Gn3.21)]. Total depth is >100 cm.

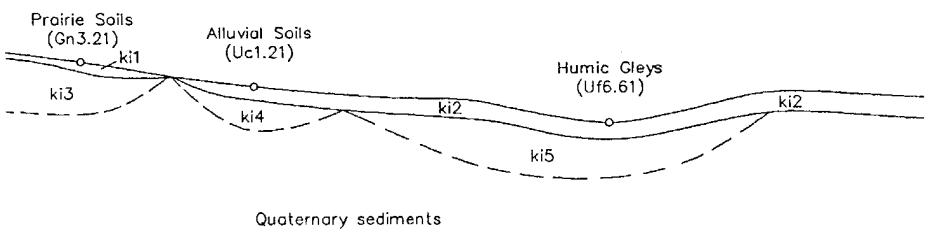
Alluvial plain. Up to 30 cm of organic black massive sandy loam **(ki2)** overlies <20 cm loose bleached light grey sand with iron staining **(ki4).** Boundary is clear [Alluvial Soils (Uc1.21)]. Total depth is >100 cm.

Low lying areas and swamps. Up to 70 cm **ki2** overlies >110 cm mottled black massive clay **(ki5).** Boundary is gradual to diffuse [Humic Gleys (Uf6.61)]. Total depth is >200 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ki1 Low wet bearing strength
Very high organic content
Shrink-swell



■ *Schematic cross-section of Killalea soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

ki2 Low available water-holding capacity
Very high organic material
Low permeability
Low wet bearing strength
Shrink-swell
Strong sodicity
Strongly acid

ki3 Low permeability
Low wet bearing strength
Low available water-holding capacity
Strong sodicity
Strongly acid

ki4 Low available water-holding capacity
High permeability
Strongly acid
Strong sodicity

ki5 Low permeability
Low wet bearing strength
Shrink-swell
Strongly acid
Strong sodicity

Fertility

General fertility is moderate to high. The soils of the drainage and alluvial plains are strongly acid with a moderate CEC. The soils on the drainage plain are well structured and well drained, but soils on the alluvial plain are seasonally waterlogged.

Erodibility

ki1 and **ki2** have very low erodibility ratings because of high organic content. The subsoils have moderate erodibility ratings.

Erosion Hazard

Erosion hazard for non-concentrated flows is slight. The calculated soil loss for the first 12 months of urban development ranges up to 5 t/ha for topsoils and 10 t/ha for exposed subsoils. The erosion hazard for concentrated flows is low.

Surface Movement Potential

Highly reactive organic soil materials **(ki1, ki2)** are not generally suitable for use as a foundation materials. **ki5** is slightly to moderately reactive.

Landscape Limitations

Flood hazard
Waterlogging
Permanently high watertable

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing. Low to moderate limitations for regular cultivation and grazing on freely drained areas.

wi	WINGECARRIBEE	Swamp

Landscape—low lying alluvial plains and closed depressions (swamps) on Quaternary alluvium. Relief <10 m. Slopes <3%. Extensively cleared with scattered stands of tall open-forest and areas of closed-sedgeland.

Soils—deep (>150 cm) Acid Peats (0) occur in swamps. Gleyed Podzolic Soils (Dg4.51) occur on flats.

Limitations—run-on, waterlogging, permanently high watertables, high organic matter, low wet bearing strength.

LOCATION

Low lying alluvial plains and closed depressions (swamps) on alluvium on the Moss Vale Tableland. Examples include Wingecarribee Swamp and Wildes Meadow Swamp.

LANDSCAPE

Geology

Quaternary alluvium and Tertiary gravels

Topography

Low lying alluvial plains and closed depressions (swamps). Local relief <10 m. Slopes <3%. Broad swamp lowlands <5 km wide in valley bottoms.

Vegetation

Extensively cleared with scattered stands of tall open-forest including swamp gum and mountain grey gum (*Eucalyptus cypellocarpa*). Closed-sedgeland including common reed (*Phragmites australis*), sedge (*Calorophus minor*), cord-rush (*Restio* sp.), bare twig-rush (*Baumea juncea*), tassel rope-rush and bullrushes (*Typha* sp.) (Pidgeon 1938).

Land Use

Part of this area has been disturbed and drained. An area within Wingecarribee Swamp has been mined for gravels.

Existing Erosion

Erosion is absent. Swamps are almost entirely depositional sites, being very effective sediment traps.

Included Soil Landscape

Small areas of Disturbed Terrain **(xx)** occur.

SOILS

Dominant Soil Materials

wi1—Greasy spongy black organic peat (topsoil)

Colour	black (10YR 1.7/1)
Texture	loam to silty loam
Structure	moderately pedal, 2–5 mm platy peds
Fabric	sandy
pH	4.0
Stones	nil
Roots	abundant, in-ped

wi2—Black organic clay loam (topsoil)

Colour	black (7.5YR 2/1)
Texture	clay loam to silty clay loam
Structure	massive to weakly pedal, 2–5 mm crumb peds
Fabric	earthy/rough-faced peds
pH	5.5
Stones	nil
Roots	abundant, in-ped

wi3—Waterlogged dark brown medium clay (subsoil)

Colour	dark brown (7.5YR 3/3) yellow mottling (70%) at depth
Texture	medium to heavy clay
Structure	apedal massive
Fabric	dense
pH	6.0
Stones	nil
Roots	nil

Occurrence and Relationships

Swamps. Up to 35 cm greasy spongy black organic peat **(wi1)** overlies >100 cm waterlogged dark brown medium clay **(wi3).** Boundary is gradual [Acid Peats (0)]. Total soil depth is >150 cm.

Flats. Up to 30 cm black organic clay loam **(wi2)** overlies >100 cm **wi3.** Boundary is sharp [Gleyed Podzolic Soils (Dg4.51)]. Total soil depth is >150 cm.

LIMITATIONS TO DEVELOPMENT

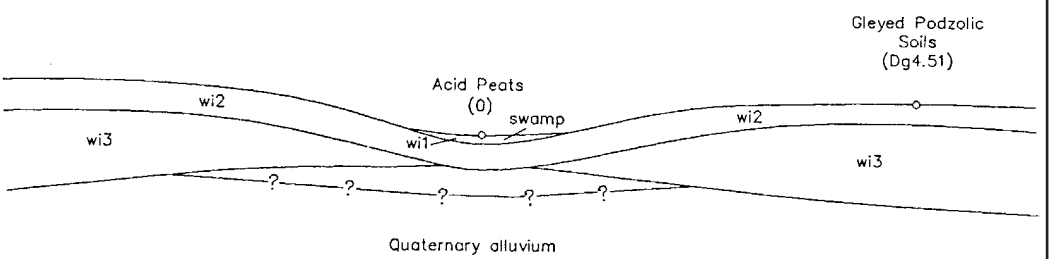
Soil Limitations

wi2 High organic matter
Low wet bearing strength
Sodicity
Salinity

wi3 Low permeability
Low wet bearing strength
Sodicity
Low fertility

Fertility

The general fertility is moderate to very low. The peaty topsoil **(wi1)** and organic clay loam **(wi2)** have moderate fertility. They are both high in organic matter and have high CEC. The subsoil material **(wi3)** has low fertility and is often permanently waterlogged.



■ *Schematic cross-section of Wingecarribee soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Erodibility

All soil materials have low erodibility.

Erosion Hazard

Erosion hazard for this soil landscape for non-concentrated flows is slight. The calculated soil loss for the first 12 months of urban development ranges up to 5 t/ha for topsoils and 5 t/ha for exposed subsoils. The erosion hazard for concentrated flows is moderate to high.

Surface Movement Potential

Slight to moderate reactivity would occur with peat.

Landscape Limitations

Waterlogging
Permanently high watertable
Run-on

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing in swampy areas. Low to moderate limitations for regular cultivation and grazing in better drained areas.

5.9 Disturbed Landscapes

- **Disturbed Terrain (xx)**

xx DISTURBED TERRAIN Disturbed

Occurs within other landscapes and is mapped as **xx**. The topography varies from level plains to undulating terrain and has been disturbed by human activity to a depth of at least 100 cm. The original soil has been removed, greatly disturbed or buried. Most of these areas have been levelled to slopes of <5%. Landfill includes soil, rock, building and waste material. The original vegetation has been completely cleared.

Limitations are dependent on nature of fill material and include subsidence resulting in a mass movement hazard, soil impermeability leading to poor drainage, and low fertility. Care must be taken when these sites are developed. A survey at a suitable scale as well as geotechnical analysis should be undertaken because of variability of materials throughout the sites. Seek advice from local councils concerning localised areas of disturbed terrain.

5.10 Associated Soil Landscapes

- **Maddens Plains (md)**
- **Faulconbridge (fb)**
- **Lucas Heights (lh)**
- **Picton (pn)**
- **Kurnell (kn)**
- **Gwynnevile (gw)**
- **Warragamba (wb)**
- **Mangrove Creek (mc)**

md MADDENS PLAINS Residual (Assoc.)

Landscape—moderate to gently undulating rises with dells (swamps) on plateau surfaces of Hawkesbury Sandstone. Local relief <40 m. Slopes <10%. Very broad drainage depressions and scattered rock outcrop <15%. Sedgelands, swamp, wet heath, dry heath and isolated stands of open-woodland and scrubland.

Soils—Acid Peats (0) occur in swamps, Gleyed Podzolic Soils (Dg4.31) occur in drainage lines, Siliceous Sands (Uc5.11) and Podzols (Uc2.31) occur on lower slopes, Yellow Earths—Laterites [(KS–Gn2.81, Gn4.81), Lithosols (Uc1.2)] occur on crests.

Limitations—seasonal and permanent waterlogging, low fertility, high erosion hazard, high shrink-swell (topsoil).

LOCATION

Hawkesbury Sandstone plateau surfaces on the eastern edges of the Woronora Plateau. The two major occurrences are at the southern extremity of Maddens Plains and between Burke River and Little River.

LANDSCAPE

Geology

Hawkesbury Sandstone—medium- to coarse-grained quartz sandstone with minor shale and laminite lenses and Quaternary sands, clayey quartz sand with humic matter. Localised exposures of friable sandstone.

Topography

Moderate to gently undulating rises on plateau surfaces with widespread dells (swamps) (Young 1986). Local relief ranges from 10–40 m and slope gradients 1–10%. The dominant landform elements are broad, usually waterlogged, drainage depressions and benches, 300–800 m wide. Localised outcrops of sandstone occur on small isolated hillcrests and ridges.

Vegetation

Uncleared sedgelands and eucalypt woodland. In the most frequently waterlogged areas common species include saw-sedge (*Gahnia* sp.), bog rush (*Schoenus* sp.) and bare twig-rush (*Baumea juncea*). Wet heathlands, which seasonally dry, contain swamp banksia (*Banksia robur*), coastal tea-tree (*Leptospermum laevigatum*) and dagger hakea (*Hakea teretifolia*). Open-woodland is dominated by scribbly gum (*Eucalyptus haemostoma*) occurring on hillcrests and well-drained slopes.

Land Use

Mostly Water Board Catchment area. The peaty soils and sinks of this soil landscape are important for retaining and slowly filtering water into the Sydney and Wollongong water supplies (Young 1986).

Existing Erosion

Sheet erosion occurs on the non-organic soils especially on exposed batters and after fire in wet heath. Isolated gully erosion is evident along some drainage lines, often to bedrock, and is associated with road drainage works.

Included Soil Landscape

Small areas of Faulconbridge **(fb)** soil landscape have been included in this soil landscape.

SOILS

md1—Friable organic peat (topsoil)

Colour	brownish black (10YR 2/2) to black (10YR 2/1)
Texture	peat
Structure	fibrous
pH	4.0–5.0
Stones	nil
Roots	abundant

md2—Loose grey sand (topsoil)

Colour	light grey (10YR 7/1) to pale yellow (10YR 7/4) with red mottles 50%
Texture	sand to loamy sand
Structure	apedal single-grained to weakly pedal, 2–5 mm polyhedral peds
Fabric	sandy
pH	4.0–6.0
Stones	nil
Roots	nil

md3—Earthy yellowish brown light sandy clay loam (topsoil or subsoil)

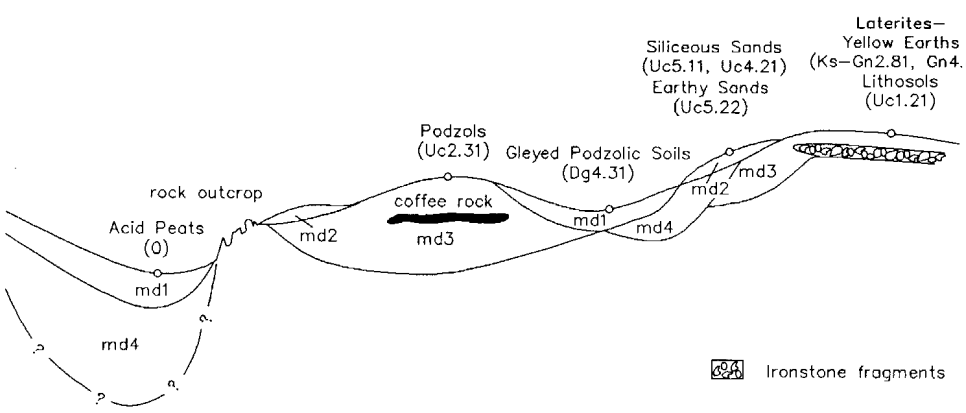
Colour	bright yellowish brown (10YR 6/6) to yellow orange (10YR 8/6)
Texture	light sandy clay loam to sandy clay loam
Structure	weakly pedal 2–5 mm polyhedral peds to apedal single-grained
Fabric	earthy and rough-faced, porous
pH	4.0–6.0
Stones	nil
Roots	nil

md4—Mottled gleyed clayey sand (subsoil)

Colour	light grey (10YR 8/1) to dull yellow orange (10YR 7/2) with orange mottles 40%
Texture	clayey sand to sandy clay loam
Structure	apedal massive
Fabric	earthy
pH	3.0–4.5
Stones	nil
Roots	nil

Occurrence and Relationships

Drainage depressions and poorly drained benches. Up to 180 cm of organic peat **(md1)** [Acid Peats (0)] overlies >200 cm mottled gleyed clayey sand **(md4).** The boundary between soil materials is sharp [Gleyed Podzolic Soils (Dg4.31)]. Total soil depth varies between 150 cm and 500 cm.



■ *Schematic cross-section of Maddens Plains soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Periphery of drainage depressions and poorly drained benches. Up to 100 cm of loose grey sand **(md2)** overlies <80 cm **md4** [Siliceous Sands (Uc5.11)] or overlies <80 cm earthy yellowish brown light sandy clay loam **(md3)** [Gleyed Podzolic Soils (Dg4.31)]. Boundaries between soil materials are gradual. The total depth varies from 100–200 cm.

Well-drained slopes. Up to 80 cm **md2** overlies **md3.** The boundary between soil materials is gradual [Siliceous Sands (Uc5.11, Uc4.21) and Earthy Sands (Uc5.22)]. Total depth is 100–200 cm.

Very well-drained positions (upper slopes). Up to 40 cm **md1** overlies <60 cm **md3.** The boundary between soil materials is sharp. In some locations there is a coffee rock pan [Podzols (Uc2.31)]. The total depth is 100–200 cm.

Hillcrests and upper slopes. Up to 50 cm of **md3** occurs with abundant ironstone and rock fragments [Laterites-Yellow Earths (KS–Gn2.81, Gn4.81)]. In some instances soil depth is very shallow [Lithosols (Uc1.2)].

LIMITATIONS TO DEVELOPMENT

Soil Limitations

md1 Very high organic matter
Strongly acid
Low wet bearing strength
High shrink-swell
Sodicity

md2 Low available water-holding capacity
Strongly acid
High aluminium toxicity
Low fertility
Sodicity

md3 Low available water-holding capacity
Strongly acid
High aluminium toxicity
Low fertility
Sodicity
Stoniness

md4 Low available water-holding capacity
Strongly acid
High aluminium toxicity
Low fertility
Sodicity
Waterlogging

Fertility

The fertility is very low. The peaty topsoils are strongly acid with high organic matter. The subsoil materials have very low nutrient status, are often extremely acid and are often permanently waterlogged.

Erodibility

md2, md3, md4 have low erodibility as they consist of well-drained coarse sands. **md1** has low erodibility consisting of coarse sand grains bound together by organic matter.

Erosion Hazard

The erosion hazard for non-concentrated flows is slight to very high. Calculated soil loss during the first 12 months of urban development ranges up to 65 t/ha for topsoil and 80 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows is very high.

Surface Movement Potential

Stable. Except for **md1** all materials are sufficiently coarse grained to be considered stable.

Landscape Limitations

Seasonal and permanent waterlogging
Permanently high watertables
Low fertility

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation or grazing.

fb FAULCONBRIDGE Residual (Assoc.)

Landscape—level to gently undulating crests and ridges on plateau surfaces of the Hawkesbury Sandstone. Local relief <20 m. Slopes <5%. Infrequent rock outcrop. Partially cleared eucalypt woodland.

Soils—shallow (<50 cm) Earthy Sands (Uc4.21, Uc5.22) and Yellow Earths (Gn1.21, Gn2.21, Gn2.24); some very shallow (<30 cm) Siliceous Sands/Lithosols (Uc1.2) associated with rock outcrop.

Limitations—shallow, highly permeable soil, very low soil fertility and isolated rock outcrop.

