Natural Resources
Adelaide and Mt Lofty Ranges

Best practice land management guidelines for small grazing properties

In the Adelaide and Mount Lofty Ranges Natural Resources Management region

Government of South Australia
Adelaide and Mount Lofty Ranges
Natural Resources Management Board

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Photographic benchmarks depicting herbage mass 'food on offer'

Courtesy of the Appila/Bundaleer Pasture Group and Primary Industries and Resources SA

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1. Introduction

1.1 About this manual

The purpose of producing this *Best practice land management guidelines for small grazing properties* is to promote sustainable integrated land management and to encourage landholders to adopt best practice when managing livestock.

The guidelines were written in association with industry and contain technical information that will be of benefit to landholders and others throughout the region, who are seeking information on improving grazing practices.

The guidelines take into account the impacts of different soil types, irrigated and dryland grazing, as well as differences in livestock behaviour. Soil, topography and rainfall data is collated to determine baseline indicative stocking rates for non-commercial livestock enterprises. It is a comprehensive tool which focuses on sustainable land management practices and encourages landholders to better manage livestock to avoid land degradation.

The project addresses overgrazing issues in the region that potentially lead to soil loss, acidification, reduction in water quality, sedimentation of waterways, loss of biodiversity with a reduction of soil biota and native grasses.

This document is part of a larger project funded by the Australia Government.

How will this manual assist land managers?

This manual provides information and resources on key aspects of managing a small grazing property. It provides recommendations on a range of practical land management issues which will encourage better decision making, and lead to an improvement in the condition of the region's natural resources.

It is expected that landholders will be able to:

- understand threats to key natural resources of the region
- develop a property management plan
- conserve soil
- adopt an integrated approach to weed control
- combat soil acidity
- grow more productive pastures
- adopt suitable stocking rates and grazing strategies
- apply suitable grazing pressure without degrading land
- improve water quality
- understand the benefit to grazing enterprises of adopting best practice
- utilise links to further information.

1.2 The Natural Resources Management Act

The *Natural Resources Management Act 2004* (the NRM Act) identifies soil, water, native flora and fauna, geological features and ecosystems as natural resources that require protection and, in some cases rehabilitation to restore ecosystems to a healthy condition. The NRM Act requires that these natural resources are managed within the principles of ecologically sustainable development.

The Adelaide and Mount Lofty Ranges Natural Resources Management Board (the board) has identified a range of strategies and actions in its *Adelaide and Mount Lofty Ranges Natural Resources Management Plan* to encourage communities to achieve sustainable development and protect the region's natural ecosystems. Details of these strategies can be found in 'Volume 1 Strategic plan for the region 2014–15 to 2023–24 part 1 and 2' at **www.naturalresources.sa.gov.au/adelaidemtloftyranges**.

Figure 1. Grazing land on the Fleurieu Peninsula

Community groups, industry and a range of other organisations play a vital part in implementing initiatives to manage natural resources. However, it is the individual landholder who has a 'duty of care' under the NRM Act to manage natural resources. This duty of care is an important principle which underpins the land management objectives of improving water quality, rehabilitating watercourse ecosystems, preventing erosion, protecting biodiversity and reversing agriculturally induced soil acidity.

2. Summary of guidelines

This summary chart steps landholders through a series of actions to improve soil, pasture and grazing management. These actions support 'best practice' land management and are explained in further detail in this manual.

3. The region

The Adelaide and Mount Lofty Ranges Natural Resources Management Board's region supports a mosaic of bushland remnants, farming land, urban development, rolling hills and plains, diverse marine environments and more than 200 km of spectacular beaches and coastline.

Covering nearly a million hectares, just over half of which is land, the region extends from the Barossa Valley to the Fleurieu Peninsula. It follows the ridge of the western Mount Lofty Ranges (to 800 m) and takes in metropolitan Adelaide and the Adelaide Plains. The region extends up to 30 km into Gulf St Vincent and includes ecosystems that are found nowhere else in the world.

As the most biologically diverse region in South Australia, it is home to half of the State's species of native plants and three-quarters of its native birds. It also contains some of the State's most productive primary industries supplying local and international markets and contributing to South Australia's economic and social wellbeing.

Average annual rainfall ranges from 400 mm to the north of Adelaide to 1200 mm at Mount Lofty.

The region has a wide range of soil types, with the more common being low fertility ironstone soils over deeply weathered rock, acidic sandy loams and loamy soils over rock.

Livestock grazing on perennial and annual pastures is a major enterprise in the higher rainfall districts. Perennial horticulture and viticulture is significant in the Barossa Valley, central ranges and McLaren Vale, while seasonal horticulture is prevalent on the Northern Adelaide Plains and in the high rainfall area of Piccadilly Valley. Mixed farming with cereal, pulse and oilseed crops and livestock grazing on annual pastures, occurs in the Gawler, Two Wells and Mallala farming district (Figure 2).

In 2001 the population of the region was 1.13 million people and in 2016 it was estimated at 1.32 million.

In recent years there has been:

- a decrease in young people aged 15–24 years
- a decrease in people aged 25–34 years
- an increase in people aged 40 plus.

These changes are consistent with national demographic trends which include less people having children and an ageing population.

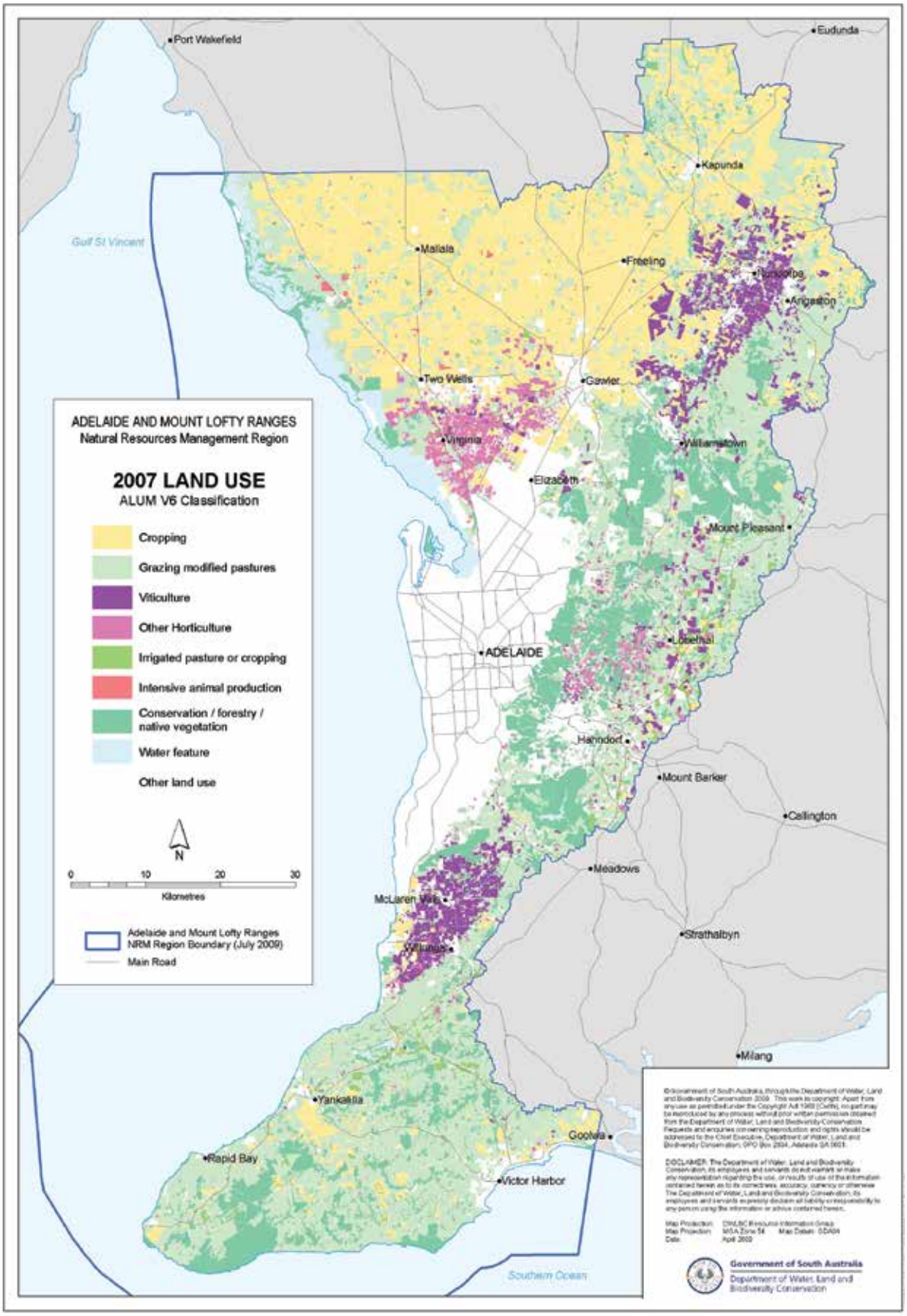


Figure 2. Land use in the Adelaide and Mount Lofty Ranges NRM region

4. Impacts of grazing on natural resources

Poor grazing management can have a significant impact on natural resources resulting in declining water quality, degraded aquatic ecosystems, increased soil acidity and a loss of top soil. In severe situations, gully erosion can lead to significant losses of prime agricultural land.

Furthermore a loss of biodiversity is a common occurrence when livestock are permitted to graze remnant native vegetation, or overgraze native grass pastures, and it is not uncommon to find well established native trees destroyed when they are ring-barked by livestock.

Environmental problems are also encountered when poor grazing management promotes the spread of weeds, many of which are classified as 'declared' plants or weeds of national significance.

4.1 Soil erosion

Where grazing pressure is excessive a loss of ground cover can cause erosion (Figure 3) resulting in soil loss and sedimentation in watercourses. In addition, there is the potential for gully erosion to occur at these sites.

Losing even small amounts of topsoil is considered significant on the shallow soils of the Mount Lofty Ranges. The loss of 1 mm of topsoil over a hectare represents 10 to 12 tonnes per hectare of actual soil.

The greatest potential for water erosion is on sandy textured soils on steep slopes. Contributing further to the risk of erosion is the degree of surface disturbance resulting from the trampling effects of livestock.

Cultivation of hilly land when re-seeding pastures is discouraged in the region because of the potential for significant erosion during heavy rainfall events, consequently direct drilling of pasture seed is advised.

Livestock tracking along fence lines can also create serious gully erosion on sloping land, so placement of new fences requires careful consideration.

While most landholders recognise the need to protect watercourses, the practice of grazing livestock through these sites still occurs on some properties. Unfortunately significant environmental damage results when vegetation is destroyed. Banks become unstable and the risk of mass erosion is increased, especially during severe rainfall events. In these situations many tonnes of soil can enter the watercourse in a single event (Figure 4), so fencing off watercourses to exclude livestock should be a priority for all landholders.

Preserving aquatic plants such as the common reed (*Phragmites australis*) and rushes (*Juncus* spp.) should be a key objective of landholders managing watercourses since these plants are very effective in holding soil together.

Figure 3. Erosion caused by overgrazing

Figure 4. Streambank erosion on the Onkaparinga River at Oakbank

4.2 Soil acidity

Acidic soils can be detrimental to plant growth because they restrict the availability of nutrients thereby limiting plant growth which can lead to a lack of ground cover. Increased weed growth and erosion is often a consequence.

Soil acidification is a natural process of soil formation and is the result of millions of years of weathering. However, it can be greatly accelerated by the following agricultural practices:

- intensive legume based pasture production (clovers and medics)
- removal of nutrients in farm products (e.g. hay and silage)
- adding nitrogen fertilisers such as urea, ammonium sulphate and ammonium nitrate.

While the relationship between soil acidity and poor plant growth is generally well known, there are other significant environmental impacts:

- clay will eventually breakdown in highly acidic soils with a potential decline in soil structure and increased sedimentation of waterways
- survival of soil microbes (bacteria and fungi), earthworms and some insects is poor in acidic soils
- acidity is also harmful to fish and other stream biota.

4.3 Soil structure

A decline in soil structure can be attributed to over cultivation, loss of organic matter and a decline in soil organisms. Poorly structured soils generally exhibit poor drainage, contain limited oxygen for root growth and can easily be eroded. Trafficking wet soil can also lead to compaction of surface soil and sub-surface soil, which inhibits plant growth resulting in less vegetative cover.

Figure 5. Well-structured soils encourage good plant growth

5a: No structure. Sandy soil. Lacks organic matter.

5b: Good structure. Allows water and air into soil.

5c: Poor structure. Heavy impermeable clay. Improved by organic matter.

4.4 Water quality

The greater Adelaide area sources, on average, 60% of its drinking water from the Mount Lofty Ranges Water Protection Area (the Watershed) which is proclaimed under the *Environment Protection Act 1993*.

Approximately 90% of the watershed consists of privately owned land, much of which is used for grazing. This land use can have a direct impact on water quality by degrading ecosystems which creates a health hazard for the human population.