LOCATION

Ridge and plateau surfaces on the Hawkesbury Sandstone of the Woronora Plateau.

LANDSCAPE

Geology

Hawkesbury Sandstone consisting of medium- to coarse-grained quartz sandstone with minor shale and laminite lenses.

Topography

Level to gently undulating, broad crests and ridges on plateau surfaces. Local relief <20 m and slopes <5%. Broad convex ridge crests (300–800 m) are the dominant landform element. Rock outcrop is occasionally present.

Vegetation

Partially cleared low eucalypt woodland with dry sclerophyll shrub understorey. The low woodland includes red bloodwood (*Eucalyptus gummifera*), budawang ash (*Eucalyptus dendromorpha*), sydney peppermint (*Eucalyptus piperita*) and scribbly gum (*Eucalyptus haemastoma, Eucalyptus racemosa*). Other species include smooth-barked apple (*Angophora costata*), coastal banksia (*Banksia integrifolia*), old man banksia (*Banksia serrata*), christmas bush (*Ceratopetalum gummiferum*), brush kurrajong (*Commersonia fraseri*) and blueberry ash (*Elaeocarpus reticulatus*).

Land Use

Uncleared bushland.

Existing Erosion

Minor sheet erosion occurs as sheetwash. Minor trail erosion.

SOILS

Dominant Soil Materials

fb1—Loose olive brown loamy sand (topsoil)

Colour	olive brown (2.5Y 4/3) to dark greyish yellow (2.5YR 5/2)
Texture	sand to fine sandy loam
Structure	apedal single-grained
Fabric	sandy
pH	4.0–6.0
Stones	few
Roots	common

fb2—Earthy yellow light sand clay loam (subsoil)

Colour	brownish yellow (10YR 5/8, 10YR 6/8) to light olive brown (2.5Y 4/6)
Texture	sandy clay loam to sandy clay
Structure	apedal massive
Fabric	earthy
pH	5.5–6.5
Stones	few
Roots	common to rare

fb3—Mottled brownish yellow earthy sandy clay loam (subsoil)

Colour	brownish yellow (10YR 5/8, 10YR 6/8) to yellowish brown (2.5Y 5/6) orange mottles (50%)
Texture	sandy clay loam to sandy clay
Structure	apedal massive
Fabric	earthy
pH	4.5–6.0
Stones	few
Roots	nil

Occurrence and Relationships

Up to 10 cm of loose, olive brown loamy sand **(fb1)** overlies sandstone bedrock [Lithosols or Siliceous Sands (Uc1.2)], or it can overlie 15–30 cm of earthy olive brown clayey sand **(fb2)** which overlies <30 cm of mottled brownish yellow earthy sandy clay loam **(fb3)**. Boundaries between **fb1** and **fb3** are usually clear. There is a diffuse to gradual boundary between **fb2** and **fb3** [Earthy Sands (Uc5.22) or Yellow Earths (Gn2.24, Gn1.21, Gn2.21)]. Total soil depth ranges from 30–100 cm.

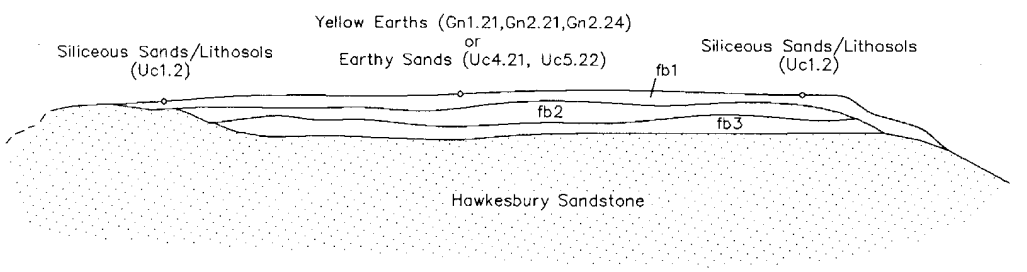
LIMITATIONS TO DEVELOPMENT

Soil Limitations

fb1 High permeability
Low available water-holding capacity
Low fertility
High aluminium toxicity
Strongly acid

fb2 Very low fertility
Localised stoniness
Strongly acid
High aluminium toxicity

fb3 Low available water-holding capacity
Stoniness
Very low fertility
Very strongly acid
Very high aluminium toxicity



■ ***Schematic cross-section of Faulconbridge soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

Fertility

Very low fertility. The soil materials are very strongly acid, have low available water-holding capacities, are shallow, highly permeable, with low organic matter content and very low cation exchange capacity (CEC). They are often severely deficient in nutrients.

Erodibility

fb1 consists of highly permeable, coarse, loose, sand grains which have a very low to low erodibility depending on organic matter present. **fb2** and **fb3** are very low in organic matter and consist of fine sand grains which are weakly cemented in a clay matrix and are moderately erodible.

Erosion Hazard

The erosion hazard for non-concentrated flows is low to moderate. Calculated soil loss during the first 12 months of urban development ranges up to 10 t/ha for topsoil and up to 20 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows is also low.

Surface Movement Potential

Shallow depths and low clay contents make these soils stable to slightly reactive.

Landscape Limitations

Shallow soil
Rock outcrop

Urban Capability

Generally low limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation. Moderate limitations for grazing with careful management.

lh LUCAS HEIGHTS Residual (Assoc.)

Landscape—gently undulating crests, ridges and plateau surfaces of the Mittagong Formation (alternating bands of shale and fine-grained sandstones). Local relief 10–50 m. Slopes <10%. Rock outcrop is absent. Extensively or completely cleared, dry sclerophyll low open-forest and low woodland.

Soils—moderately deep (50–150 cm), hardsetting Yellow Podzolic Soils and Yellow Soloths (Dy2.41) and Lateritic Podzolic Soils (Dy3.61) on crests; Yellow Earths (Gn2.24) on outer edges of crests. Earthy Sands (Uc5) in valley flats.

Limitations—stoniness, low soil fertility, low available water-holding capacity.

LOCATION

Ridge and plateau surfaces on Mittagong Formation. Examples occur on the southern reaches of the Woronora Plateau.

LANDSCAPE

Geology

Mittagong Formation—interbedded shale, laminite and fine- to medium-grained quartz sandstone. The Mittagong Formation is located stratigraphically between the Ashfield Shale and Hawkesbury Sandstone. It is often relatively shallow. Minor areas of Hawkesbury Sandstone and minor areas of Ashfield Shale sporadically form surface soil materials within this landscape. Localised laterite outcrops occur.

Topography

Gently undulating plateau surfaces and ridges, 200–1 000 m wide, with level to gently inclined slope gradients of <10%. Local relief is <30 m. Rock outcrop is absent.

Vegetation

Extensively cleared low open-forest and low woodland with a shrub understorey. Dominant tree species include turpentine (*Syncarpia glomulifera*), smooth-barked apple (*Angophora costata*), red bloodwood (*Eucalyptus gummifera*), black ash (*Eucalyptus sieberi*) and sydney peppermint (*Eucalyptus piperita*). Understorey and shrub species include blue mountains mallee ash (*Eucalyptus stricta*) and heath banksia (*Banksia ericifolia*).

Land Use

Uncleared bushland.

Existing Erosion

Erosion on this soil landscape is generally low. Minor gully and sheet erosion occur occasionally along unpaved roads.

SOILS

Dominant Soil Materials

lh1—Loose greyish brown fine sandy loam (topsoil)

Colour	greyish brown (7.5YR 5.2) to yellowish brown (10YR 5/6)
Texture	fine sandy loam to light sandy clay loam
Structure	apedal single-grained
Fabric	sandy
pH	4.5–6.5
Stones	common, iron-coated platy <10 cm
Roots	common

lh2—Bleached stony hardsetting yellow orange sandy clay loam (topsoil)

Colour	yellow orange (10YR 8/6) (bleached 10YR 7/3 when dry) to bright yellowish brown (10YR 7/6)
Texture	sandy clay loam
Structure	apedal massive
Fabric	earthy
pH	4.0–6.0
Stones	50% stratified, re-oriented, angular to sub-rounded
Roots	rare

lh3—Mottled earthy yellowish brown sandy clay loam (subsoil)

Colour	yellowish brown (2.5Y 5/6) to dull yellow orange (10YR 7/2)
Texture	sandy clay loam
Structure	apedal massive
Fabric	earthy
pH	4.5–6.0
Stones	50% stratified and re-oriented
Roots	rare

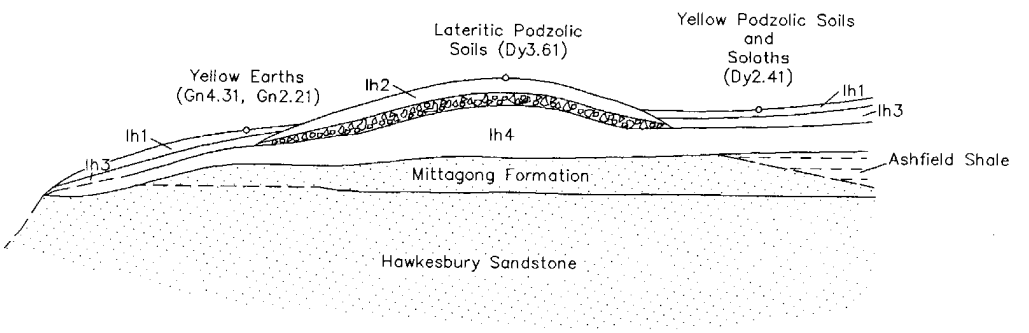
lh4—Strongly pedal bright yellowish brown sandy clay (subsoil)

Colour	bright yellowish brown (10YR 7/6) to dull yellowish orange (10YR 6/4)
Texture	sandy clay to heavy clay
Structure	strongly pedal, 10–50 mm polyhedral to sub-angular blocky
Fabric	rough-faced, porous
pH	4.0–5.0
Stones	>50% stratified bands, iron-coated fragments
Roots	nil

Occurrence and Relationships

Crests and slopes. Loose greyish brown sandy loam **(lh1)** overlies mottled earthy yellowish brown sandy clay loam **(lh3)** [Yellow Earths (Gn2.24)].

Crests and plateau surfaces. 10–20 cm bleached stony hardsetting yellow orange sandy clay loam **(lh2)** usually overlies strongly pedal yellowish brown sandy clay **(lh4)** which extends to depth of 100 cm [Yellow Podzolic Soils and Soloths (Dy2.41, Dy2.21)]. Ironstone is often abundant, especially



■ *Schematic cross-section of Lucas Heights soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

in elevated positions. The boundary between the soil materials is clear [Lateritic Podzolic Soils (Dy3.61)]. The total soil depth is <100 cm.

Valley flats and depressions. Loose sands and sandy loams **(lh1)** [Earthy Sands (Uc5)]. Depth varies from 100–200 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

lh1 Stoniness
High permeability
Low available water-holding capacity
Low fertility

lh2 High erodibility
Stoniness
Low available water-holding capacity
Hardsetting surface
Low permeability
Very low fertility
Localised sodicity

lh3 Stoniness
Low available water-holding capacity
Very low fertility
Sodicity

lh4 Low wet bearing strength
Stoniness
Low permeability
Low available water-holding capacity (localised)
Very low fertility
Strongly acid
High potential aluminium toxicity

Fertility

Fertility of soil materials is low. The soils have low available water-holding capacity and low CEC as well as low to very low intrinsic nutrient levels. Topsoils are hardsetting and stony. The subsoils are occasionally sodic and impermeable. General fertility is moderate as soils are moderately deep and well structured.

Erodibility

lh1 is moderately erodible as it consists of loose fine sand grains with moderate amounts of organic matter. **lh2** is highly erodible when disturbed as it is dominated by fine sand. This material is hardsetting and coherent and usually resists erosion if not disturbed. **lh3** is highly erodible as it is dominated by fine sand weakly bound in a clay matrix. **lh4** is moderately erodible. It consists of fine sand and clay with a very low organic matter content.

Erosion Hazard

The erosion hazard for non-concentrated flows is generally moderate but ranges from slight to extreme. Calculated soil loss during the first 12 months of development ranges up to 10 t/ha for both topsoil and exposed subsoil. Soil erosion hazard for concentrated flows is high.

Surface Movement Potential

Soils are generally slightly reactive but may be moderately reactive where depth exceeds 1.5 m.

Landscape Limitations

Surface movement potential

Urban Capability

Generally low limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation. Low to moderate limitations for grazing.

pn PICTON Colluvial (Assoc.)

Landscape—steep to very steep sideslopes on Wianamatta Group and derived colluvial materials, usually having a southerly aspect. Relief 90–300 m. Slope gradients >20%. Extensively cleared open-forest.

Soils—shallow to deep (50–200 cm) Red Podzolic Soils and Brown Podzolic Soils (Dr2.11, Dr3.11, Db1.11) on upper slopes. Brown Podzolic Soils, Yellow Podzolic Soils and Soloths (Db1.11, Dy4.41, Dy4.42, Dy5.11) on lower slopes and benches with Red Earths (Gn3.11, Gn4.11) and Brown Earths (Gn4.11) on colluvial material. Very deep (>300 cm) Yellow Podzolic Soils and Soloths (Dy3.11) on lower slopes and in drainage lines.

Limitations—extreme erosion hazard, mass movement (slump) hazard, steep slopes, occasionally impermeable and highly plastic shrink-swell subsoils.

LOCATION

Steep to very steep hills in north-western section of Moss Vale Tableland north of the Tourist Road.

LANDSCAPE

Geology

Wianamatta Group. Ashfield Shale—laminite and dark grey shale. Bringelly Shale—shale, calcareous claystone, laminite, fine- to medium-grained lithic quartz sandstone, and rare coal.

Topography

Steep to precipitous hills on fine-textured Wianamatta Group shales (local relief 90–300 m, slope gradients 20–80%). Steep concave upper slopes and irregular lower slopes with southerly and south-westerly aspects are the dominant landform elements. Indications of mass movement processes, predominantly soil creep and slump, are widespread.

Vegetation

Extensively cleared tall open-forest. Common species include sydney blue gum (*Eucalyptus saligna*) and blackbutt (*Eucalyptus pilularis*). Other species include turpentine (*Syncarpia glomulifera*), grey ironbark (*Eucalyptus paniculata*), white stringybark (*Eucalyptus globoidea*), rough-barked apple (*Angophora floribunda*), and broad-leaved apple (*Angophora bakeri*). Sweet pittosporum (*Pittosporum undulatum*) and breynia (*Breynia oblongifolia*) are common understorey species (Benson 1981).

Land Use

Grazing on improved, voluntary and native pastures.

Existing Erosion

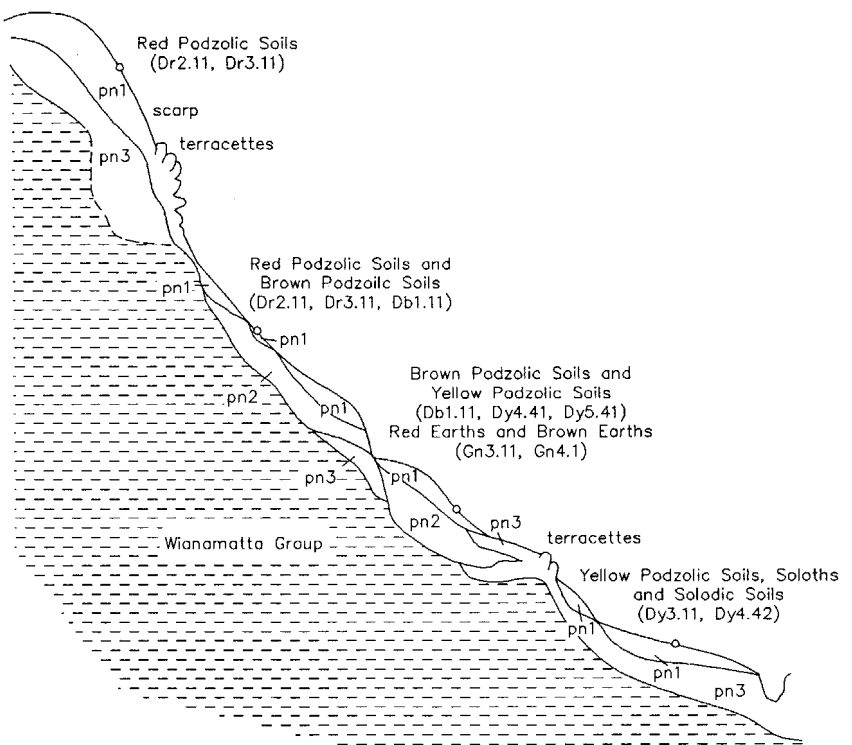
Slumps, flows, sheet and tunnel erosion occur throughout this soil landscape. Small discontinuous gullies are common in drainage lines where subsoils are more plastic. There are isolated patches of conspicuous and severe sheet erosion.