Cryptosporidium and Giardia are water-borne pathogens which are found in our rivers and reservoirs. Contamination through faeces occurs when livestock, especially young sheep and cattle, have free access to watercourses. These pathogens can cause serious illness with symptoms similar to gastro-enteritis, so costly water treatment is required to provide safe drinking water. Excluding livestock from watercourses reduces pathogen numbers and minimise the risk to human health.

Correcting poor soil nutrient levels by applying fertiliser is important in most grazing systems, however, overuse of fertiliser can be a source of water pollution (eutrophication). Applications of phosphorus and nitrogen in excess of plant requirements can be potentially damaging to the aquatic environment. This nutrient build up can create problems of excessive plant growth and lead to blooms of algae and weeds. It is also now recognised that high nutrient levels are the primary cause of seagrass loss in the Adelaide metropolitan waters, so testing soils to determine appropriate fertiliser requirements is good practice.

Even small quantities of sediment entering a watercourse can affect the growth of aquatic plants by reducing the amount of light they need for photosynthesis and growth. Fish can swallow large quantities of sediment, causing illness, reduced growth and eventual death. Sediment is also harmful to the gills of fish, clogging gill mucus and causing asphyxiation (Figure 6). Deposited sediment can smother whole stream beds and reduce the variation of habitats and flows. Recent studies on several species of native fish have found that all of their eggs die, even when lightly coated in fine sediment. Invertebrates (such as mayflies) use gills for respiration which in silt-laden water become clogged and are less effective.

Figure 6. Fish species are susceptible to nutrient pollution from soil erosion

4.5 Biodiversity

Since Europeans arrived, the native vegetation of the region has been subjected to broadscale clearance and disturbance. Approximately 14% of the pre-European native vegetation cover remains today. The most common vegetation type was grassy woodland dominated by the smooth-barked gums: river red gum (*Eucalyptus camaldulensis*), SA blue gum (*Eucalyptus leucoxylon*) and manna gum (*Eucalyptus viminalis*). For decades these species were targeted for clearance leaving only scattered trees and small, isolated weed-infested remnants.

Where remnant native vegetation sites exist on private land, considerable damage can be done by grazing livestock, especially to understorey, consequently fencing off these sites is recommended.

The continued loss of native grass pastures due to overgrazing is a further issue. Kangaroo grass (*Themeda triandra*) does not survive well when subjected to high grazing pressures and will quickly disappear from the landscape. Some native grasses can be quite intolerant of fertiliser, however grasses such as weeping rice grass (*Microlaena stipoides*) and wallaby grass (*Austrodanthonia* spp.) will respond to rotational grazing and low levels of phosphorus and nitrogen applications. In general, native grasses adapt well to dry conditions and provide good ground cover in times of drought compared with some introduced pasture species such as perennial ryegrass (*Lolium perenne*).

5. Climate of the region

Table 1. Average monthly maximum temperature (degrees centigrade) – Roseworthy 1997–2017

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest	26.8	27.9	24.4	20.9	17.2	14.4	13.8	14.6	16.4	18.9	24.0	25.6	22.9
Highest	36.2	34.1	34.3	27.0	21.9	17.7	16.5	18.8	22.4	28.6	32.3	33.5	24.6

Table 2. Average monthly maximum temperature (degrees centigrade) – Mount Barker 1863–2017

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest	23.2	22.0	20.8	16.4	13.5	11.7	10.8	11.4	3.4	15.7	19.3	20.2	18.4
Highest	31.9	31.7	30.1	25.4	20.2	18.3	15.5	20.6	19.8	25.5	28.5	30.5	22.1

Table 3. Average monthly minimum temperature (degrees centigrade) – Roseworthy 1997–2017

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest	11.4	11.5	10.0	6.6	6.5	3.4	4.6	2.5	5.0	6.2	7.9	9.6	8.9
Highest	17.3	18.4	16.7	12.9	11.2	8.3	6.7	6.6	9.3	10.8	14.7	15.5	10.4

Table 4. Average monthly minimum temperature (degrees centigrade) – Mount Barker 1862–2017

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest	8.9	9.1	7.4	4.9	3.9	1.7	1.9	2.3	2.8	4.7	6.5	5.4	6.8
Highest	14.9	15.2	13.8	11.4	10.1	8.7	7.4	7.2	9.5	10.3	12.6	13.4	9.7

Topography and altitude vary throughout the region with quite marked differences in temperature and rainfall. Piccadilly, Aldgate and Uraidla, in the Mount Lofty Ranges, all have an average annual rainfall in excess of 1000 mm while the average annual rainfall at Gawler is 388 mm, and Two Wells 408 mm. Maximum temperatures can also be 5 degrees centigrade cooler at high altitude.

The risk of frosts is moderate to high in most areas which are inland from the coast, with areas at high altitude being particularly susceptible.

Seasonal rainfall has a significant influence on agricultural enterprises with autumn rains signifying the start of the growing season which extends through to November. This is followed by 4 to 5 months of dry weather interspersed with isolated rainfall events.

Evaporation can be over 1000 mm per annum with evaporation exceeding rainfall during summer. In winter, when rainfall exceeds evaporation, pasture growth can slow due to cold temperatures and waterlogged soils.

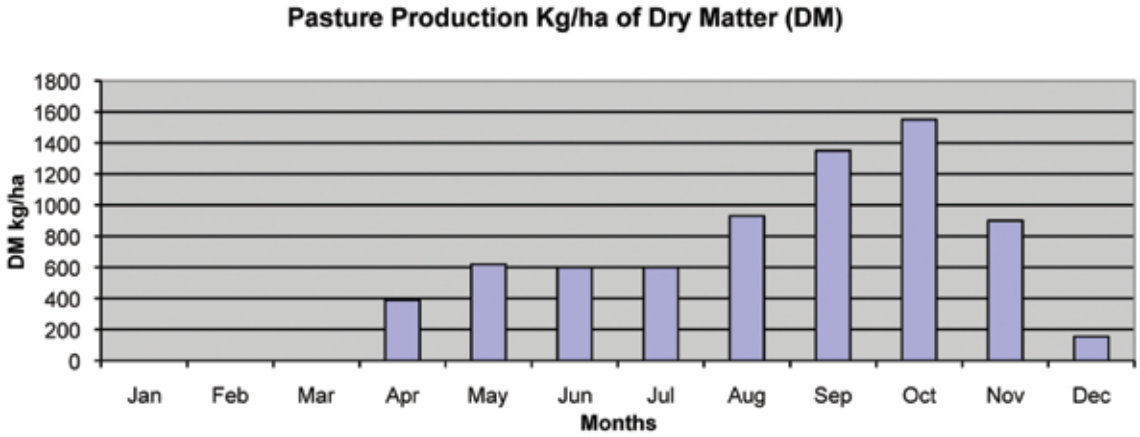


Figure 7. Typical monthly pasture production chart for high rainfall areas of the region (>650 mm p.a.)

5.1 Implications on pasture growth

Rainfall, temperature and sunlight all play a part in determining pasture productivity, with rainfall being the biggest influence on pasture dry matter production (i.e. plant matter excluding moisture) (Figure 7).

Temperature

When soil temperatures drop below 8 degrees, most commonly in June and July, pastures cease growing and enter a semi-dormant phase until August when temperatures rise and trigger further growth.

Frost can impact severely on some pasture species such as native kangaroo grass (*Themeda triandra*) causing older leaves to be severely damaged. Frost tolerant varieties include perennial ryegrass (*Lolium perenne*), phalaris (*Phalaris aquatica*), wallaby grass (*Rytidosperma* spp. previously *Austrodanthonia* spp.) and weeping rice grass (*Microlaena stipoides*).

Rainfall

The timing and intensity of rainfall events can have a marked impact on how effective rain is for pasture production (Figures 8, 9 and 10). Run-off may vary according to the nature of ground cover, slope and soil type, but on average this accounts for approximately 10% of the rain that falls.

In an area which receives 700 mm of rain in a particular year, 70 mm will be lost as run-off, and a further amount will be lost through evaporation. This figure can be as high as 50 mm during the growing season, and much higher during the warmer months of summer. Consequently only 580 mm will be available to promote pasture growth during winter and spring.

Sunlight

Pastures are directly affected by the amount of sunlight they receive. Increased day-length in spring will promote more active growth whilst cloudy days will inhibit pasture production. On hilly properties north facing slopes will often produce the most productive pastures.

5.2 Rainfall distribution at three key regional sites

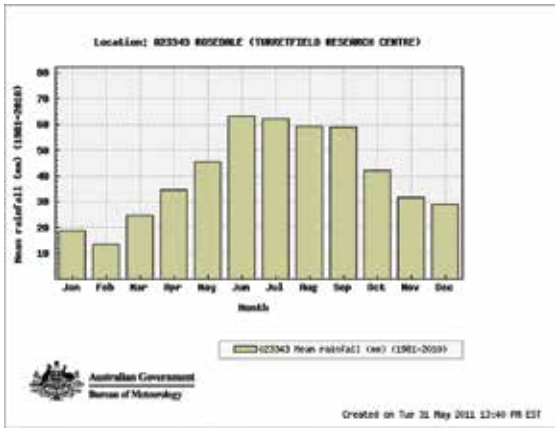


Figure 8. Average annual rainfall at Rosedale (between Gawler and Lyndoch) 483 mm
Source: Bureau of Meteorology 2011a

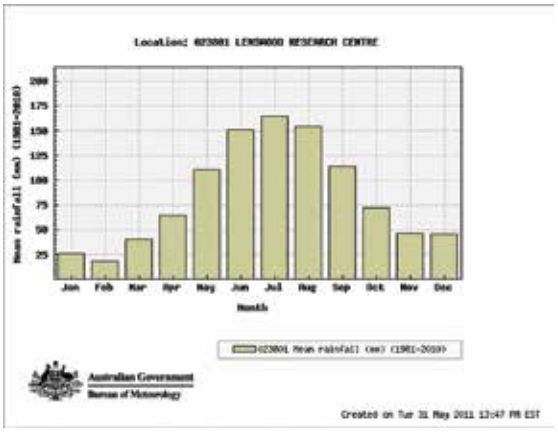


Figure 9. Average annual rainfall at Lenswood 1009 mm
Source: Bureau of Meteorology 2011b

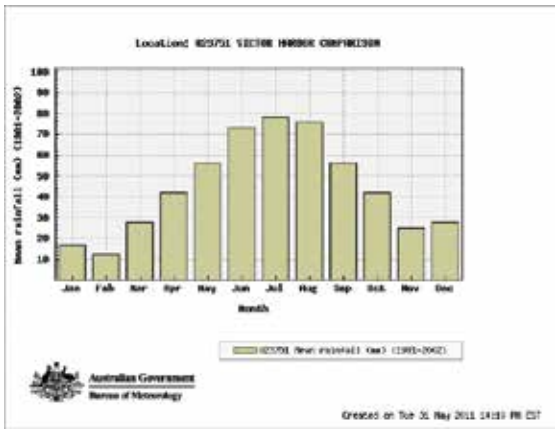


Figure 10. Average annual rainfall at Victor Harbor 528 mm
Source: Bureau of Meteorology 2011c