SOILS

Dominant Soil Materials

pn1—Hardsetting dark brown massive sandy loam (topsoil)

Colour	dark brown (10YR 3/3) to dark reddish brown
Texture	sandy loam to fine sandy clay loam
Structure	apedal massive
Fabric	earthy
pH	6.5–5.5
Stones	<60% 2–20 mm weakly weathered sub-rounded to angular gravel
Roots	abundant (in top 5 cm)



■ ***Schematic cross-section of Picton soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

pn2—Strongly pedal dark reddish brown sandy clay (subsoil)

Colour	dark reddish brown (5YR 3/2, 5YR 3/4) occasional red or grey mottles <50% at depth
Texture	sandy clay to light clay
Structure	strongly pedal, 2–5 mm polyhedral peds
Fabric	smooth-faced
pH	6.5
Stones	20% 6–20 mm sub-angular
Roots	few, ex-ped

pn3—Mottled bright brown stony light clay (subsoil)

Colour	bright brown (7.5YR 3/4) to dark reddish brown (2.5YR 3/4) with light grey mottles (25%)
Texture	light to light medium clay
Structure	strongly pedal, 6–20 mm polyhedral to sub-angular blocky
Fabric	rough-faced, porous
pH	5.0–4.0
Stones	80% weakly weathered, sub-angular to platy gravel
Roots	rare

Occurrence and Relationships

Crests and upper slopes. Up to 80 cm hardsetting dark brown massive sandy loam **(pn1)** overlies a similar depth of mottled bright brown stony light clay **(pn3)** which directly overlies weathering shale bedrock [Red Podzolic Soils (Dr2.11, Dr3.11)]. Total soil depth is usually >150 cm.

Where there has been more recent downslope movement, **pn1** is much shallower (<30 cm) on the source slope, and this overlies <40 cm strongly pedal dark reddish brown sandy clay **(pn2)** and <50 cm of **pn3.** Boundaries between soil materials are clear [Red Podzolic Soils and Brown Podzolic Soils (Dr2.11, Dr3.11, Db1.11)]. Total soil depth can be <100 cm.

Colluvial benches. Materials are typically chaotically mixed with soil types varying considerably over short distances. Up to 80 cm of **pn1** overlies <100 cm of **pn2** and >100 cm of **pn3**. Boundaries between soil materials are gradual to clear [Brown and Yellow Podzolic Soils (Db1.11, Dy4.41 and Dy5.11) or Red Earths (Gn3.11) and Brown Earths (Gn4.1)]. Total soil depth is >200 cm.

Footslopes and drainage lines. Up to 50 cm of **pn1** overlies up to 150 cm of **pn3** which overlies strongly weathered shale [Yellow Podzolic Soils, Soloths and Solodic Soils (Dy3.11, Dy4.42)]. The boundary between soil materials is clear. Total soil depth is >200 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

pn1 High erodibility (localised)
Strongly acid

pn2 Low permeability
Strongly acid
Low fertility

pn3 Moderate stoniness
Sodicity
Extreme erodibility
Low fertility
Shrink-swell (localised)

Fertility

General fertility is moderate to low. The topsoil **(pn1)** has high organic matter content, moderate CEC and generally low nutrient status. It is strongly acid and may have high potential for aluminium toxicity. The other soil materials have low fertility with very low nutrient status. They are also locally sodic. Soils are deep, but poor structure often inhibits root penetration with depth.

Erodibility

Soil materials **pn1, pn2** are moderately erodible. The topsoil **(pn1)** can be coherent with earthy fabric, has high organic matter content or sandy fabric, but can have a relatively high percentage of silt and fine sand. **pn2** is moderately erodible, having small, smooth-faced aggregates which contain a large percentage of silt and are prone to slaking. **pn3** is highly erodible, consisting of structured, slaking clay and silt. Slope failure due to throughflow and development of tunnels is common.

Erosion Hazard

The erosion hazard for non-concentrated flows is extreme. The steep slopes are subject to mass movement when saturated. Calculated soil loss for the first 12 months of urban development ranges from 300 t/ha for topsoil on steeper slopes and up to 170 t/ha for exposed subsoil.

Soil erosion hazard for concentrated flows is high to very high.

Surface Movement Potential

Slightly reactive subsoils in areas of deep clayey soils with tall trees in a landscape with complex drainage. There are isolated areas of moderately reactive soils.

Landscape Limitations

Steep slopes
Mass movement hazard
Seasonal waterlogging (localised)
Water erosion hazard
Surface movement potential

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation or grazing.

kn KURNELL Aeolian (Associated)

Landscape—gently undulating to rolling coastal dunefields and relict dunes on Quaternary sand. Local relief to 15 m. Slope gradients <15%. North-south oriented dunes with convex narrow crests, broad gently inclined concave swales and isolated swamps. Extensive heathland.

Soils—deep (>200 cm) sandy Podzols (Uc2.31, Uc2.32, Uc2.34) on dunes and in swales. Organic Acid Peats (O) in swamps.

Limitations—extreme wind erosion hazard, highly permeable soils, very low fertility, moderate shrink-swell (subsoil) and permanently high watertables.

LOCATION

Windblown sands and dunes on the Windang Peninsula on the Coastal Plain.

LANDSCAPE

Geology

Quaternary (Pleistocene) windblown medium- to fine-grained well sorted marine quartz sand.

Topography

Transgressive north-south oriented dunes 5–15 m high, with convex narrow crests. Local relief is <20 m. Slopes <15%. Where residential development has occurred, beach ridges have been levelled and swampy swales filled.

Vegetation

Extensively cleared with pockets of heathland which include native heath, spiny-headed mat-rush (*Lomandra longifolia* sp. *longifolia*), and darwinia (*Darwinia fasicularis*). Coastal banksia (*Banksia integrifolia*) and coastal tea-tree (*Leptospermum laevigatum*) occasionally form scrub thickets.

Land Use

Walking tracks, golf course, residential areas.

Existing Erosion

No appreciable erosion where slopes are low and a substantial ground cover is maintained.

Included Landscape

Small areas of Disturbed Terrain **(xx)** occur.

SOILS

Dominant Soil Materials

kn1—Loose brownish grey sand (topsoil)

Colour	brownish grey (10YR 5/1) to (10YR 8/1)
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	5.0–6.5
Stones	nil
Roots	nil

kn2—Mottled greyish brown sand (subsoil)

Colour	greyish brown (7.5YR 4/2) to brownish grey (10YR 6/1) with faint yellow mottles >30%
Texture	sand
Structure	apedal, single-grained
Fabric	sandy
pH	5.5–7.0
Stones	nil
Roots	nil

kn3—Brown soft sandy iron pan coffee rock

Colour	brown (10YR 4/6) to bright yellowish brown (10YR 7/6)
Texture	sand to loamy sand
Structure	apedal massive
Fabric	sandy to earthy
pH	5.5–7.0
Stones	nil
Roots	nil

kn4—Loose bright yellowish brown sand (subsoil)

Colour	bright yellowish brown (7.5YR 6/6) to brown (10YR 6/6)
Texture	sand
Structure	apedal, single-grained to weakly cohesive
Fabric	sandy to earthy
pH	4.5–6.0
Stones	nil
Roots	nil

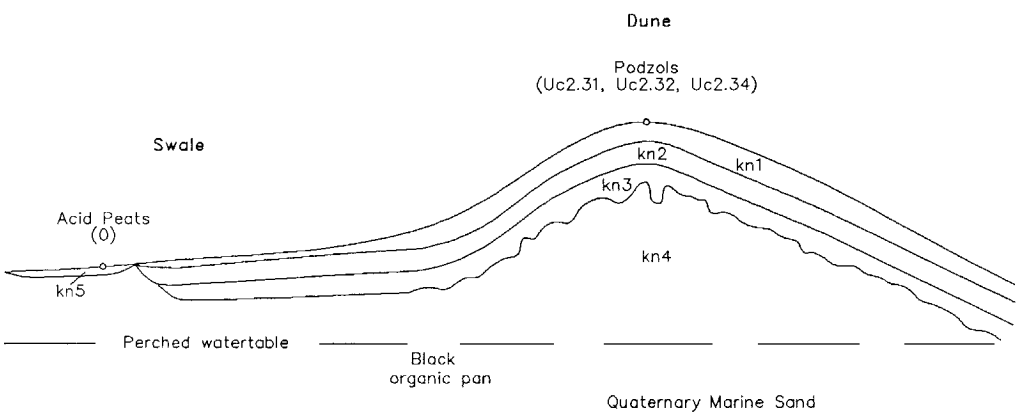
kn5—Black sticky peat (subsoil)

Colour	black (10YR 3/1)
Texture	silt loam to silty clay loam
Structure	apedal massive
pH	4.5–6.0
Stones	nil
Roots	common

Occurrence and Relationships

Dunes. Up to 80 cm of loose brownish grey sand **(kn1)** overlies <15 cm of coffee rock **(kn3).** Up to 130 cm yellow brown sand **(kn4)** overlies <50 cm mottled greyish brown sand **(kn2).** The boundaries between **kn1** and **kn3** are even, and **kn2, kn3** and **kn4** are sharp and irregular [Podzols (Uc2.31, Uc2.32, Uc2.34)]. Total depth is >250 cm.

Swales. Up to 25 cm of brown sand **(kn1)** overlies <25 cm black sticky peat **(kn5)** [Acid Peats (0)], often resulting in perched watertables.



■ *Schematic cross-section of Kurnell soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

LIMITATIONS TO DEVELOPMENT

Soil Limitations

kn1 Low available water-holding capacity
Low fertility

kn2 Low available water-holding capacity
Low fertility

kn3 Low available water-holding capacity
Hardsetting surface
Very low fertility

kn4 Low available water-holding capacity
Very low fertility
Strongly acid
High potential aluminium toxicity

kn5 Low available water-holding capacity (dry)
Hardsetting (dry)
High organic matter
Strongly acid
High potential aluminium toxicity
Shrink-swell

Fertility

Soil fertility is low to very low. Nutrient status is low as is CEC and available water-holding capacity. Roots are generally restricted to soil occurring above **kn3**, a coherent coffee rock pan.

Erodibility

The soil materials have very low erodibility. The soil materials **kn1, kn2, kn3** are stable well-drained coarse sands, **kn4** has coarse sand grains weakly held together by iron compounds and **kn5** by organic matter.

Erosion Hazard

The erosion hazard for non-concentrated flows is slight. Calculated soil loss during the first 12 months of urban development ranges up to 5 t/ha for topsoil and 35 t/ha for exposed subsoil. Soil erosion hazard for wind erosion and concentrated flows is extreme.

Surface Movement Potential

Slight to moderate reactivity occurs with peat; otherwise, stable.

Landscape Limitations

Permanently high watertables
Highly permeable soils
Extreme wind erosion hazard
Very low fertility

Urban Capability

Generally moderate limitations for urban development. High to severe limitations on sand dunes.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

gw GWYNNEVILLE Residual (Assoc.)

Landscape—undulating to steep hills on Illawarra Coal Measures and Dapto Latite Member on the Coastal Plain. Local relief 10–70 m. Slopes 3–25%. Broad to narrow (250–850 m) rounded ridges and gently to steeply inclined slopes. Structural benches and occasional rock outcrop. Extensively cleared tall open-forest and open-forest.

Soils—shallow (50–100 cm Brown Podzolic Soils (Db3.11) and Xanthozems (Gn4.34) on upper slopes, Lithosols (Um1.43, Uc1.23) on simple slopes and shallow (<50 cm) Brown Earths (Uf6.13) on midslopes and lower slopes.

Limitations—Extreme erosion hazard, steep slopes, mass movement hazard, local flooding. Reactive impermeable and low wet bearing strength clay subsoils.

LOCATION

Undulating to steep hills on the Coastal Plain. Examples include Koonawarra and Lakelands.

LANDSCAPE

Geology

Illawarra Coal Measures—resistant interbedded quartz-lithic sandstone, grey siltstone and claystone, carbonaceous claystone, clay and laminite; and Dapto Latite Member—melanocratic coarse-grained to porphyritic latite.

Topography

Undulating to steep hills (local relief 10–70 m); slope gradients 3–25%. Landform elements include broad to moderate ridges (250–800 m), steeply inclined to moderately inclined footslopes, and isolated rises on the Coastal Plain. This soil landscape is characterised by localised structural benches up to 80 m wide and localised bedrock outcrops and deep colluvial deposits.

Vegetation

In residential areas the original tall open-forest and open-forest have been extensively cleared. Remaining species include bangalay (*Eucalyptus botryoides*), blackbutt (*Eucalyptus pilularis*), grey ironbark (*Eucalyptus paniculata*), two-veined hickory (*Acacia binervata*) and black wattle (*Acacia mearnsii*). Swamp mahogany (*Eucalyptus robusta*) and forest red gum (*Eucalyptus tereticornis*) occur in poorly drained areas.

Land Use

Land use is predominantly urban residential.

Existing Erosion

Evidence of widespread previous mass movement includes isolated collapsed batters and indications of previous slumps and landslides.

SOILS

Dominant Soil Materials

gw1—Friable brownish black moderately pedal sandy loam (topsoil)

Colour	brownish black (7.5YR 2/2) to dull yellowish brown (10YR 5/3)
Texture	sandy loam to loam
Structure	moderately pedal, 1–10 mm crumb to polyhedral peds
Fabric	rough-faced, porous
pH	6.0–7.0
Stones	<2–20% gravels and cobbles (6–600 mm) rare to common
Roots	rare

gw2—Friable moderately pedal dull yellowish brown sandy clay loam (topsoil or subsoil)

Colour	dull yellowish brown (10YR 5/3) to brownish black (10YR 3/2)
Texture	sandy clay loam
Structure	moderately pedal, 2–10 mm crumb to polyhedral peds
Fabric	rough-faced, porous
pH	6.5
Stones	10–90% (2–600 mm) fragments and gravels
Roots	few, ex-ped

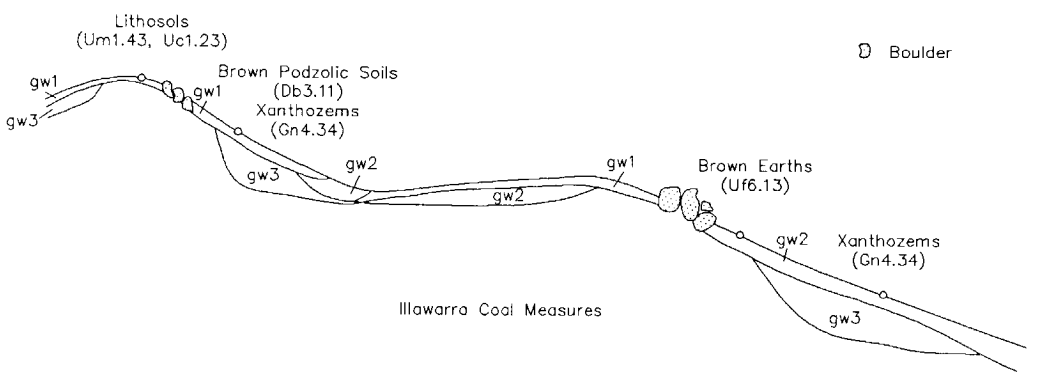
gw3—Brown moderately pedal light clay (subsoil)

Colour	brown (7.5YR 4/6) to dull yellowish brown (10YR 5/4) occasional orange mottles <25% at depth
Texture	light to heavy clay
Structure	moderately pedal, 5–20 mm polyhedral or blocky peds
Fabric	rough-faced, porous
pH	5.0–6.5
Stones	common, gravel
Roots	nil

Occurrence and Relationships

Soil material distribution is variable throughout this landscape, reflecting previous mass movement.

Ridges. 10–30 cm of friable brownish black moderately pedal sandy loam **(gw1)** overlies bedrock. Boundaries between soil materials are gradual [Lithosols (Um1.43, Uc1.23)]. Total depth is <50 cm.



■ *Schematic cross-section of Gwynneville soil landscape illustrating the occurrence and relationship of the dominant soil materials.*

Upper slopes and midslopes. 10–30 cm of friable brown loam **(gw1)** overlies <100 cm brown moderately pedal light clay **(gw3).** Boundaries between soil materials are clear [Brown Podzolic Soils (Db3.11)] or gradual [Xanthozems (Gn4.34)]. Total depth is >150 cm.

In localised positions on midslopes and lower slopes. 20–50 cm of dull yellowish brown moderately pedal sandy clay loam **(gw2)** overlies either <20 cm **gw3** or bedrock. Boundaries are gradual [Xanthozems (Gn4.34), Brown Earths (Uf6.13)]. Total depth is <60 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

gw1 High permeability
Low available water-holding capacity
Stoniness (localised)

gw2 High permeability
Low available water-holding capacity
Stoniness

gw3 Low permeability
Low available water-holding capacity
Stoniness (localised)

Fertility

General fertility is moderate with high CEC and low to moderate organic matter. **gw3** has low permeability. Soils are shallow and have poor root penetration at depth.

Erodibility

The soil erodibility is moderate.

Erosion hazard

The erosion hazard for this soil landscape for non-concentrated flows is extreme. Calculated soil loss during the first 12 months of urban development ranges up to 560 t/ha for topsoil and 500 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows is moderate.

Surface Movement Potential

The soil materials vary from stable topsoils to moderately reactive subsoil.

Landscape Limitations

Steep slopes
Mass movement hazard
Rock fall hazard (localised)
Erosion hazard

Urban Capability

Generally high to severe limitations for urban development on steep slopes. Moderate limitations midslopes and lower slopes.

Rural Capability

Generally low to moderate limitations for grazing but high to severe limitations for regular cultivation.

wb WARRAGAMBA Colluvial (Assoc.)

Landscape—narrow convex crests and ridges, steep colluvial sideslopes on Narrabeen Group. Local relief 80–130 m. Slopes >35%. Tall open-forest and remnant closed-forest in sheltered positions.

Soils—shallow to deep (50–150 cm) Lithosols (Uc6.1) on crests, Brown Earths (Gn3.2) and Red Podzolic Soils (Dr3.41) on upper slopes and Yellow Podzolic Soils (Dy4.41) on lower slopes.