5.3 Average annual rainfall across the region

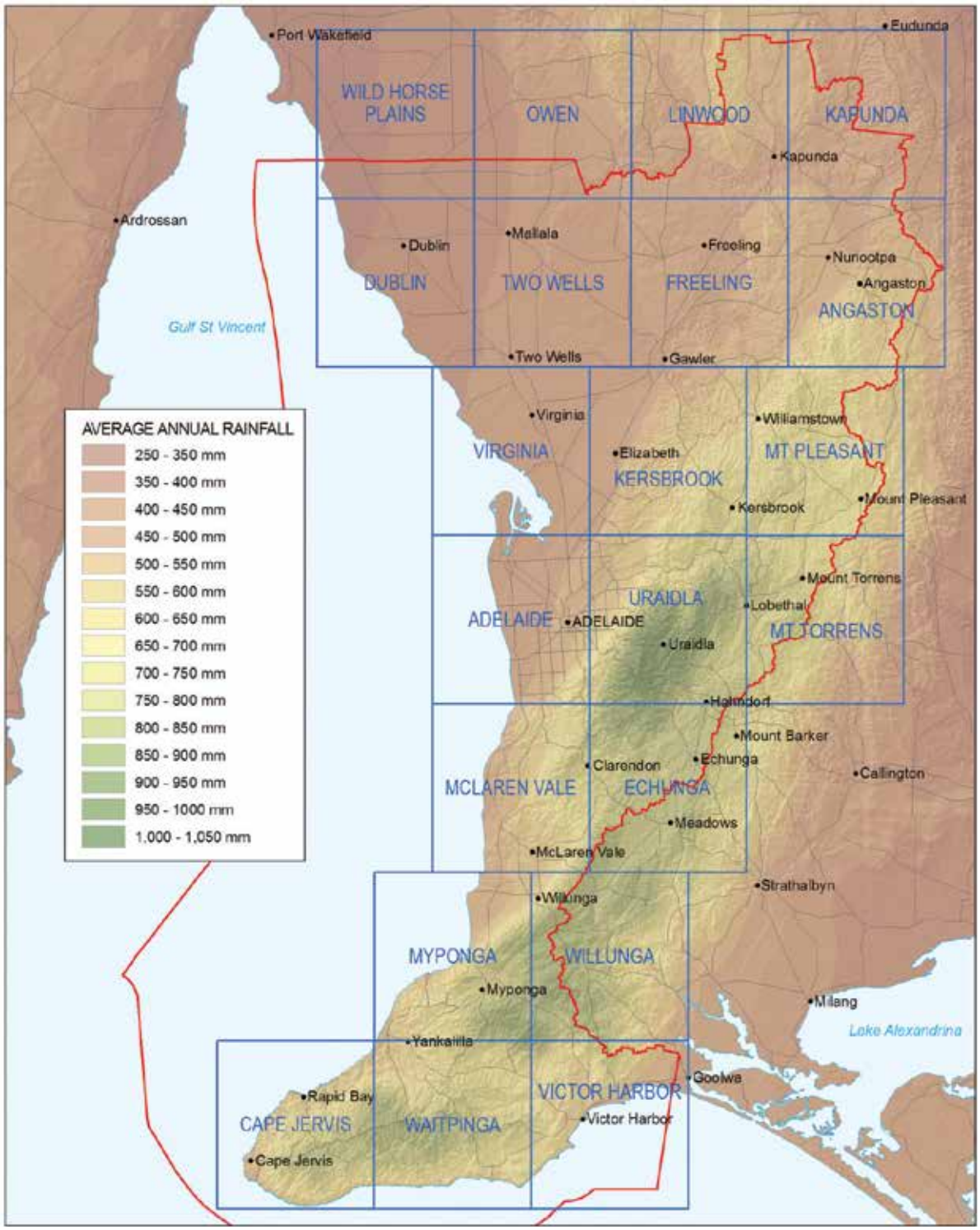


Figure 11. Long term average annual rainfall in the AMLR NRM region.
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

Average annual rainfall should always be considered as a guide only since actual rainfall can vary significantly from year to year. Landholders should understand that this variability will directly affect the amount of feed produced by pastures.

The statistics in Table 5 highlight the variability in rainfall for two locations in the region over a six year period from 2005 to 2010. From this one can see that 2006 was a significantly dry year. Pasture growth would have been considerably less, resulting in the land supporting fewer animals. In this situation livestock numbers should be reduced to avoid overgrazing.

Table 5. Variability in annual rainfall for Adelaide and Lenswood 2005–10

Location	Annual rainfall mm per year						Average annual rainfall mm
	2005	2006	2007	2008	2009	2010	
Adelaide (Kent Town)	630	288	465	402	517	592	549
Lenswood	1134	680	903	825	1103	1071	1022

Table 6. Average annual rainfall for locations in the AMLR NRM region
Source: Science Resource Centre, Department of Environment and Natural Resources, June 2011

Location	Average annual rainfall mm (1980–2009)	Long term average annual rainfall mm (since records began)
Lenswood Research Centre	1007	1022
Longwood	969	967
Cleland Conservation Park	966	989
Parawa	927	945
Second Valley Forest	909	954
Cherry Gardens	893	923
Lobethal	888	888
Cudlee Creek	837	858
Belair (State Flora Nursery)	834	777
Hahndorf	780	850
Clarendon	774	813
Echunga	768	806
Gumeracha	762	797
Kersbrook	737	741
Yankalilla	733	749
Woodside	710	804
Blackwood	707	707
Birdwood	694	722
Myponga	681	680
Williamstown	675	682
Upper Hermitage	639	645
Mount Pleasant	616	669
Willunga	604	646

Table 6. continued

Location	Average annual rainfall mm (1980–2009)	Long term average annual rainfall mm (since records began)
Adelaide (Glen Osmond)	603	627
Second Valley	602	609
Angaston	549	558
Adelaide (Kent Town)	544	549
Tanunda	532	547
Lyndoch	530	557
Victor Harbor	528	536
Normanville	517	522
Greenock	511	531
Truro	505	494
Keyneton	496	533
Kapunda	484	494
Port Elliot	483	500
Freeling	483	485
Eudunda	466	480
Tarlee	464	470
Hamley Bridge	450	463
Roseworthy	440	444
Gawler	424	468
Bolivar	408	425
Owen	404	424
Two Wells	391	399
Mallala	387	401
Lower Light	382	386
Port Parham	334	358

5.4 Climate change

Climate change is likely to influence how we manage land in the future. In this region, average annual rainfall is expected to decrease by up to 10% by 2030, while temperatures are predicted to rise by up to 1.2 degrees. These changes may result in a greater frequency of extreme climatic events, in particular more intense rainfall episodes. More variable breaks in the winter growing season coupled with changes in flowering times and insect breeding cycles are all likely to create additional land management challenges in the future.

Maintaining current pasture mixes could be difficult with less rainfall, since pasture cultivars have a minimum annual rainfall requirement. Some new varieties of perennial ryegrass (*Lolium perenne*) need a minimum of 700 mm rainfall per annum. In a drying climate there may be a need to swap to more drought tolerant varieties such as cocksfoot (*Dactylus glomerata*) or phalaris (*Phalaris aquatica*).

6. Soils of the region

Australian soils are some of the oldest in the world having experienced severe weathering and leaching over millions of years. As a consequence nutrient and organic matter levels can be low. The inherent features of a soil are usually determined by the type of parent rock and the nature of environmental exposure over time. Features such as soil colour, layers, texture, and to some extent structure, are used to describe a soil type.

6.1 Soil profiles

There are many different soil types which have quite distinctive characteristics such as colour, texture, structure and fertility. When assessing a soil it is important to examine the soil profile which consists of a series of layers or 'horizons' (Figure 12). The features of these horizons depend very much on the age of the soil, the nature of the parent material, climate, slope, vegetation and chemical reactions in the soil. Some profiles consist of quite shallow soils over parent rock. Others can be deep sands with little horizon differentiation. Knowledge of soil profiles is important when deciding what plants to grow. Most pastures have roots which only grow to a depth of approximately 10 to 15 cm, while perennial horticultural crops may penetrate to a depth of one metre or more. An examination of soil profiles may reveal limitations to growth such as waterlogging, salinity or acidity, and physical barriers such as hard pans, which can often inhibit the growth of plant roots.