Limitations—mass movement hazard, steep slopes, severe soil erosion hazard, rock fall.

LOCATION

Moderate to very steep slopes and ridges of Illawarra Escarpment. Examples include Barren Grounds Nature Reserve and southern region of Lake Avon.

LANDSCAPE

Geology

Narrabeen Group—fine-grained lithic sandstone occasionally interbedded with thin shale lenses.

Topography

Moderate to very steep slopes and narrow ridges. Relief 80–130 m. Slope gradients 20–50%. Narrow sandstone and colluvial benches with abundant sandstone boulders. Closely spaced incised drainage lines.

Vegetation

Predominantly uncleared tall open-forest and pockets of closed-forest. Common canopy species include sydney blue gum (*Eucalyptus saligna*), blackbutt (*Eucalyptus pilularis*) and turpentine (*Syncarpia glomulifera*). In sheltered locations closed-forest species include coachwood (*Ceratopetalum apetalum*), sassafras (*Doryphora sassafras*) and cabbage tree palm (*Livistona australis*).

Land Use

Undisturbed bushland, Water Board Catchment areas and plateau edge of Barren Grounds Nature Reserve.

Existing Erosion

Moderate sheet erosion on steep hillslopes. Signs of previous landslip and rock fall have occurred on steep slopes with wet, unstable and disturbed soils.

Included Soil Landscapes

Small pockets of Hawkesbury **(ha)** soil landscape and Faulconbridge **(fb)** soil landscape have been included within this soil landscape.

SOILS

Dominant Soil Materials

wb1—Friable brownish black loamy sand (topsoil)

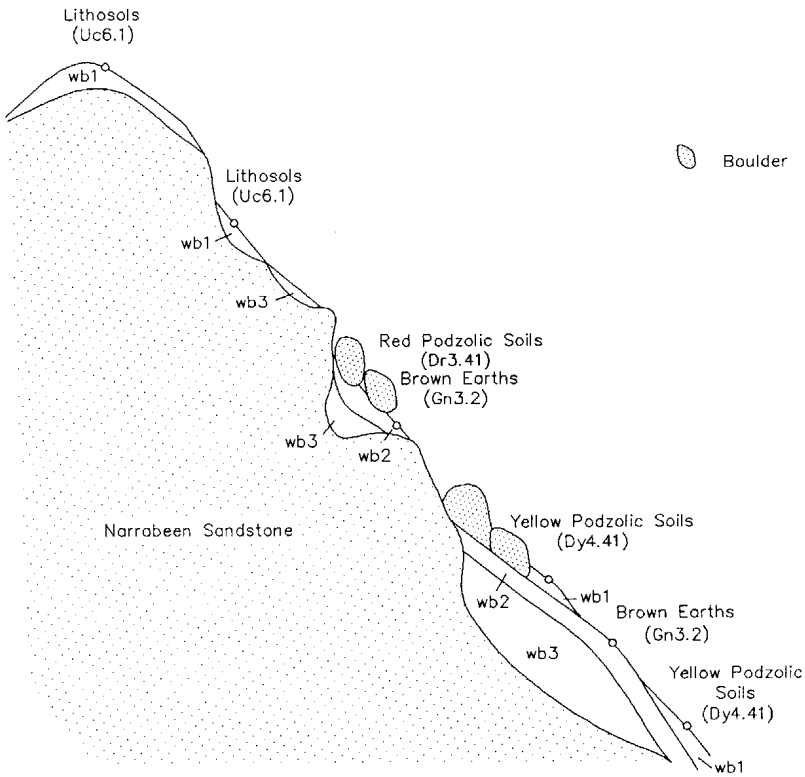
Colour	brownish black (10YR 2/2) to yellowish brown (10YR 5/6)
Texture	loamy sand
Structure	apedal single-grained
Fabric	sandy
pH	3.5
Stones	2–10% <2 mm angular, dispersed
Roots	abundant

wb2—Very dark reddish brown clayey sand (topsoil and subsoil)

Colour	very dark reddish brown (5YR 2/3) to yellowish brown (10YR 5/6)
Texture	clayey sand to light sandy clay loam
Structure	weakly pedal <2 mm crumb to polyhedral peds
Fabric	sandy (slowly) porous to rough-faced, porous
pH	3.5–5.0
Stones	common 60–200 mm angular and sub-angular, dispersed
Roots	common, ex-ped

wb3—Dull brown strongly pedal medium clay with faint mottles at depth (topsoil and subsoil)

Colour	dull brown (7.5YR 5/4) to reddish brown (5YR 4/6) yellow and red mottles 50%
Texture	clay loam to medium clay
Structure	strongly pedal, 20–50 mm angular blocky peds
Fabric	rough-faced, porous
pH	3.5–4.0
Stones	>10% 2–6 mm angular, dispersed
Roots	nil



■ ***Schematic cross-section of Warragamba soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

Occurrence and Relationships

Crests and ridges. Friable brownish black loamy sand **(wb1)** overlies bedrock [Lithosols (Uc6.1)]. The soil depth is usually <50 cm.

Sideslopes. Up to 35 cm clayey sand **(wb2)** overlies <70 cm dull brown strongly pedal medium clay **(wb3).** Boundary between materials is gradual [Brown Earths (Gn3.2)]. Total soil depth is <100 cm. Occasionally **wb2** is absent and **wb3** exposed to the surface.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

wb1 Stoniness
High permeability
Very strongly acid
Low fertility
Low available water-holding capacity

wb2 Stoniness
Erodibility (localised)
High permeability
Very strongly acid
High potential aluminium toxicity
Low fertility
Low available water-holding capacity

wb3 Stoniness
High erodibility (localised)
Very strongly acid
High potential aluminium toxicity
Low fertility

Fertility

Fertility is low to moderate. The soil materials are very strongly acid and have low or moderate available water-holding capacities, very low nutrient status, with low nitrogen and very low phosphorus levels and low to moderate CEC. The subsoils may have low permeability and potential aluminium toxicity.

Erodibility

The **wb1** soil material has low to moderate erodibility, consisting dominantly of highly permeable coarse sand grains held together by organic matter. The other soil materials have moderate erodibility as they are well graded with porous and coherent fabric.

Erosion Hazard

Despite the low to moderate erodibility of the soil materials, steep slopes produce an erosion hazard for non-concentrated flows which is extreme. Calculated soil loss during the first 12 months of development ranges up to 650 t/ha for topsoil and 500 t/ha for exposed subsoil. Soil erosion hazard for concentrated flows is high to extreme.

Surface Movement Potential

Soils are generally shallow and therefore slightly reactive. Large variations in soil properties occur over short distances.

Landscape Limitations

Severe erosion hazard
Steep slopes
Water erosion hazard
Shallow soils (localised)
Surface movement potential (localised)
Mass movement hazard
Rock fall hazard (localised)
Rock outcrop

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

mc MANGROVE CREEK Estuarine (Assoc.)

Landscape—vegetated tidal flats in estuarine areas on Holocene sediments. Relief <3 m. Slopes <3%. Mangrove open-scrub, saltmarsh herbland, sedgeland and low open-forest.

Soils—deep (>150 cm) Siliceous Sands (Uc1.21) and Calcareous Sands (Uc1.11) and Solonchaks (Uc1.11) occur on mangrove flats. Humic Gley Soils (Uc4.53) and Solonchaks (Uc1.11) occur on saltmarshes.

Limitations—regular tidal flooding and waterlogging, saline soil, very low soil fertility.

LOCATION

Vegetated tidal flats in estuarine areas on Holocene sediments on the Coastal Plain. Examples occur at Mangrove Island, Minnamurra River and Crookhaven River and Greenwell Point.

LANDSCAPE

Geology

Holocene sediments—silty to peaty quartz sand, silt and clay. Common shell layers in sandy mud and muddy sand.

Topography

Local relief <3 m and slopes <3%. These tidal flats and creeks in coastal inlets and estuaries are regularly inundated by brackish tidal waters. Four shore parallel zones are recognised, each zone with a different drainage and inundation pattern. At the lowest elevation is the mudflat zone. In order of increasing elevation are the mangrove zone, the saltmarsh zone and littoral forest zone. Minor differences in topography often result in a mosaic of zones.

The mudflat zone is inundated except at low tide. It is characterised by rapidly migrating, shallow (<70 cm), non-directional, meandering channels with reversible flows which widen rapidly in the downstream direction.

The mangrove zone is inundated only during high tide, and the saltmarshes are inundated only during spring flood tides. These zones have non-directional, often interrupted drainage. The forest zone is rarely flooded and has interrupted or absent drainage. Clarke and Hannon (1967, 1969, 1970 and 1971) have described the plant ecology of tidal flat communities.

Vegetation

Mainly open-scrub where the common species are grey mangrove (*Avicennia marina*), river mangrove (*Aegiceras corniculatum*) and scattered decorative paperbark (*Melaleuca decora*).

Shoreward of the mangroves the low open-forest is dominated by swamp oak (*Casuarina glauca*) and less commonly swamp mahogany (*Eucalyptus robusta*), forest red gum (*Eucalyptus tereticornis*) and bangalay (*Eucalyptus botryoides*). This open-forest often has an understorey of sand couch (*Sporobolus virginicus*).

Saltmarsh is found in areas less frequently inundated. Common species of saltmarsh include sea-blite (*Suaeda australis*), glasswort (*Salicornia quinqueflora*), sand couch (*Sporobolus virginicus*), streaked arrowgrass (*Triglochin striata*) and sea rush (*Juncus kraussi*).

Land Use

Mangroves and saltmarshes are recognised as important breeding areas for commercial fish and crustaceans (West 1985) and for some species of water birds. Oyster leases are located on the seaward edges of tidal flats at Minnamurra and Greenwell Point.

Existing Erosion

There is little appreciable erosion. Minor wave erosion is caused by powerboats (Scholar 1974). Sediments eroded from surrounding catchments are often deposited on this unit, enlarging the mangrove communities (West 1985).

SOILS

Dominant Soils Materials

mc1—Greasy smelly organic mottled dark brown silty loam (topsoil)

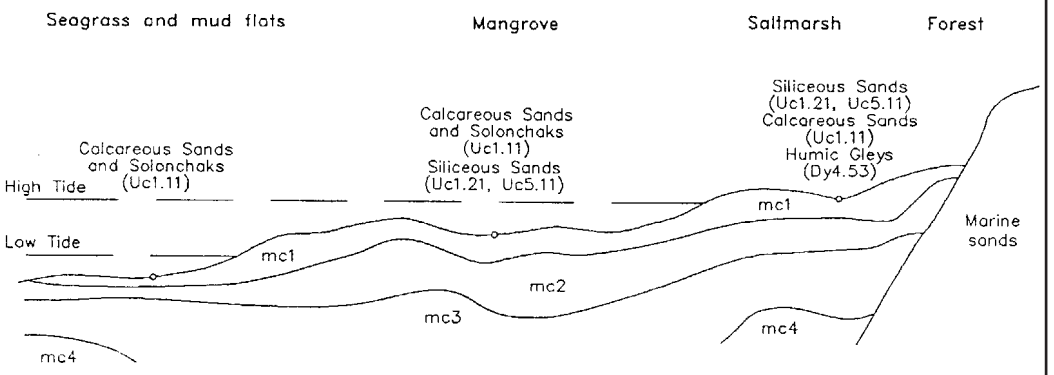
Colour	dark brown (10YR 3/3) to yellowish grey (2.5Y 4/1) with dark red mottles (50%)
Texture	silty loam
Structure	apedal massive
Fabric	earthy
pH	7.0–8.5
Stones	nil
Roots	nil

mc2—Shelly organic black sandy loam (subsoil)

Colour	black (10YR 2/1) to dull yellowish brown (10YR 4/3)
Texture	sandy loam
Structure	apedal massive
Fabric	sandy
pH	5.0–8.5
Stones	nil
Roots	common

mc3—Shelly greyish yellow sand (subsoil)

Colour	dark greyish yellow
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	6.5–9.0
Stones	quartz pebbles common
Roots	rare



■ ***Schematic cross-section of Mangrove Creek soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

mc4—Gleyed mottled sandy clay (subsoil)

Colour	grey (5Y 5/1) with orange brown mottles (40%)
Texture	sandy clay
Structure	apedal massive
Fabric	sandy
pH	7.5–9.0
Stones	nil
Roots	rare

Associated Soil Materials

Charcoal Sands. Up to 80% charcoal fragments within a sandy loam matrix

Midden Materials. Large quantities of oyster and other mollusc shells occur in the soil materials. These are Aboriginal sites and should not be disturbed.

Occurrence and Relationships

Mangrove Flats. Up to 30 cm greasy smelly organic mottled dark brown silty loam **(mc1)** overlies <50 cm shelly organic black sandy loam **(mc2)** and >100 cm shelly greyish yellow sand **(mc3).** The boundaries are gradual to diffuse [Siliceous Sands (Uc1.21, Uc5.11), Calcareous Sands (Uc1.11) and Solonchaks (Uc1.11)]. Total soil depth is >200 cm.

Saltmarshes. Up to 20 cm **mc1** overlies <20 cm **mc2** and <50 cm **mc3** which in turn overlies >200 cm gleyed mottled sandy clay **(mc4).** Boundaries are gradual to diffuse [Humic Gley Soils (Uc4.53) and Calcareous Sands (Uc1.11)]. Total soil depth is >300 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

mc1 Low wet bearing strength
Strongly saline
Low permeability
High organic matter
Very low fertility
Acid sulphate potential
Strongly sodic

mc2 High organic matter
Strongly sodic
Strongly saline
Low wet bearing strength
Very low fertility
Very strongly acid
Acid sulphate potential
Potential aluminium toxicity

mc3 High organic matter
Strongly saline
Strongly sodic
Very low fertility
Strongly acid
Acid sulphate potential
Low wet bearing strength

mc4 Low wet bearing strength
Strongly saline
Strongly sodic
Low permeability
Low available water-holding capacity
Low fertility
Acid sulphate potential
Moderately alkaline

Fertility

The general fertility is very low. The soil materials are strongly saline and are frequently inundated by tidal waters. These soils should not be drained as this will result in organic sulphur compounds being oxidised. The sulphuric acid produced results in the soils becoming extremely acid.

Erodibility

mc1 and **mc2** have very low erodibility. They consist of sands strongly bound by abundant organic fibrous matter. **mc3** has very low erodibility consisting predominantly of well-drained coarse sands. **mc4** has a moderate erodibility as it has a low organic matter content and consists of fine and coarse sand grains imbedded in a clay matrix. **mc4** clays are highly dispersible in freshwater, where they are highly erodible.

Erosion Hazard

The erosion hazard for non-concentrated flows is low. Calculated soil loss for the first 12 months of urban development ranges up to 10 t/ha of topsoil and 20 t/ha of exposed subsoil. The erosion hazard for wave and concentrated flows is also low.

Surface Movement Potential

These materials become highly reactive following draining and leaching. Both drained *in situ* material and deposited fill composed of these materials should be tested to determine surface movement potential prior to construction.