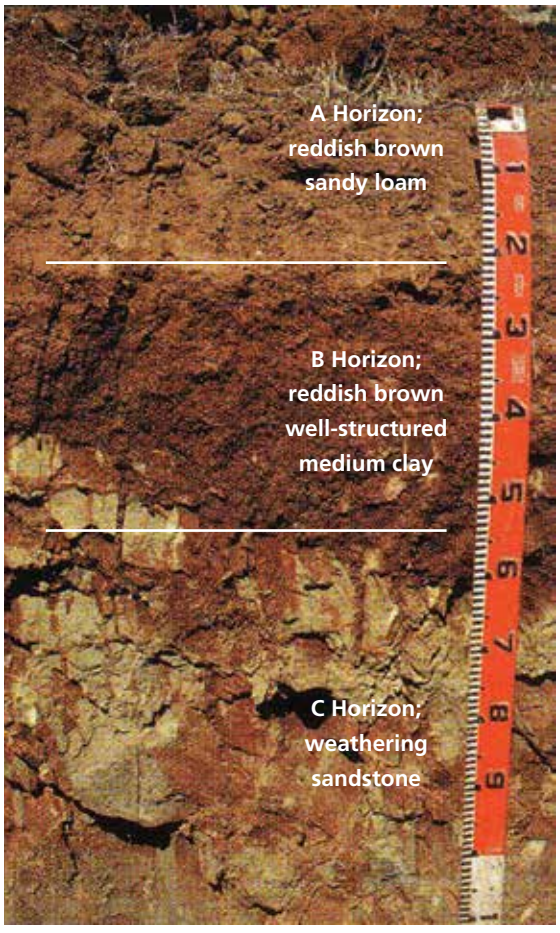


Figure 12. Hard red-brown texture contrast soils with highly calcareous lower subsoils

6.2 Soil types

Soils in the higher rainfall areas of the region are generally acidic and can exhibit low to moderate soil fertility with natural deficiencies in phosphorus, sulphur and molybdenum. Soils in low rainfall areas of the region such as the Adelaide Plains and the Northern Hills are generally neutral to alkaline. In highly alkaline soils manganese and copper deficiencies are likely to occur.

Highly leached sandy soils can create problems for pasture growth, since nutrients are readily washed through the soil profile (leaching). Pale or whitish soil horizons are often features of these soils. Maintaining sufficient nutrient levels to optimise plant growth is a more challenging task when managing these soils compared with the more fertile red brown earths.

There are many different soil types within the region such as the black cracking clays at Yankalilla through to peat soils at Willunga, so landholders should be aware of their soil type(s) and understand the level of fertility and barriers to plant growth.

Similar soil types in the region have been put into 'soil groups' and mapped. (Figure 13).

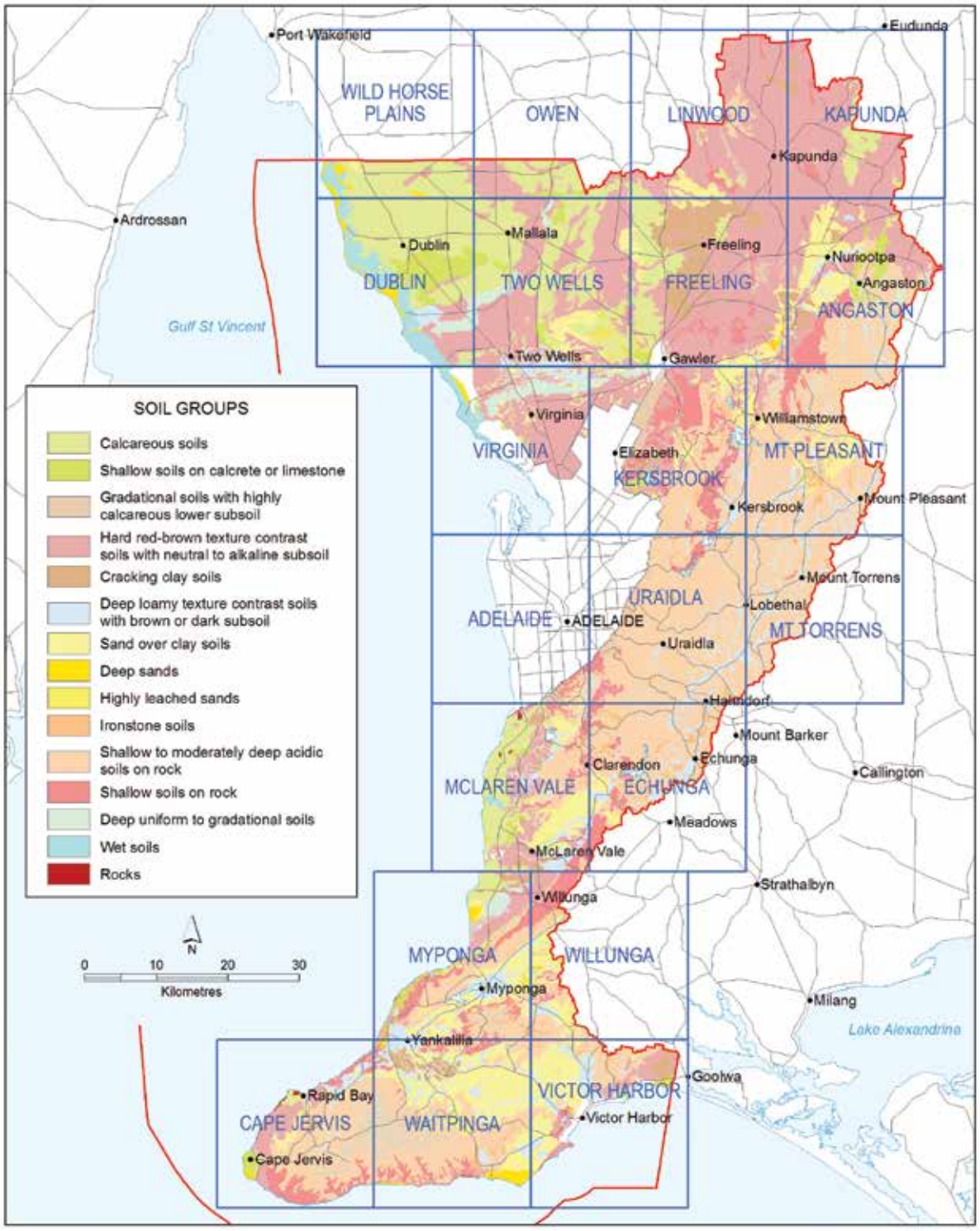


Figure 13. Soil groups of the Adelaide and Mount Lofty Ranges NRM region
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

The map depicts the distribution of 15 generalised soil groups, and is based on an interpretation of soil landscape mapping units, which invariably comprise several soils. The most commonly occurring soil group in each landscape unit is delineated on this map.