Landscape Limitations

Flood hazard
Waterlogging
Permanently high watertable
Wave erosion hazard

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

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7 Appendices

7 APPENDICES

Appendix 7.1A Common and Scientific Names of Plant Species

Common Name	Scientific Name
bangalay	E*ucalyptus botryoides*
bangalow palm	*Archontophoenix cunninghamiana*
bare twig-rush	*Baumea juncea*
bastard rosewood	*Synoum glandulosum*
beach pennywort	*Hydrocotyle bonariensis*
bird lime tree	*Pisonia umbellifera*
bitou bush	*Chrysanthemoides monilifera*
black apple	*Planchonella australis*
black ash	*Eucalyptus sieberi*
blackbutt	*Eucalyptus pilularis*
black plum	*Diospyros australis*
black sallee	*Eucalyptus stellulata*
black wattle	*Acacia mearnsii*
bleeding heart	*Omalanthus populifolius*
blueberry ash	*Elaeocarpus reticulatus*
blue-leaved stringybark	*Eucalyptus agglomerata*
blue mountains mallee ash	*Eucalyptus stricta*
bog rush	*Schoenus* sp.
bolly gum	*Litsea reticulata*
bolwarra	*Eupomatia laurina*
bracelet honey-myrtle	*Melaleuca armillaris*
breynia	*Breynia oblongifolia*
brittlewood	*Claoxylon australe*
broad-leaved apple	*Angophora bakeri*
broad-leaved geebung	*Persoonia levis*
brown barrel	*Eucalyptus fastigata*
brown beech	*Pennantia cunninghamii*
brush bloodwood	*Baloghia lucida*
brush cherry	*Syzygium australe*
brush kurrajong	*Commersonia fraseri*
brush muttonwood	*Rapanea howittiana*
budawang ash	*Eucalyptus dendromorpha*
buff hazelwood	*Symplocos thwaitesii*
bullrushes	*Typha* sp.
burrawang	*Macrozamia communis*
button grass	*Gymnoschoenus sphaerocephalus*
cabbage gum	*Eucalyptus amplifolia*
cabbage tree palm	*Livistona australis*
celery wood	*Polyscias elegans*
cheese tree	*Glochidion ferdinandi*
christmas bell	*Blandfordia nobilis*
christmas bush	*Ceratopetalum gummiferum*
churnwood	*Citronella moorei*
coachwood	*Ceratopetalum apetalum*
coast canthium	*Canthium coprosmoides*
coastal banksia	*Banksia integrifolia*
coastal grey box	*Eucalyptus bosistoana*
coastal heath	*Monotoca eliptica*
coastal tea-tree	*Leptospermum laevigatum*
common reed	*Phragmites australis*
common sundew	*Drosera spathulata*
coral heath	*Epacris microphylla*
cord-rush	*Restio* sp.
corkwood	*Duboisia myoporoides*
dagger hakea	*Hakea teretifolia*
darwinia	*Darwinia fasicularis*
deciduous fig	*Ficus superba*

decorative paperbark	*Melaleuca decora*
dog rose	*Bauera rubioides*
drooping she-oak	*Allocasuarina verticillata*
drumsticks	*Isopogen* spp.
featherwood	*Polyosma cunninghamii*
flaky-barked tea-tree	*Leptospermum attenuatum*
flintwood	*Scolopia braunii*
forest oak	*Allocasuarina torulosa*
forest red gum	*Eucalyptus tereticornis*
giant stinging tree	*Dendrocnide excelsa*
glasswort	*Salicornia quinqueflora*
grey gum	*Eucalyptus punctata*
grey ironbark	*Eucalyptus paniculata*
grey mangrove	*Avicennia marina*
grey myrtle	*Backhousia myrtifolia*
gully gum	*Eucalyptus smithii*
hairpin banksia	*Banksia spinulosa*
hairy clerodendrum	*Clerodendrum tomentosum*
hairy spinifex	*Spinifex sericeus*
heath banksia	*Banksia ericifolia*
hickory	*Acacia implexa*
hill banksia	*Banksia spinnulosa,* var. *collina*
illawarra flame tree	*Brachychiton acerifolium*
kangaroo grass	*Themeda australis*
knobby club-rush	*Isolepsis nodosus*
koda	*Ehretia acuminata*
large mock olive	*Notelaea longifolia*
lemon-scented gum	*Eucalyptus citriodora*
lillypilly	*Acmena smithii*
linear paperbark	*Melaleuca linariifolia*
long-leaved box	*Eucalyptus goniocalyx*
maidens wattle	*Acacia maidenii*
marram grass	*Ammophila arenaria*
marsh banksia	*Banksia paludosa*
moreton bay fig	*Ficus macrophylla*
mountain devil	*Lambertia formosa*
mountain grey gum	*Eucalyptus cypellocarpa*
mountain spotted gum	*Eucalyptus mannifera*
murrogun	*Cryptocarya microneura*
muttonwood	*Rapanea variabilis*
narrow-leaved peppermint	*Eucalyptus radiata*
native holly	*Oxylobium ilicifolium*
native cherry	*Exocarpos cupressiformis*
native laurel	*Cryptocarya glaucescens*
native quince	*Alectryon subcinereus*
native tamarind	*Dipolglottis cunninghamii*
necklace fern	*Asplenium flabellifolium*
northern boobialla	*Myoporum acuminatum*
old man banksia	*Banksia serrata*
olivers sassafras	*Cinnamomum oliveri*
paroo lily	*Dianella caerulea*
pigeonberry ash	*Elaeocarpus kirtonii*
pine-leaf geebung	*Persoonia pinifolia*
pittosporum	*Pittosporum* spp.
plum pine	*Podocarpus elatus*
port jackson fig	*Ficus rubiginosa*
prickly broom-heath	*Monotoca scoparia*
prickly-leaved paperbark	*Melaleuca styphelioides*
prickly tree-fern	*Cyathea leichhardtiana*
red ash	*Alphitonia excelsa*
red bloodwood	*Eucalyptus gummifera*

red cedar	*Toona australis*
red-fruited olive plum	*Cassine australis*
ribbon gum	*Eucalyptus viminalis*
ribbonwood	*Euroschinus falcata*
river mangrove	*Aegiceras corniculatum*
river oak	*Casuarina cunninghamiana*
river peppermint	*Eucalyptus elata*
rough-barked apple	*Angophora floribunda*
rough tree-fern	*Cyathea australis*
sand couch	*Sporobolus virginicus*
sandpaper fig	*Ficus coronata*
sassafras	*Doryphora sassafras*
saw-sedge	*Gahnia* sp.
screw fern	*Lindsaea linearis*
scribbly gum	*Eucalyptus sclerophylla, Eucalyptus racemosa, Eucalyptus haemastoma*
scrub beefwood	*Stenocarpus salignus*
scrub she-oak	*Allocasuarina distyla*
sea-blite	*Suaeda australis*
sea rush	*Juncus kraussi*
sedge	*Calorophus minor*
silvertop ash	*Eucalyptus sieberi*
slender rice flower	*Pimelea linifolia*
small-leaved fig	*Ficus obliqua*
small-leaved gum	*Eucalyptus panifolia*
smooth-barked apple	*Angophora costata*
smooth mock olive	*Notelaea venosa*
snow-wood	*Parachidendron pruinosum*
spear grass	*Stipa rudis*
spiny-headed mat-rush	*Lomandra longifolia* sp. *longifolia*
spotted gum	Euc*alyptus maculata*
streaked arrowgrass	*Triglochin striata*
swamp banksia	*Banksia robur*
swamp heath	*Epacris paludosa*
swamp gum	*Eucalyptus ovata*
swamp mahogany	*Eucalyptus robusta*
swamp oak	*Casuarina glauca*
sweet pittosporum	*Pittosporum undulatum*
sydney blue gum	*Eucalyptus saligna*
sydney blue gum/bangalay	*Eucalyptus saligna/botryoides*
sydney golden wattle	*Acacia longifolia*
sydney peppermint	*Eucalyptus piperita*
tassel rope-rush	*Hypolaena fastigata*
thin-leaved stringybark	*Eucalyptus eugenioides*
turpentine	*Syncarpia glomulifera*
tussock grass	*Poa* sp.
two-veined hickory	*Acacia binervata*
waratah	*Telopea speciosissima*
wattle	*Acacia* sp.
weeping willow	*Salix babylonica*
whalebone tree	*Streblus brunonianus*
white cedar	*Melia azedarach* var. *australasica*
white euodia	*Euodia micrococca*
white stringybark	*Eucalyptus globoidea*
white-topped box	*Eucalyptus quadrangulata*
whitewood	*Elaeocarpus kirtonii*
wilkiea	*Wilkiea huegeliana*
wire grass	*Aristida vagans*
woollybutt	*Eucalyptus longifolia*
yellowwood	*Sarcomelicope simplicifolia*

Appendix 7.1B Scientific and Common Names of Plant Species

Scientific Name	Common Name
Acacia binervata	two-veined hickory
Acacia implexa	hickory
Acacia longifolia	sydney golden wattle
Acacia maidenii	maidens wattle
Acacia mearnsii	black wattle
Acacia sp.	wattle
Acmena smithii	lillypilly
Aegiceras corniculatum	river mangrove
Alectryon subcinerius	native quince
Allocasuarina distyla	scrub she-oak
Allocasuarina littoralis	black she-oak
Allocasuarina torulosa	forest oak
Allocasuarina verticillata	drooping she-oak
Alphitonia excelsa	red ash
Angophora bakeri	broad-leaved apple
Angophora costata	smooth-barked apple
Angophora floribunda	rough-barked apple
Ammophila arenaria	marram grass
Archontophoenix cunninghamiana	bangalow palm
Aristida vagans	wire grass
Asplenium flabellifolium	necklace fern
Avicennia marina	grey mangrove
Backhousia myrtifolia	grey myrtle
Baloghia lucida	brush bloodwood
Banksia ericifolia	heath banksia
Banksia integrifolia	coastal banksia
Banksia paludosa	marsh banksia
Banksia robur	swamp banksia
Banksia serrata	old man banksia
Banksia spinulosa	hairpin banksia
Banksia spinnulosa, var. *collina*	hill banksia
Bauera rubioides	dog rose
Baumea juncea	bare twig-rush
Blandfordia nobilis	christmas bell
Brachychiton acerifolium	illawarra flame tree
Breynia oblongifolia	breynia
Calorophus minor	sedge
Canthium coprosmoides	coast canthium
Cassine australis	red-fruited olive plum
Casuarina cunninghamiana	river oak
Casuarina glauca	swamp oak
Ceratopetalum apetalum	coachwood
Ceratopetalum gummiferum	christmas bush
Chrysanthemoides monilifera	bitou bush
Cinnamomum oliveri	olivers sassafras
Citronella moorei	churnwood
Claoxylon australe	brittlewood
Clerodendrum tomentosum	hairy clerodendrum
Commersonia fraseri	brush kurrajong
Cryptocarya glaucescens	native laurel
Cryptocarya microneura	murrogun
Cyathea australis	rough tree-fern
Cyathea leichhardtiana	prickly tree-fern
Darwinia fasicularis	darwinia
Dendrocnide excelsa	giant stinging tree
Dianella caerulea	paroo lily
Diospyros australis	black plum
Dipolglottis cunninghamii	native tamarind

Doryphora sassafras	sassafras
Drosera spathulata	common sundew
Duboisia myoporoides	corkwood
Ehretia acuminata	koda
Elacocarpus kirtonii	pigeonberry ash, whitewood
Elaeocarpus reticulatus	blueberry ash
Epacris padudosa	swamp heath
Epacris microphylla	coral heath
Eucalyptus agglomerata	blue-veined stringybark
Eucalyptus amplifolia	cabbage gum
Eucalyptus bosistoana	coastal grey box
Eucalyptus botryoides	bangalay
Eucalyptus citriodora	lemon-scented gum
Eucalyptus cypellocarpa	mountain grey gum
Eucalyptus dendromorpha	budawang ash
Eucalyptus elata	river peppermint
Eucalyptus eugenioides	thin-leaved stringybark
Eucalyptus fastigata	brown barrel
Eucalyptus globoidea	white stringybark
Eucalyptus goniocalyx	long-leaved box
Eucalyptus gummifera	red bloodwood
Eucalyptus haemastoma	scribbly gum
Eucalyptus longifolia	woollybutt
Eucalyptus maculata	spotted gum
Eucalyptus mannifera	mountain spotted gum
Eucalyptus ovata	swamp gum
Eucalyptus paniculata	grey ironbark
Eucalyptus panifolia	small-leaved gum
Eucalyptus pilularis	blackbutt
Eucalyptus piperita	sydney peppermint
Eucalyptus punctata	grey gum
Eucalyptus quadrangulata	white topped box
Eucalyptus racemosa	scribbly gum
Eucalyptus radiata	narrow-leaved peppermint
Eucalyptus robusta	swamp mahogany
Eucalyptus saligna	sydney blue gum
Eucalyptus saligna/botryoides	sydney blue gum/bangalay
Eucalyptus sclerophylla	scribbly gum
Eucalyptus sieberi	silvertop ash, black ash
Eucalyptus smithii	gully gum
Eucalyptus stellulata	black sallee
Eucalyptus stricta	blue mountains mallee ash
Eucalyptus tereticornis	forest red gum
Eucalyptus viminalis	ribbon gum
Euodia micrococca	white euodia
Eupomatia laurina	bolwarra
Euroschinus falcata	ribbonwood
Exocarpos cupressiformis	native cherry
Ficus coronata	sandpaper fig
Ficus macrophylla	moreton bay fig
Ficus obliqua	small-leaved fig
Ficus rubiginosa	port jackson fig
Ficus superba	deciduous fig
Gahnia sp.	saw-sedge
Glochidion ferdinandi	cheese tree
Gymnoschoenus sphaerocephalus	button grass
Hakea teretifolia	spikey hakea, dagger hakea
Hydrocotyle bonariensis	beach pennywort
Hypolaena fastigata	tassel rope-rush, sedge
Isolepsis nodosus	knobby club-rush
Isopogen sp.	drumsticks

Juncus kraussi	sea rush
Lambertia formosa	mountain devil
Leptospermum attenuatum	flaky-barked tea-tree
Leptospermum laevigatum	coastal tea-tree
Lindsaea linearis	screw fern
Litsea reticulata	bolly gum
Livistona australis	cabbage tree palm
Lomandra longifolia sp. *longifolia*	spiny-headed mat-rush
Macrozamia communis	burrawang
Melia azedarach var. *australasica*	white cedar
Melaleuca armillaris	bracelet honey-myrtle
Melaleuca decora	decorative paperbark
Melaleuca linariifolia	linear paperbark
Melaleuca styphelioides	prickly-leaved paperbark
Monotoca eliptica	coastal heath
Monotoca scoparia	prickly broom-heath
Myoporum acuminatum	northern boobialla
Notelaea longifolia	large mock olive
Notelaea venosa	smooth mock olive
Omalanthus populifolius	bleeding heart
Oxylobium ilicifolium	native holly
Parachidendron pruinosum	snow-wood
Pennantia cunninghamii	brown beech
Persoonia levis	broad-leaved geebung
Persoonia pinifolia	pine-leaf geebung
Phragmites australis	common reed
Pimelea linifolia	slender rice flower
Pisonia umbellifera	bird lime tree
Pittosporum spp.	pittosporum
Pittosporum undulatum	sweet pittosporum
Planchonella australis	black apple
Poa sp.	tussock grass
Podocarpus elatus	plum pine
Polyosma cunninghamii	featherwood
Polyscias elegans	celery wood
Rapanea howittiana	brush muttonwood
Rapanea variabilis	muttonwood
Restio sp.	cord-rush
Salicornia quinqueflora	glasswort
Sarcomelicope simplicifolia	yellowwood
Salix babylonica	weeping willow
Schoenus sp.	bog rush
Scolopia braunii	flintwood
Spinifex sericeus	hairy spinifex
Sporobolus virginicus	sand couch
Stenocarpus salignus	scrub beefwood
Stipa rudis	spear grass
Streblus brunonianus	whalebone tree
Symplocos thwaitesii	buff hazelwood
Syncarpia glomulifera	turpentine
Synoum glandulosum	bastard rosewood
Syzygium australe	brush cherry
Telopea speciosissima	waratah
Themeda australis	kangaroo grass
Toona australis	red cedar
Triglochin striata	streaked arrowgrass
Typha sp.	bullrushes
Wilkiea huegeliana	wilkiea

Appendix 7.2 Erosion Hazard

Erosion hazard is a measure of the susceptibility of an area of land to prevailing agents of erosion (Morse *et al*. 1982). It is determined by the factors of climate, topography, soil erodibility and land use. Each specific land use has its own erosion hazard. The land use used to determine erosion hazard in this study is the development of residential housing. In the Kiama area land disturbance during the first 12 months of residential development leads to significant soil erosion.

Soil erosion hazard is presented as the average annual loss of surface soil over the first 12 months of residential development. Acceptable soil loss figures vary depending on the criteria being considered. To maintain water quality of adjacent streams, more than 2 t/ha/y may not be acceptable. However, acceptable soil losses for cropping lands may vary from 1–10 t/ha/y depending on the depth and fertility of the soil.

For urban areas soil losses during the first year of residential development have been grouped into five categories:

	t/ha/y
Slight	0–10
Moderate	10–30
High	30–50
Very High	50–80
Extreme	>80

Slight. Indicates that no appreciable sheet or rill erosion damage will occur during development. Soil conservation management should include simple practices such as rapid establishment of ground cover as soon as possible.

Moderate. Implies that significant erosion may occur during development. Provided that appropriate soil conservation measures are adopted during development, long-term and short-term erosion problems may be avoided.

High. Implies significant erosion may occur during development unless appropriate soil conservation measures are implemented. More intensive soil conservation measures are needed to control erosion over the long term.

Very High. Implies that significant erosion will occur both during and after development even with intensive soil conservation measures.

Extreme. Implies that erosion will occur to such an extent that soil erosion control is impractical and uneconomic. Development is not recommended. Where development proceeds in spite of this recommendation, detailed engineering, geotechnical and other studies will be necessary.

Appendix 7.3 Surface Movement Potential

Surface movement potential is an estimate of the potential soil shrink and swell movements which may occur with changes in soil moisture content. Surface movement can cause expensive damage to inappropriately designed buildings, roads and underground services.

The N.S.W. Building Licensing Board (now the NSW Building Services Corporation) has issued a *Classification of NSW Soils for Housing* (N.S.W. Building Licensing Board, n.d.*a*) where soils are ranked into five classes depending on their reactivity. The Board has also provided specifications for the design of footings and concrete slabs for buildings on soils of various reactivity ratings in their publication *Code of Practice for Footing and Slab Design in NSW* (N.S.W. Building Licensing Board, n.d.*b*).

Reactivity ratings were previously defined by the N.S.W. Building Licensing Board for a number of soil associations mapped by Walker (1960*a*). The *Soil Landscapes of the Sydney 1:100 000 Sheet* map and report were referred to in and now supersede Walker's map for the purposes of the design standard.

For each soil landscape the range of most commonly occurring soil reactivity ratings as defined by the N.S.W. Building Licensing Board have been identified. This has been achieved by considering common soil and horizon depths, field textures, structure, fabric, consistence, surface condition and drainage. Site observations of road and pavement cracking and deformation and building damage have also been made.

Additionally, selected samples were tested in the laboratory for particle size, USCS classification, electrical conductivity and volume expansion. More complete testing was not considered to be necessary because of:

1) the high variability of reactivity encountered over short distances for most soils within the Sydney region (Hicks pers. comm.);
2) the lack of correlation between currently recognised expensive engineering soil tests—such as loaded shrinkage and swelling tests—and simpler, cheaper soil tests such as linear shrinkage or volume expansion (Coffey and Partners Pty. Ltd. 1985); and
3) considerations of map scale.

Soil profiles were examined to depths where soil moisture is assumed to be constant (up to 150 cm for soil landscapes without large trees and 300 cm for soil landscapes with trees).

Reactivity Classification Classes are defined by the Board as follows:

Stable. Non-cohesive or non-plastic soils or <15% finer than 76 micron soils, or >2 m of rock.

Slightly Reactive. Less than 0.5 m clay over rock (or non-cohesive soils >2 m deep). Expected maximum surface movement is <15 mm.

Moderately Reactive. Expected maximum surface movement is 15–40 mm.

Highly Reactive. Expected maximum surface movement is 40–60 mm.

Extremely Reactive. Expected maximum surface movement is >60 mm.

In landscapes where a range of reactivity categories occurs, it may be necessary to collect and test several samples for each building site to determine appropriate foundation types.

Appendix 7.4 Physical Test Results for Each Soil Material

Material	Particle Size Analysis (% whole soil)					E.A.T. Class	Dispersion (%)	Volume Expansion (%)	USCS Class
	Clay	Silt	Fine Sand	Coarse Sand	Gravel				
Albion Park									
apl	30	11	8	10	41	5	75	20	CL
ap2	10	16	36	24	14	8	75	8	ML
ap3	37	18	26	14	5	3(2)	87	18	CL
ap4	5	11	14	21	49	8	70	2	GM
ap5	51	10	7	4	28	5	78	39	CL
Barren Grounds									
ba1	6	7	32	40	15	3(2)	60	5	SM
ba2	3	17	75	0	5	7	0	17	Pt
ba3	4	5	25	50	16	3(1)	25	3	SM
ba4	13	16	22	49	0	3(1)	29	7	SM
ba5	16	21	23	34	6	3(1)	20	1	SC
Barrengarry									
bgl	31	26	30	13	0	3(2)	15	9	ML
bg2	28	29	30	13	0	3(2)	5	10	CL
bg3	50	20	22	8	0	5	7	14	CL
bg4	58	17	17	8	0	6	3	17	CL
bg5	58	17	17	8	0	6	3	17	CL
Bombo									
bo1	16	21	51	12	0	5	17	2	ML
bo2	28	12	33	18	9	3(1)	14	4	CL
bo3	41	15	20	10	14	5	18	10	CL
bo4	42	17	15	11	15	3(1)	4	16	CL
bo5	56	15	16	8	5	6	5	14	CL
Cambewarra									
cal	9	5	17	49	20	3(1)	*	0	SM
ca2	36	26	26	12	0	6	0	7	CL
ca3	55	29	9	7	0	6	0	11	CL
ca4	40	21	18	21	0	3(1)	9	18	CL
Coolongatta									
col	20	25	44	9	2	8	33	SH	CL
co2	29	9	37	16	9	2(1)	6	8	ML
co3	62	22	14	2	0	6	3	18	CH*2
co4	29	18	41	12	0	6	5	9	CL
Ellerslie									
ell	18	22	40	20	0	8	15	11	ML
el2	17	14	30	39	0	3(1)	17	7	ML
el3	21	23	45	11	0	3(1)	19	6	CL
el4	6	24	63	7	0	3(2)	29	12	ML
el5	10	13	33	32	12	3(2)	20	7	SM
el6	35	27	23	9	6	5	38	2	CL
Fairy Meadow									
fal	25	11	26	24	11	3(2)	12	20	CL
fa2	11	10	35	29	15	3(2)	13	11	SC
fa3	20	16	37	19	8	3(1)	14	8	ML
fa4	42	11	14	16	17	5	14	18	CL

1 shrinkage
2 reactive
3 non-expansive

Appendix 7.4 Physical Test Results for Each Soil Material (Continued)

Material	Particle Size Analysis (% whole soil)					E.A.T. Class	Dispersion (%)	Volume Expansion (%)	USCS Class
	Clay	Silt	Fine Sand	Coarse Sand	Gravel				
Fountaindale									
fol	15	46	14	12	13	8	6	14	ML
fo2	26	28	14	14	18	3(1)	24	9	ML
fo3	50	25	21	4	0	5	11	25	CL
fo4	66	25	6	3	0	5	12	33	CL
Greenwell Point									
gpl	9	9	64	16	2	3(2)	50	10	ML
gp2	25	19	45	10	1	3(1)	27	*	ML
gp3	63	11	24	2	0	6	3	27	CL
gp4	52	11	33	2	2	6	4	25	CL
Hawkesbury									
hal	0	4	31	65	0	3(1)	ND	O	SM
ha2	18	7	18	43	14	3(1)	17	1	SM
ha3	32	14	35	11	8	5 11	11	11	CL
Illawarra Escarpment									
esl	13	27	42	18	0	2(1)	45	2	ML
es2	16	25	37	15	7	3(1)	21	5	ML
es3	18	14	46	22	0	3(1)	5	9	ML
es4	45	19	34	2	0	6	2	13	CL
Jamberoo									
jal	55	28	9	8	0	6	3	14	CL
ja2	61	29	8	2	0	6	3	12	CL
ja3	23	38	28	11	0	3(1)	5	10	CL
Kiama									
kal	19	11	17	41	12	3(1)	0	15	OL
ka2	29	12	54	5	0	3(2)	13	7	ML/CL
ka3	68	24	6	2	0	6	3	12	CL
ka4	53	18	28	1	0	5	17	24	CL
Killallea									
kil	23	44	32	1	0	3(2)	39	0	ML
ki2	23	24	36	12	5	3(1)	7	0	OL
ki3	10	18	31	32	9	3(1)	11	0	OL
ki4	8	25	53	14	0	3(1)	22	4	ML
ki5	33	26	34	7	0	3(1)	5	13	OL
Nowra									
nol	12	10	51	27	0	3(2)	14	0	OL
no2	28	10	54	8	0	5	13	0	ML
no3	18	10	43	21	8	3(3)	9	4	ML
no4	34	17	43	6	0	6	0	8	CL
no5	39	8	46	7	0	6	0	10	CL
no6	57	33	5	5	0	5	21	10	CL
no7	20	13	30	27	10	3(1)	14	5	ML

1 shrinkage
2 reactive
3 non-expansive

Appendix 7.4 Physical Test Results for Each Soil Material (Continued)

Material	Particle Size Analysis (% whole soil)					E.A.T. Class	Dispersion (%)	Volume Expansion (%)	USCS Class
	Clay	Silt	Fine Sand	Coarse Sand	Gravel				
Pulpit Rock									
pr1	10	9	38	31	12	3(2)	43	0	SM
pr2	3	4	38	46	9	3(1)	0	1	SW
pr3	15	9	34	42	0	5	33	7	SM
pr4	41	16	23	20	0	3(3)	41	6	CL
pr5	26	17	23	34	0	2(1)	47	7	CL
Robertson									
ro1	31	25	28	16	0	6	5	18	ML
ro2	39	25	22	14	0	3(1)	6	17	CL
ro3	49	26	17	8	0	3(1)	0	19	CL
ro4	70	21	4	5	0	6	2	17	ML
Seven Mile									
sm1	1	9	42	48	0	5	50	6	SW
sm2	0	3	20	77	0	*	0	0	PT
sm3	0	1	44	55	0	*	0	SH	SW
sm4	5	16	26	28	25	3(2)	40	4	SW
sm5	26	9	42	20	3	S(1)	29	10	SC/CL
sm6	42	20	34	4	0	5	29	11	CL
Shellharbour									
sh1	10	39	33	11	7	8	69	14	ML
sh2	37	26	16	21	0	3(3)	35	22	CL
sh3	22	17	15	46	0	2(2)	54	23	SC/CL
sh4	44	15	9	7	25	2(1)	87	39	CL
sh5	34	25	13	7	21	2(1)	94	13	CL
Shoalhaven									
sfl	14	9	59	18	0	3(1)	29	2	ML
sf2	24	34	35	7	0	3(1)	0	13	ML
sf3	37	27	10	20	6	3(1)	12	8	CL
sf4	42	14	27	11	6	5	9	9	CL
Wattamolla									
wtl	27	8	43	11	11	3(2)	11	20	ML
wt2	21	26	33	11	9	2(1)	27	0	CL
wt3	32	23	32	13	0	3(1)	14	17	CL
wt4	34	32	16	5	13	2(2)	48	5	CL
wt5	47	21	22	10	0	6	4	12	CL
Wildes Meadow									
wm1	25	24	33	8	10	3(1)	12	9	ML
wm2	34	23	25	8	10	3(1)	5	8	CL
wm3	37	25	22	5	11	6	0	9	CL
wm4	35	21	18	11	15	6	0	6	CL
Wingecarribee									
wil	*	*	*	*	*	*	*	*	*
wi2	29	49	17	5	0	3(1)	13	5	ML
wi3	67	25	6	2	0	3(3)	17	19	CL

1 shrinkage
2 reactive
3 non-expansive

Appendix 7.4 Physical Test Results for Each Soil Material (Continued)

Material	Particle Size Analysis (% whole soil)					E.A.T. Class	Dispersion (%)	Volume Expansion (%)	USCS Class
	Clay	Silt	Fine Sand	Coarse Sand	Gravel				
Wollongong									
wgl	*	*	*	*	*	*	*	*	*
wg2	0	2	11	87	0	N/A	0	0	SP
wg3	0	2	11	87	0	N/A	0	0	SP

1 shrinkage
2 reactive
3 non-expansive

Appendix 7.5 Soil Erodibility

Soil erodibility is the susceptibility of a soil to erode (Houghton and Charman 1986). It is based solely on soil properties. Landscape properties such as slope gradient, slope length, landform element and rainfall characteristics are not included in the assessment.

Soil erodibility is rated for each soil material using the Soil Conservation Service's *SOILOSS* erosion prediction program (Rosewell and Edwards 1988). The program follows the Universal Soil Loss Equation of Wischmeier and Smith (1978) and applies only to topsoils affected by sheet erosion. The erodibility factor (K) is based on a series of laboratory tests including particle size analysis and organic carbon test data, as well as field assessment of soil structure and permeability. It is ranked into five classes depending on K values:

	K Value
very low	0.00–0.01
low	0.01–0.02
moderate	0.02–0.04
high	0.04–0.06
very high	>0.06

The erodibility ratings given in the text for each soil material generally correspond to these categories.

Appendix 7.6 Fertility Ranking Procedures

General Fertility. General fertility refers to the intrinsic fertility (ability of soil to support plant growth without the addition of fertiliser) of typical whole soil profiles encountered in any particular soil landscape. It takes into account the collective fertility of typical soil material sequences.

Each soil material is ranked into one of five classifications according to its fertility for soil conservation purposes (revegetation and top-dressing). The fertility rankings do not apply to whole soils, and they are not intended as a guide to fertility for agricultural, pastoral or horticultural purposes. Rankings include:

Very Low. Not generally suitable as a revegetation medium. May have toxicity or severe structural problems which are difficult to overcome. Regular fertiliser maintenance and attention to soil moisture supply are essential.

Low. Marginally suitable as a revegetation medium. May have significant structural problems or extremely poor chemical fertility. Regular maintenance is often required.

Moderate. Moderately suitable as a revegetation medium. May have limited structural problems or poor chemical fertility. Regular maintenance may be required.

High. Desirable revegetation medium. May have limited structural problems and moderate chemical fertility.

Very High. Desirable revegetation medium. Good physical and chemical fertility.

Fertility rankings have been based on the following laboratory analyses in addition to field observations and physical soil test results (see Appendix 7.8).

Physical and chemical test results ranked according to these criteria are listed in Appendix 7.7.

Rankings for Laboratory Tests

FINAL GENERAL FERTILITY[1]

Test		Units	V.Low	Low	Mod.	High	V.High
AWC	●	%	5–10	10–15	15–20	20–25	>25
OM	✚	%	<1	1–2	2–4	4	—
Bray P	✱	ppm	0–5	5–10	10–20	20–25	>25
P sorption	✱	ppm	<125	126–250	251–400	401–600	>600
CEC	■	me%	0–6	6–12	12–25	25–40	>40
BS	■	%	0–20	20–40	40–60	60–80	>80
Ex K	■	me%	0–0.2	0.2–0.3	0.3–0.7	0.7–2	>2
Ex Ca	■	me%	0–0.3	0.3–1	1–3	3–8	>8
Ex Mg	■	me%	0–0.3	0.3–1	1–3	3–8	>8
Ex Na	■	me%	0–0.1	0.1–0.3	0.3–0.7	0.7–2	>2
			(Extreme)	(Very Strong)	(Strong)	(Medium)	(Slight)
Acid	✚	pH	<4.5	4.5–5.0	5.1–5.5	5.6–6.0	6.1–6.5
			(Very Strong)	(Strong)	(Moderate)	(Mild)	(Neutral)
Alk	✚	pH	>9.0	8.5–9.0	7.9–8.4	7.4–7.8	6.6–7.3
			(Strongly sodic)		(Sodic)		(Non-sodic)
ESP	▲	me%	>14		6–14		6.0
			(High)	(Very saline)	(Moderate)	(Slight)	(Non-saline)
ECe	▼	dS/m	>16	8–16	4–8	2–4	0–2
Ex Al/ CEC	✱	%	>35	15–35	10–15	5–10	0–5

References:

✱ NSW Agriculture & Fisheries (Abbott 1985)
■ Metson (1961)
▲ Northcote and Skene (1972)
✚ Bruce and Rayment (1982)
Charman and Murphy (1991)
● McKeague (1987)
▼ United States Salinity Laboratory (1954)

[1] Final general fertility is the fertility ranking to which the soil would belong if all other soil tests indicated moderate.

Legend

AWC *Available water-holding capacity*. A measure of soil water storage capacity, particularly that available for plants (see Section 4.3).

OM *Organic matter*. Estimated from organic carbon (OC) test results. Provides an indication of degradation, biological activity and general fertility (see Section 4.3).

Bray P *Bray phosphate*. Low Bray phosphate tests results indicate a lack of soil phosphate available to plants and usually a high likelihood of phosphate fertiliser response (especially pastures).

P sorption A soil's capacity for sorbing (fixing) phosphorus is related to its texture and clay mineralogy: sorption increases with increasing clay content.

CEC *Cation Exchange Capacity*. This is an indication of the number of sites within a soil which may temporarily hold positively charged ions. It is a general indicator of potential fertility.

BS *Base Saturation*. This is the percentage of Cation Exchange Capacity which is saturated with potassium, calcium, magnesium and sodium ions. It provides an indication of how closely nutrient status approaches potential fertility.

Ex K *Exchangeable Potassium*. Low exchangeable potassium may indicate a likelihood of low potassium reserves and/or potassium deficiency.[1]

Ex Ca *Exchangeable Calcium*. Low exchangeable calcium may indicate a likelihood of calcium deficiency.[1]

Ex Mg *Exchangeable Magnesium*. Low exchangeable magnesium may indicate a likelihood of magnesium deficiency.[1]

Ex Na *Exchangeable Sodium*. High exchangeable sodium indicates a likelihood of dispersible soils or an increase in salinity.

Acid *Acidity*. Very acid soils are often deficient in major plant nutrients which are in a form available to plants. Metal ions may occur in toxic concentrations (see Section 4.3).

Alk *Alkalinity*. Very alkaline soils are often deficient in trace elements in a form available to plants (see Section 4.3).

ESP *Exchangeable Sodium Percentage* (Sodicity). This is the percentage of cation exchange sites filled by sodium ions (see Section 4.3).

ECe *Electrical Conductivity* (Salinity). When converted to electrical conductivity in a saturation extract (ECe), this relates to plant salt tolerances (see Section 4.3).

Ex Al/CEC *Exchangeable Aluminium/Cation Exchange Capacity*. Percentage of cation exchange sites filled by aluminium ions. This is an indication of the extent of potential aluminium toxicity (see Section 4.3).

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[1] Relative proportions of exchangeable cations as well as amounts of exchangeable cations should also be considered when assessing fertility.