The groups are categorised as follows:

Group 1 Calcareous soils

Group 2 Shallow soils on calcrete or limestone

Group 3 Gradational soils with highly calcareous lower subsoil

Group 4 Hard red-brown texture contrast soils with neutral to alkaline soils

Group 5 Cracking clay soils

Group 6 Deep loamy texture contrast soils with brown or dark subsoil

Group 7 Sand over clay soils

Group 8 Deep sands

Group 9 Highly leached sands

Group 10 Ironstone soils

Group 11 Shallow to moderately deep acidic soils on rock

Group 12 Shallow soils on rock

Group 13 Deep uniform to gradational soils

Group 14 Wet soils

Group 15 Rocks

It should be pointed out however, that these maps are broad representations based on soil landscape mapping units, with the group name being determined by the dominant soil type. Other soil types will also be present. A soil landscape mapping unit is an area of land (typically 0.5 to 50 square kms in area) with recognisable topographic features and a limited range of soil types.

So while maps can be a useful guide to determine the likelihood of a particular soil type being present on the property, the only certain way to know what soils exist, is to examine the soil on site. Often cuttings can expose soil profiles, or landholders can use an inexpensive hand held auger to raise the various soil horizons. If necessary professional assistance can be sought to characterise the properties of the soil and gain a better understanding of what restrictions there may be to plant growth, and how best to manage that soil.

The following soil types, and their properties, are examples of soils from within the regional soil groups listed above, and which appear on soil maps throughout this document. It should be stated however, that the variability of soil types within soil groups means that landholders may not necessarily have soil profiles which are precisely the same.

Photographs and soil properties were obtained courtesy of the Soil and Land Program (2007).

Soil group 1: calcareous soils

Soil profile: Calcareous loam over clay loam over clay.

Location: Mallala, Easting: 268400, Northing: 6186450.

General description: Calcareous loam becoming more calcareous with depth, overlying substrate clay within 120 cm.

Drainage: Well drained. The soil rarely remains wet for more than a day or so following heavy or prolonged rainfall.

Fertility: Inherent fertility is moderate. Nutrient retention capacity is favourable, but high surface carbonate content reduces availability of phosphorus, copper, zinc, manganese and iron.

pH: Alkaline at the surface, strongly alkaline with depth.

Rooting depth: 68 cm at the pit site, with few roots below 15 cm.

Barriers to root growth: High pH, high boron concentrations and probable high sodicity restrict root growth.

Erosion potential: Water – low. Wind – moderately low.

Figure 14. Calcareous soil

Soil group 2: Shallow soils on calcrete or limestone

Soil profile: Red gradational loam over limestone.

Location: Cape Jervis, Easting: 246000, Northing: 6060850.

General description: Well-structured dark red loam grading to a red friable clay moderately shallow over calcareous rock.

Drainage: Well drained. The soil is unlikely to remain saturated for more than a day following rain.

Fertility: Natural fertility is moderate. At the pit site, phosphorus levels are low, copper and zinc appear to be low. Organic carbon levels are high.

pH: Acidic throughout. Dolomite is required.

Rooting depth: 60 cm at the pit site.

Barriers to root growth: Moderately shallow depth to rock is the main limitation. This will be highly variable across the paddock.

Erosion potential: Water – high, due to the slope of the land. The soil itself is relatively erosion resistant. Wind – low.

Figure 15. Shallow soil over limestone

Soil group 3: Gradational soils with highly calcareous lower subsoil

Soil profile: Gradational red clay loam.

Location: Willunga, Easting: 273500, Northing: 6094450.

General description: Well-structured clay loam overlying a finely polyhedral red clay with soft carbonate accumulations at depth, grading to sandy or sandy clay sediments.

Drainage: The soil is well drained and is never likely to be saturated. The calcareous subsoil is moderately sodic and indicates that excessive irrigation will cause a water table to develop within a metre of the soil surface.

Fertility: Natural fertility is high. Neutral pH helps to maintain nutrient availability.

pH: Neutral at the surface, alkaline with depth.

Rooting depth: 170 cm at the pit site, with few roots below 90 cm.

Barriers to root growth: The strong carbonate layer restricts root growth.

Erosion potential: Water – low. Wind – low.

Figure 16. Gradational soil with calcareous subsoil

Soil group 4: Hard red-brown texture contrast soils with neutral to alkaline subsoil

Soil profile: Loam over poorly structured red clay.

Location: Kapunda, Easting: 311350, Northing: 6201000.

General description: Hard loam to clay loam abruptly overlying a coarsely structured dispersive red clay, calcareous with depth, continuing below 100 cm.

Drainage: Moderately well drained. Water perches on the clayey subsoil for a week or so following heavy rainfall.

Fertility: Inherent fertility is moderately high. Nutrient availability is favoured by neutral pH. Trace element concentrations in the surface are satisfactory.

pH: Neutral at the surface, strongly alkaline with depth.

Rooting depth: 56 cm at the pit site.

Barriers to root growth: The hard dispersive clayey subsoil restricts root growth and density but does not prevent root growth.

Erosion potential: Water – moderately low. Wind – low.

Figure 17. Red brown texture contrast soil with alkaline subsoil

Soil group 5: Cracking clay soils

Soil profile: Grey cracking clay.

Location: Freeling, Easting: 300200, Northing: 6189850.

General description: Strongly structured dark cracking clay grading to a coarsely structured dark grey heavy clay with variable soft carbonate, over heavy clay

Drainage: Moderately well drained. The cracking soil accepts water readily when dry, but after the cracks close, water moves slowly through the soil.

Fertility: Natural fertility is very high. Nutrient retention capacity is very high. Zinc may be deficient, as is often the case on dark cracking clays.

pH: Alkaline at the surface, strongly alkaline in the subsoil.

Rooting depth: About 100 cm in the pit.

Barriers to root growth: The lenticular structure of the underlying light brown clay is very hostile to roots. High pH, high boron and high sodicity from 100 cm prevent any further root growth.

Erosion potential: Water – low. Wind – low.

Figure 18. Dark cracking clay soil

Soil group 6: Deep loamy texture contrast soils with brown or dark subsoil

Soil profile: Sandy clay loam over dark clay.

Location: Yankalilla, Easting: 272400, Northing: 6095850.

General description: Black medium to fine textured well-structured surface soil, overlying a dark, mottled clayey subsoil, calcareous with depth and formed on heavy clay.

Drainage: The soil is imperfectly drained. A perched water table can form with prolonged irrigation.

Fertility: The inherent fertility of the soil is very high. Phosphorus, potassium, calcium, magnesium and trace elements are all high by agricultural standards.

pH: Alkaline at the surface becoming strongly alkaline with depth.

Rooting depth: 200 cm in the pit, with few below 140 cm.

Barriers to root growth: The tight clay below 90 cm affects root proliferation to some extent. Salinity is high in the tree line and is almost certainly reducing yields. High alkalinity at depth will limit root growth.