Appendix 7.7 Fertility for Each Soil Material

	General Fertility	Available Water Capacity	NUTRIENT STORAGE POTENTIAL: Organic Matter	Cation Exchange Capacity	Base Saturation	Available Phosphate	NUTRIENT STATUS: Bray P	Exch. K	Exch. Ca	Exch. Mg	TOXICITY: Acidity	Alkalinity	Sodicity (Sodic)	Salinity (Saline)	Exch. A1/CEC
Albion Park															
ap1	M-H	H	M	M	VH	VH	VL	M	M	VH	St	-	St	N-sal	L
ap2	M-H	H	H	VH	VH	M	VL	H	VH	M	N	N	N-sod	N-sal	-
ap3	M-H	H	VL	M	VH	H	VL	L	VL	VH	M	-	St	N-sal	-
ap4	M-H	H	L	M	VH	M	VL	M	H	H	M	-	St	N-sal	-
ap5	M-H	VH	H	M	VH	VH	VL	L-M	L	H	St	-	St	N-sal	L
Barren Gr'nds															
ba1	M-L	M	L	VL	M	L	VL	VL	VL	VL	Ext	-	St	N-sal	L
ba2	M-L	VH	VH	M	VH	VH	VL	M	M-H	L-M	VSt	-	N-sod	N-sal	L
ba3	L	VL	VL	VL	VH	L	VL	VL	L	VL	St	-	St	N-sal	L
ba4	L	L	VL	L	VH	M	VL	H	H	M	St	-	St	N-sal	VL
ba5	L	M	L	VL	VH	M	VL	VL	VL	VL	Ext	-	St	N-sal	VL
Barrengarry															
bg1	M-H	M	VH	M	H	VH	VL	H	H	M-H	St-M	-	N-sod	Sl	-
bg2	M-H	M	H	M	M	H	VL	H	L	M	M	-	N-sod	N-sal	-
bg3	M-H	L	VL	L	M	VH	VL	H	VL	M	St	-	N-sod	N-sal	-
bg4	M-H	M	VL	M	M	VH	VL	H	VL	M	VSt	-	Sl-sod	N-sal	-
bg5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bombo															
bo1	M	M	H	M	H	M	L	H	L	M-H	St	-	Sl-sod	Sl	VH
bo2	L	-	M	L	H	VH	VL	VL	L-M	M	St	-	Sod	N-sal	VL
bo3	L	M	L	M	L	VH	VL	L	L-M	H	VSt	-	Sod	N-sal	VL
bo4	-	-	M	M	VL	VH	VL	M	L-M	M	VSt	-	N-sod	N-sal	VL
bo5	-	-	L	M	M	VH	VL	VL	L	H	St	-	Sod	N-sal	L
Cambewarra															
ca1	M	VL	-	L	M	-	-	M	M	L	St	-	Sod	N-sal	L
ca2	M	M	VH	M	H	VH	L	L-M	VL	H	St	-	Sod	N-sal	M
ca3	M-L	L	L	M	L	VH	VL	L-M	L	M	St	-	N-sod	N-sal	VL
ca4	M-L	L	VL	M	L	VH	VL	L-M	L	M-H	St	-	N-sod	Sl	L
Coolongatta															
co1	L-M	M	H	L	H	-	-	M	L	M	St	-	N-sod	N-sal	-
co2	M	VL	VL	L	M	-	-	M	L	M	St	-	Sod	N-sal	-
co3	M	-	L	M	L	-	-	M-H	L	H	VSt	-	N-sod	N-sal	-
co4	L	-	-	M	L	-	-	L-M	L	H	Ext	-	N-sod	N-sal	VL

L *low*
M *moderate*
N *neutral*
H *high*

VL *very low*
VH *very high*
St *strong*
VSt *very strong*

Ext *extremely*
Sl *slightly*
Sod *sodic*

N-sod *non-sodic*
Sl-sod *(+/- 0.5)*
N-sal *non-saline*

Appendix 7.7 Fertility for Each Soil Material (Continued)

			NUTRIENT STORAGE POTENTIAL				NUTRIENT STATUS				TOXICITY				
	General Fertility	Available Water Capacity	Organic Matter	Cation Exchange Capacity	Base Saturation	Available Phosphate	Bray P	Exch. K	Exch. Ca	Exch. Mg	Acidity	Alkalinity	Sodicity (Sodic)	Salinity (Saline)	Exch. A1/CEC
Ellerslie															
el1	M	M	H	M	VH	M	VL	M-H	VH	M	Sl	-	N-sod	N-sal	-
el2	L	L	L	L-M	VH	M	L	L	H	M	Sl	-	Sl-sod	N-sal	-
el3	L-M	M	L	L	L	M	L	VL	M	L	St	-	Sod	N-sal	M
el4	M	VH	H	M	VH	M	VH	VL	H	M	Sl	-	N-sod	N-sal	-
el5	L-M	L-M	M	L	M	H	L	L	M	L	St	-	Sl-sod	N-sal	M
el6	M	-	L	L	M	H	VL	L-M	M	M	St	-	N-sod	N-sal	L
Fairy Meadow															
fa1	M	L	VH	M	VH	H	M	H	VH	H	M	-	N-sod	N-sal	-
fa2	L	L-M	H	L-M	VH	M	M	M	VH	M	N	N	N-sod	N-sal	-
fa3	L	M	M	M	VH	M	VH	M	VH	H	Sl	-	N-sod	N-sal	-
fa4	L	M	L	M	H	VH	VL	H	H	H	VSt	-	N-sod	N-sal	H
Fountaindale															
fo1	M-H	H	VH	M	H	H	L	H	M	H	M	–	N-sod	N-sal	-
fo2	M	M	M	M	M	VH	VL	M	M	H	M	–	N-sod	N-sal	-
fo3	M-L	L	L	H	M	VH	VL	L-M	L	VH	St	–	N-sod	N-sal	L
fo4	M-L	L	M	M	M	VH	VL	M	L	H	St	–	N-sod	N-sal	L
Greenwell Pt															
gp1	L	-	H	L	VH	-	-	L-M	H	M	Sl	–	Sod	N-sal	-
gp2	L	L	L	L	H	-	-	L	M	M	St	–	Sod	N-sal	-
gp3	L	-	-	M	M	-	-	L-M	L	H	VSt	–	N-sod	N-sal	VL
gp4	L	L	-	M	L	-	-	M	L	H	Ext	–	N-sod	N-sal	L
Hawkesbury															
ha1	L	L	H	L	H	VL	L	L-M	VL	L	Ext	-	N-sod	N-sal	-
ha2	VL	L	L	L	H	H	VL	VL	VL	VL	Ext	-	N-sod	N-sal	VL
ha3	L	L	VL	M	H	H	VL	M	VL	H	St	-	N-sod	N-sal	L
Ill. Escarp.															
ie1	M	L	H	L	L-M	M	L	M	M	L	St	-	N-sod	N-sal	L
ie2	M	L	VH	M	H	L	L	H	H	M-H	M	-	N-sod	N-sal	-
ie3	M	L	M	L	M	H	VL	L-M	M	M	St	-	N-sod	N-sal	L
ie4	M	L	M	L	L	VH	VL	VL	VL	L	St	-	N-sod	N-sal	VL
Jamberoo															
ja1	M	L	VH	M	L-M	VH	VL	M-H	L	M	VSt	-	Sl-sod	N-sal	VL
ja2	M-L	VL	L	M	L	VH	VL	VL-L	VL	M	VSt	-	Sl-sod	N-sal	VL
ja3	M	L	L	M	VL	VH	VL	M	VL	L-M	VSt	-	N-sod	N-sal	VL

L *low*
M *moderate*
N *neutral*
H *high*

VL *very low*
VH *very high*
St *strong*
VSt *very strong*

Ext *extremely*
Sl *slightly*
Sod *sodic*

N-sod *non-sodic*
Sl-sod *(+/- 0.5)*
N-sal *non-saline*

Appendix 7.7 Fertility for Each Soil Material (Continued)

			NUTRIENT STORAGE POTENTIAL				NUTRIENT STATUS				TOXICITY				
	General Fertility	Available Water Capacity	Organic Matter	Cation Exchange Capacity	Base Saturation	Available Phosphate	Bray P	Exch. K	Exch. Ca	Exch. Mg	Acidity	Alkalinity	Sodicity (Sodic)	Salinity (Saline)	Exch. A1/CEC
Kiama															
ka1	M	L	VH	M	H	VH	VL	VL-L	M	M	M	–	Sod	N-sal	-
ka2	L-M	M	L	L	VL	H	VL	L	M	L	St	–	Sl-sod	N-sal	VL
ka3	L	VL	L	L	L	VH	VL	VL	VL	M	Ext	–	Sod	N-sal	L
ka4	L-M	M	VL	M-H	L	VH	VL	L	VL	H	VSt	–	N-sod	N-sal	VL
Killalea															
ki1	M-H	-	H	M	H	M	VL	H	H	M-H	M	-	N-sod	N-sal	-
ki2	M	L	VH	M	H	VH	L	M	M	M	Ext	-	Sod	M	-
ki3	M	L	H	L-M	H	H	M	VL	H	M	St	-	St	N-sal	-
ki4	M	L	VH	M	VH	M	VL	M	H	M	St	-	Sod	VH	-
ki5	M	M	VH	M	H	VH	VL	M	H	H	Ext	-	Sod	VH	L
Nowra															
no1	L	L	VH	L	H	M	L	H	L	M	M	–	Sod	N-sal	-
no2	L	VL	L	L	H	H	VL	M	VL	M	VSt	–	Sod	VSl	L
no3	L	VL	L	L	M	M	VL	M	VL	M	M	–	Sod	N-sal	-
no4	L-M	L	VL	M	L	VH	VL	L	VL	M	VSt	–	Sod	N-sal	VL
no5	L-M	L	VL	M	L	VH	VL	L-M	VL	M	VSt	–	Sod	N-sal	VL
no6	M	M	L	M	VL	VH	VL	M	VL	M	VSt	–	N-sod	N-sal	M
no7	L-M	–	–	L	VL	–	–	M	VL	M	Sl	–	–	–	-
Pulpit Rock															
pr1	L	L-M	M	VL	H	M	VL	M	M	M	St	-	Sod	N-sal	L
pr2	L	VL	L	VL	L	L	VL	M	L	L	St	-	Sod	N-sal	H
pr3	L	L	VL	L	H	M	M	L-M	H	M	M	-	Sl-sod	N-sal	-
pr4	L	L	L	M	L	H	VL	M	L	M	St	-	N-sod	N-sal	VL
pr5	L	L	VL	L-M	L	H	VL	L	L	M	St	-	N-sod	N-sal	VL
Robertson															
ro1	M-H	L	VH	M	L	VH	VL	H	L	M	M	-	Sl-sod	N-sal	VL
ro2	M-H	M	H	M	L	VH	VL	M	VL	L	VSt	-	N-sod	N-sal	VL
ro3	M-H	L	VH	M	M-H	VH	VL	H	L	M	VSt	-	Sl-sod	N-sal	-
ro4	M-H	M	VL	M	L	VH	VL	M	VL	L	VSt	-	Sl-sod	N-sal	VL
Seven Mile															
sm1	L	VL	H	L-M	VH	VL	L	M	L	H	St	-	Sod	Sl-M	-
sm2	L	VL	VH	L	M	VL	L	L-M	M	M	Ext	-	Sod	N-sal	L
sm3	L	L	VL	VL	M	L	VL	VL	L	L	M	-	St-sod	N-sal	-
sm4	L	L	-	VL	L	-	-	VL-L	VL	L	St	-	Sod	N-sal	VH
sm5	L	L	-	L	VL-L	-	-	VL-L	VL	L	Ext	-	Sl-sod	N-sal	VH
sm6	L	-	-	M	VL	-	-	L-M	VL	L	Ext	-	N-sod	N-sal	VH

L *low*
M *moderate*
N *neutral*
H *high*

VL *very low*
VH *very high*
St *strong*
VSt *very strong*

Ext *extremely*
Sl *slightly*
Sod *sodic*

N-sod *non-sodic*
Sl-sod *(+/- 0.5)*
N-sal *non-saline*

Appendix 7.7 Fertility for Each Soil Material (Continued)

			NUTRIENT STORAGE POTENTIAL				NUTRIENT STATUS				TOXICITY				
	General Fertility	Available Water Capacity	Organic Matter	Cation Exchange Capacity	Base Saturation	Available Phosphate	Bray P	Exch. K	Exch. Ca	Exch. Mg	Acidity	Alkalinity	Sodicity (Sodic)	Salinity (Saline)	Exch. A1/CEC
Shellharbour															
sh1	H	M	VH	M	VH	M	VL	VL-L	VH	H	Sl	-	Sod	N-sal	-
sh2	M	L	M	H	VH	H	VL	VL-L	VH	VH	N	-	Sod	N-sal	-
sh3	M-H	M	L	H	VH	M	VL	VL-L	VH	VH	N	-	Sod	N-sal	-
sh4	M	M	L	M	VH	H	VL	L	M	H	M	-	Sod	N-sal	-
sh5	M	M	L	H	H	VH	VL	L-M	M	VH	M	-	Sod	N-sal	-
Shoalhaven															
sf1	M	L	L	L	VH	M	VL	M	L-M	H	VSt	-	Sl-sod	Sl	L
sf2	L-M	H	VH	M	L	VH	L	L	VL	M	VSt	-	Sl-sod	N-sal	L
sf3	M	VL	H	M	L	VH	L	H	VL	M	VSt	-	N-sod	N-sal	-
sf4	M	L	H	M	M	VH	L	H	L	M-H	VSt	-	Sod	Sl	L
Wattamolla Rd															
wt1	M-H	M	VH	M	VH	VH	L	H	H	H	St	-	N-sod	Sl	-
wt2	M-H	M	H	L	VH	-	VL	H	L	M	VSt	-	Sod	Sl	VL
wt3	M-H	L	H	L-M	VH	VH	VL	H	M	H	M	-	Sod	N-sal	-
wt4	M-H	-	VL	M	M	VH	VL	L-M	L-M	M	VSt	-	Sod	N-sal	VL
wt5	M-H	-	VL	H	VH	M	VL	L-M	VL	M	Sl	-	Sod	N-sal	-
Wildes Meadow															
wm1	-	VH	VH	L	H	VH	VL	L-M	VL	VL	VSt	-	Sl-sod	N-sal	VL
wm2	L	M	H	VL	H	VH	VL	VL	VL	VL	Ext	-	Sod	N-sal	VL
wm3	L	M	L	L	M	VH	VL	VL	VL	VL	Ext	-	Sod	N-sal	VL
wm4	L	M	L	VL	M	VH	VL	VL	VL	L	VSt	-	Sod	N-sal	VL
Wingecarribee															
wi1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
wi2	M	-	M	M	VH	VH	VL	H	M-H	H	M	-	St	VH	-
wi3	L	VL	L	H	VL	VH	VL	M	VL	H	VSt	-	N-sod	N-sal	VL
Wollongong															
wg1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
wg2	VL	L	VL	VL	VH	VL	VL	VL	VL	VL	-	M	Sod	N-sal	-
wg3	VL	L	VL	VL	VH	VL	L	VL	M	VL	-	M	St	N-sal	-

L *low*
M *moderate*
N *neutral*
H *high*

VL *very low*
VH *very high*
St *strong*
VSt *very strong*

Ext *extremely*
Sl *slightly*
Sod *sodic*

N-sod *non-sodic*
Sl-sod *(+/- 0.5)*
N-sal *non-saline*

Appendix 7.8 General Fertility of Kiama Soils

The soils of the Kiama 1:100 000 sheet range in fertility from infertile to very fertile.

Soils derived from Robertson Basalt, Blowhole, Bumbo and Cambewarra Latites are deep, well structured, freely draining with no impermeable clay horizon. The soils have been intensively weathered, have low non-exchangeable, available potassium reserves and only moderate amounts of readily available potassium (Vimpany *et al.* 1976).

Soils derived from Hawkesbury Sandstone are strongly acid. They are characteristically deficient in phosphate and are often locally deficient in nitrogen. Nutrient storage is apparently dependent on soil organic matter as the kaolin and illite clays typically have low CEC. Calcium and less commonly potassium deficiencies may also limit plant growth. Trace elements such as molybdenum may also be deficient. Soil productivity is often increased by additions of lime, phosphorus and nitrogen. Soils have low available water-holding capacities. Plant growth often benefits from surface mulching. See Beadle (1954) and Hannon (1956, 1958).

Soils derived from Wianamatta Group and Narrabeen Group strata are often strongly acid. They are also intrinsically deficient in phosphorus, nitrogen and calcium. These soils are dominated by illite clays and often contain adequate levels of potassium. CEC values are higher than those from sandstone soils. Trace elements such as molybdenum may be deficient. Soil productivity is often increased by additions of lime, phosphorus and nitrogen. Wianamatta Group derived soils have the longest history of agricultural and pastoral production within Australia. Salts are present deep within Wianamatta Group soils. They have low wet bearing strength and have been damaged by structural degradation in the past. Soils derived from coastal sands are usually acid and considered very impoverished, very deficient in nitrogen, phosphorus, potassium and occasionally sulphur as well as the trace elements molybdenum, copper and, in alkaline conditions, iron. CEC values are extremely low. Available water-holding capacities are universally low. For small areas the use of organic and clay materials as well as the use of surface mulches is recommended. Watering and fertilising should be light and frequent.

Soils derived from Budgong Sandstone are deep, friable and generally well drained. They have large reserves of non-exchangeable, available potassium and their present potassium status is good. They have high CEC and are slightly acid.

Soils derived from Berry Siltstone north of the Shoalhaven River have been influenced by volcanic ash and generally are friable clay loams overlying a heavy clay subsoil. Their potassium status is variable, ranging from low to moderate, depending on the degree of volcanic influence. They have moderate CEC and are moderately acid. The siltstone soils south of the Shoalhaven River are agriculturally inferior to those north of the river according to Vimpany *et al.* (1976). The surface soil is generally poorly structured, setting very hard when dry and "puggy" when wet. They have low CEC and are strongly acid.

Many alluvial soils in the Kiama mapped area have a high silt and clay content with a poor soil structure. Some are permanently waterlogged, and generally there are only limited areas of well-structured, well-drained alluvials. All have good non-exchangeable available potassium reserves and high CEC. However, acid sulphate soils occur especially throughout the Shoalhaven Floodplain.

Soils developed on Nowra Sandstone have low permeability, are stony and generally strongly acid. CEC is generally low.

8 GLOSSARY

For more extensive definitions of soil science terms, see McDonald *et al*., (1984), Morse *et al*. (1982), Houghton and Charman (1986).

aeolian—Deposits of soil material transported and/or arranged by wind.

alluvial—Of material deposited by, or in transit in, flowing water.

apedal—Of a soil in which none of the soil material occurs in the form of peds or soil aggregates in the moist state. See **soil structure.**

available water-holding capacity—The ability to hold that part of the water in the soil that can be absorbed by plant roots. Available water is the difference between field capacity and permanent wilting point.

basalt—A dark-coloured basic volcanic rock.

base saturation—The percentage of the total cation exchange capacity (CEC) saturated with basic ions.

batter—The excavated or constructed face of a cutting, embankment or dam wall.

beach ridge—An elongated low sand ridge built by waves and wind.

bench—A strip of relatively level earth or rock breaking the continuity of a slope, usually separated by a rock scarp.

Inside refers to the upper slope component.

Outside refers to the lower slope component above the scarp.

berm—A level area of loose sand between the upper limit of the swash zone and toe of the foredune, formed by marine deposition.

block gliding—Displacement of blocks of sandstone, gliding away from cliff lines.

blowout—A closed depression formed in the land surface by wind eroding sands and depositing them on adjacent land.

breccia—Igneous rock composed of angular fragments in a matrix.

cat-clay—Soil which when exposed to the air forms free sulphuric acid and has straw yellow mottles of a complex sulphate mineral, jarosite.

CEC (cation exchange capacity)—The total amount of exchangeable cations that a soil can adsorb. This has a major controlling effect on soil properties and behaviour, stability of soil structure, the availability of some nutrients for plant growth, soil pH, and the soil's likely reaction to fertilisers and other ameliorants.

clay—Soil material composed of particles finer than 0.002 mm. When used as a soil texture group, such soil contains at least 35% clay.

claystone—Non-fissile sedimentary rock composed primarily of clay-sized particles.

coffee rock—A type of brownish sand rock or soil pan formed where iron oxides and organic matter, which have leached through the soil profile, are precipitated at or above a fluctuating watertable.

colluvium—Unconsolidated soil and rock material moved largely by gravity (i.e., mass movement) deposited on a lower slope and/or at the base of a slope.

concretion—A concentric nodule.

conglomerate—A detrital sedimentary rock substantially composed of rounded gravels, stones or cobbles.

cusp—A small horn-shaped beach feature formed in the swash zone.

cutan—Coatings on ped surfaces, which may include clay skins or coatings of sesquioxide, manganese, ferromanganese, organic matter or carbonate.

debris dam—An accumulation of debris which obstructs the natural flow of water.

diatreme—A small explosive volcanic intrusion.

dispersible—Describes structural breakdown of soil into individual suspended particles in water.

dune—A sand ridge built up by wind action.

earthflow—A category of mass movement involving earth materials flowing downslope like a viscous fluid. Displacement varies from extremely slow to extremely rapid.

erodibility—The susceptibility of a soil to detachment and transportation by erosive agents, being a function of the soil's mechanical, chemical and physical characteristics.

erosion—The wearing away of the land and removal of soil by running water, rain, wind, ice or other geological agents. Erosion includes such processes as detachment, entrainment, suspension, transportation and mass movement.

eutrophic—Containing a very high concentration of plant nutrients. Oversupply of some nutrients may lead to excessive plant growth of certain species (e.g., algae), leading to oxygen depletion of water.

fabric—See **soil fabric.**

fan—A low cone of alluvial materials. The central point lies at the mouth of a gully or ravine, and the material is spread out onto the adjoining plain.

faunal casts—Soil matter reworked by passing through the digestive tracts of soil animals.

ferruginous cementation—The bonding of soil particles into a hard mass by concentration of iron around a nucleus.

flowline—A well-defined route down which water naturally concentrates and flows.

foredune—The first dune immediately landward of, and parallel to, the beach ridge, built up by onshore winds.

friable—See **surface condition.**

fungal mat—Layer of soil material held together by fungal hyphae.

geotechnical report—Report on the engineering properties of the soil and terrain.

gley—The grey or greenish grey colouration found in soils. It is often produced under conditions of poor drainage, giving rise to chemical reduction of iron and other elements.

gully—An open incised channel in the landscape generally >30 cm deep and characterised by moderately to very gently inclined floors and steep walls.

hanging valley—In the context of this document, an enclosed valley head upstream of a neck point in the drainage line. Not meant to indicate glacial landform.

Holocene—Present geological epoch which commenced 11 000 years ago.

humic—Referring to the organic matter within a soil.

humic cementation—The bonding of soil particles into a hard brittle consistency by organic substances within the soil.

hummock—A small raised feature above the general ground surface.

impermeable—Not permeable to water.

infiltration—The downward movement of water into the soil. It is governed largely by the structural condition of the soil, the nature of the soil surface including presence of vegetation and the antecedent moisture content of the soil.

intrusion—A geological feature where igneous material has been forced into the country rock.

Krasnozems—Deep, red, strongly structured clay soils with clay content gradually increasing with depth and with weak horizon differentiation.

labile—A measure of weak plasticity used in a consistence test.

laminite—Thinly bedded fine-grained sedimentary rock.

landform element—Part of the landform characterised by a distinctive slope, size, form and the type of geomorphological processes active on it.

landslip—A general term used to encompass those landslides that are composed predominantly of soil and underlying weathered material.

laterite—A soil in which an indurated iron-rich layer usually overlies a mottled clay and a pallid clay.

leaching—The removal of the more soluble materials and salts by water seeping through a soil or rock.

Lithosols—Shallow soils showing minimal profile development and dominated by the presence of weathering rock and rock fragments.

loam—A medium textured soil of approximate composition 10–25% clay, 25–50% silt and <50% sand.

mallee habit—Growth form in which a tree (usually a eucalypt) has many stems arising from its base.

massive—See **soil structure**—*apedal massive.*

mass movement—A general term encompassing erosion processes in which gravity is the primary force acting to dislodge and transport land surface materials. See **colluvium** and **landslip.**

matrix—Finer grained fraction, typically a cementing agent within a soil or rock in which larger particles are embedded.

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

mulch—A natural or artificial layer of plant residue or other material on the soil surface which provides protection against erosion and aids plant establishment mainly by restricting moisture loss and temperature variation.

nodule—A small concretionary deposit usually of sesquioxides or carbonates; usually hard.

overland flow (sheetwash)—Water flowing in a thin layer over the land surface.

pan—A hardened, compacted and/or cemented horizon in the soil profile.

ped—An individual natural soil aggregate. See also **ped shape, soil structure, soil fabric.**

pedal—Describes a soil in which some or all of the soil material occurs in the form of peds in the moist state.

ped shape—Refers to the shape of natural soil aggregates. Descriptive terms used are:

platy—The soil particles are flat or plate-like.

lenticular—The soil particles are lens shaped.

prismatic—The soil particles are prism shaped with well-defined flat surfaces.

columnar—This ped shape is similar to prismatic, but the peds are larger and their tops are domed.

polyhedral—Interlocking peds with many re-entry angles.

angular blocky—The soil particles are approximately cubic with six relatively flat, equal faces. Edges are angular.

sub-angular blocky—This ped shape is similar to angular blocky, but the edges of peds are rounded.

granular—These peds are spheroids or poly-hedrons having planar or curved surfaces which are relatively non-porous.

perched watertable—The surface of a local zone of saturation held above the main body of ground water by an impermeable layer, usually clay, and separated from it by an unsaturated zone.

permeability—The characteristic of a soil, soil horizon or soil material which governs the rate at which water moves through it.

pH—A measure of the acidity or alkalinity of a soil. A pH of 7.0 denotes neutrality, higher values indicate alkalinity, and lower values indicate acidity.

plastic—Describes soil material which is in a condition that allows it to undergo permanent deformation without appreciable volume change or elastic rebound, and without rupture.

Pleistocene—Epoch of geological time starting 1.8 million years ago.

Podzolics—A term applied to acid soils with strong texture contrast between loamy topsoils and clay subsoils.

Podzols—Acid sandy soils with strongly differentiated horizons including a bleached horizon above a coffee coloured pan and coloured subsoil.

porosity—The degree to which the soil mass has interconnected pores or cavities, generally expressed as a percentage of the whole volume of a soil horizon which is unoccupied by solid particles. It influences soil drainage characteristics.

Prairie Soils—Moderately deep, mildly acid to mildly alkaline soils with thick, dark, moderately structured topsoils.

Quaternary—That period of geological time covering the Holocene plus the Pleistocene. Up to 40 000 years ago.

rainforest—Closed-wet forest in which mesophytic species dominate. Tree species diversity is generally high. Emergents, lianes, ferns and epiphytes are usually present; eucalypts, when present, are usually canopy emergents.

reactive soil—A term used in the construction industry to describe a soil that changes volume with changes in moisture content. This can damage foundations.

regolith—Mantle of loose and weathered material overlying the bedrock.

rill—A small channel cut by concentrated runoff through which water flows during and immediately after rain.

run-on—Surface water flowing onto an area as a result of runoff occurring higher up the slope

rural capability classification—A method of land classification which ranks land according to its ability to sustain various intensities of rural use.

saltmarsh—A grassland or herbland occasionally inundated by sea water and hence having salt tolerant plant species.

sandstone—A detrital sedimentary rock with predominantly sand-sized particles.

sclerophyll—Denoting the presence of hard stiff leaves; generally indicates an adaptation to drier conditions.

sedimentation—Deposition of sediment, typically by water.

sesquioxide—Oxides of aluminium and iron.

shale—A fine-grained detrital sedimentary rock which is laminated and easily split into layers.

sheet erosion—The removal of the upper layers of soil by raindrop splash and/or runoff.

sheetwash—See **overland flow.**

shrink-swell soil—A soil which reacts to a change in water content with a change in soil volume.

siliceous—Having a high proportion of quartz. Usually a descriptor for sand.

silt—Fine soil particles in the size range 0.02–0.002 mm.

siltstone—A fine-grained sedimentary rock.

slaking—The partial breakdown of soil aggregates in water due to the swelling of clay and the expulsion of air from pore spaces.

slope—A landform element inclined from the horizontal measured as degrees or as a per-centage.

slump—A slide where the material in motion is not greatly deformed but has a backward rotation on a more or less horizontal axis—i.e., displacement along a concave surface of separation.

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

soil creep—More or less imperceptible transportation of soil particles under the influence of various erosive agents.

soil fabric—The appearance of the soil material using a X10 hand lens.

Differences in the presence or absence of peds, the lustre, or lack thereof, of the ped surfaces, and the size and arrangement of pores in the soil mass are noted. Descriptive terms used are:

earthy fabric—The soil material is cohesive and contains pores but few if any peds.

sandy fabric—The soil material consists of closely packed sand grains which are weakly cohesive with few if any peds.

roughpedfabric—Pedsareevidentandcharacteristically more than 50% of the peds are matt- or rough-faced.

smooth ped fabric—Peds are evident and characteristically more than 50% of the peds are glossy or smooth-faced.

soil horizon—A layer of soil approximately parallel to the land surface, with morphological properties different from layers below and/or above it.

soil landscape—An area of land that has recognisable and describable topography and soils that are capable of being represented on maps and of being described by concise statements.

soil material—A three-dimensional soil entity which has a degree of homogeneity and lateral continuity. Each soil material is defined and described in terms of its morphological properties.

soil structure—Refers to the distinctness, size, shape and condition of the peds. See also **ped shape, soil fabric.**

The degree of structural distinctness is referred to as grade of pedality. Descriptive terms used are:

apedal single-grained—The soil occurs as a loose, incoherent mass of individual particles (as in sands).

apedal massive—The soil occurs as a coherent mass with no distinct arrangement of soil particles.

weak pedality—The soil contains peds which are barely observable.

moderate pedality—The soil contains peds which can be identified but are not distinct.

strong pedality—The soil contains peds which are clearly observable.

Solonchaks—-Highly saline soils with pedological development in the top 30 cm.

Solonetzic Soils—Soils with prominent texture differentiation between neutral to slightly alkaline, loamy topsoils and strongly alkaline, clay subsoils.

Soloths (or **Solods)**—Acid soils with strong texture contrast between pale topsoil and clay subsoil with coarse blocky or columnar structure.

stone-line—A layer of gravel within a soil profile.

structure—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.

subplastic—A soil which appears to become more clayey with prolonged kneading. Such soils are usually well structured and well drained.

subsoil—Sub-surface material comprising the B and C horizons of soils with distinct profiles; often have brighter colours and higher clay contrasts.

surface condition—Describes the actual surface condition of the exposed soil surface.

gravelly—Over 60% of surface cover consists of gravel (2–60 mm).

hardsetting—Soil is compact and hard and appears to have apedal structure when the soil dries out.

loose—Soil which is not cohesive.

friable—Easily crumbled or cultivated.

self-mulching—Loose surface mulch of very small peds forms when soil dries out.

seasonal cracking—Shrinking clay soils which shrink when dry, expand when wet and exhibit wide cracks in the dry state.

surface movement potential—The degree to which the soil surface rises and falls with changes in moisture content. See **reactive soil, shrink-swell.**

swale—A linear level-floored open depression excavated by wind or formed by the build-up of two adjacent ridges. Typically associated with the depression between two adjacent sand dunes.

talus—An accumulation of rock fragments and other soil materials at the foot of a cliff or steep slope, usually forming a moderately to steeply inclined lower slope, aggraded by gravity.

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.

topsoil—A part of the soil profile, typically the A_1 horizon, containing material which is usually darker, more fertile and better structured than the underlying layers.

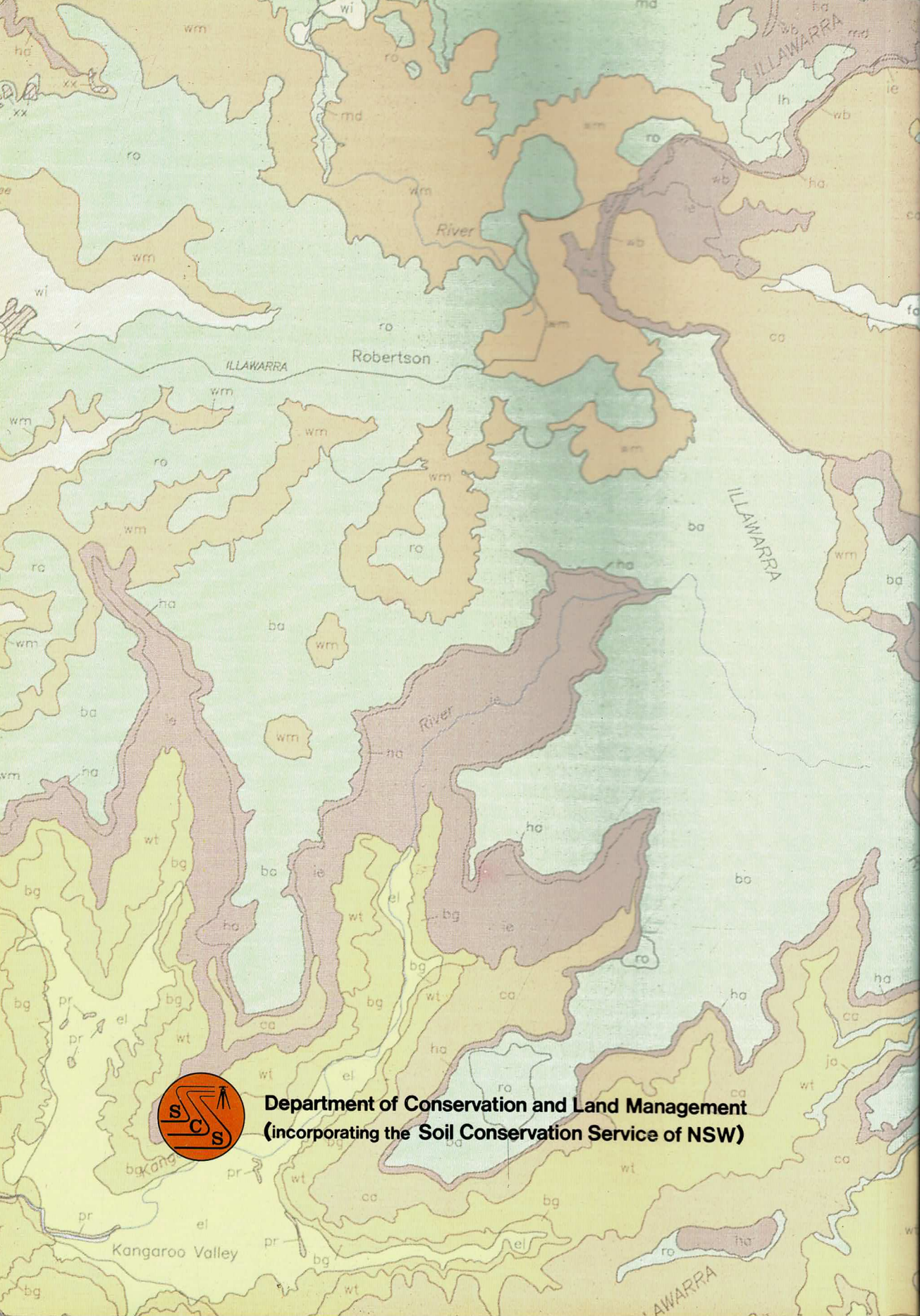
Triassic—Period of geological time, 230–180 million years before present.

understorey—A layer of vegetation below the main canopy layer.

urban capability classification—A method of land classification which ranks land according to the physical constraints applying to various intensities of urban use.

water-repellent soil—Soils which resist wetting when dry. Drops of water do not penetrate spontaneously over their surface and into pores.

weathering—The physical and chemical disintegration, alteration and decomposition of rocks and minerals at or near the earth's surface by atmospheric and biological agents.



Department of Conservation and Land Management
(incorporating the Soil Conservation Service of NSW)