Erosion potential: Water – low. Wind – low

Figure 19. Deep loam over dark clay

Soil group 7: Sand over clay soils

Soil profile: Sand over acidic clay.

Location: Back Valley, Easting: 273300, Northing: 6063100.

General description: Thick sandy surface soil, bleached with ortstein (coffee rock) nodules at base, overlying a yellow, brown and red clay subsoil grading to soft red, yellow and grey sandstone.

Drainage: Well drained. Soil is unlikely to remain wet for more than about a week.

Fertility: Natural fertility is low. This is due to the low clay content of the surface and the mineralogy of the clay in the subsoil.

pH: Acidic in surface, strongly acidic in subsoil, causing marginal aluminium toxicity, molybdenum deficiency and poor legume nodulation. Dolomitic lime is required.

Rooting depth: 120 cm at the pit site, but roots below 65 cm are confined to sand filled cracks.

Barriers to root growth: Low pH (with possible aluminium toxicity) and low nutrient status.

Erosion potential: Water – moderately low due to thick, highly permeable surface soil. Wind – moderate, due to loose sandy surface.

Figure 20. Sand over clay soil

Soil group 8: Deep sands

Soil profile: Deep bleached sand.

Location: Noarlunga, Easting: 283405, Northing: 6106750.

General description: Loose grey sand with a strongly bleached subsurface layer, becoming yellow with depth, over Tertiary sediments or a buried sand over clay profile.

Drainage: Rapidly drained. The soil rarely remains wet for more than a few hours at a time.

Fertility: Inherent fertility is low. Regular frequent monitoring and fertiliser applications are needed on these soils.

pH: Neutral to the surface, slightly acidic with depth.

Rooting depth: Roots continuing below 145 cm in the sampling pit.

Barriers to root growth: The only chemical barrier is low nutrient status and retention capacity.

Erosion potential: Water – moderately low. Wind – moderate due to low fertility, loose sandy surface.

Figure 21. Deep sand

Soil group 9: Highly leached sand

Soil profile: Imperfectly drained highly leached sand.

Location: Willunga, Easting: 279150, Northing: 6087300.

General description: Moderately deep loose sand overlying coffee rock (sand cemented by iron oxides and organic matter), grading to a yellow and brown sandy clay forming in soft red, yellow and grey sandstone

Drainage: Imperfectly to moderately well drained. Soil may remain wet for a week to several weeks.

Fertility: Natural fertility is low, due to the low clay content of the topsoil. Nutrients are easily leached from the topsoil.

pH: Acidic in the surface, strongly acidic at depth. Correction requires dolomitic lime.

Rooting depth: 115 cm at the pit site, but density is moderate to low throughout.

Barriers to root growth: Very few roots grow in the coffee rock and must grow through cracks to reach the underlying clay. The coffee rock is usually not continuous. Low fertility and low pH are major limitations to satisfactory root development.

Erosion potential: Water – low to moderately low. Wind – moderate, due to loose surface sand.

Figure 22. Highly leached sand

Soil group 10: Ironstone soils

Soil profile: Ironstone soil.

Location: Noarlunga, Easting: 288000, Northing: 6101650.

General description: Ironstone gravelly sandy loam overlying a yellow brown clay with red mottles at depth, grading to kaolinitic weathering rock.

Drainage: Moderate. A "perched" water table will form on top of the clay layer after prolonged rain, saturating the upper part of the soil for a week or more at a time.

Fertility: The natural fertility of the soil is moderate. Leaching associated with acidification is reducing the soil's fertility.

pH: Strongly acidic at the surface; acidic at depth. The acidification process must be controlled to prevent further nutrient leaching and release of toxic aluminium.

Rooting depth: 130 cm in the pit, but few roots below 40 cm.

Barriers to root growth: The clayey subsoil presents a minor constraint to root development. Low pH and possible aluminium toxicity. Moderate fertility.

Erosion potential: Water – moderate. Wind – low.

Figure 23. Ironstone soil

Soil group 11: Shallow to moderately deep acidic soils on rock

Soil profile: Acidic sandy loam over brown clay on soft rock.

Location: Kersbrook, Easting: 304150, Northing: 6151300.

General description: Medium thickness grey brown sandy loam over a friable orange clay grading to weathering schist.

Drainage: Moderately well to imperfectly drained. Water will "perch" in the bleached layer above the subsoil clay for periods of one to several weeks after prolonged rain.

Fertility: Natural fertility is low. Magnesium probably deficient.

pH: Acidic at the surface, strongly acidic at depth. Dolomite or high magnesium lime is needed for correction.

Rooting depth: 70 cm in the pit.

Barriers to root growth: Low pH (possible aluminium toxicity) from 45 cm.

Erosion potential: Water – moderately high. Wind – moderately low.

Figure 24. Shallow acidic sandy loam over brown clay

Soil group 12: Shallow soils on rock

Soil profile: Shallow sandy loam on rock.

Location: Echunga, Easting: 316775, Northing: 6114110.

General description: Medium to thick sandy loam with variable gravel, overlying weathering basement rock shallower than 50 cm.

Drainage: Rapidly drained. The soil rarely remains wet for more than a few hours following heavy or prolonged rainfall.

Fertility: Inherent fertility is moderate. These soils have about 15% clay, which is the minimum required to retain adequate levels of nutrient.

pH: Neutral.

Rooting depth: 70 cm in exposure, but roots only in cleavage planes of rock below 35 cm.

Barriers to root growth: The strength and depth of the underlying rock is the only limitation.

Erosion potential: Water – very high due to the slope. Wind – low.

Figure 25. Shallow soil over rock

Soil group 13: Deep uniform to gradational soils

Soil profile: Deep gradational clay loam.

Location: Forest Range, Easting: 299550, Northing: 6131050.

General description: Black well-structured silty loam to clay loam, overlying a black or dark grey blocky clay becoming yellow and grey mottled with depth.

Drainage: The soil is imperfectly drained due to its position in the landscape and its high clay content. The soil may remain wet for several weeks to some months.

Fertility: This soil is normally very fertile, but at this site the very low pH has weakened the nutrient retention capacity of the soil.

pH: Acidic at the surface and strongly acidic from 10 cm. This has caused severe leaching. Lime is needed for pH correction.

Rooting depth: More than 130 cm in the pit.

Barriers to root growth: Waterlogging due in part to tight clay layers at depth is the main physical constraint to root growth. High acidity and low nutrient retention capacity in the subsoil are the main chemical limitations (abnormal for this soil).

Erosion potential: Water – moderately low, provided that run on water is controlled. Stream bank erosion in creeks associated with these soils is more significant. Wind – low.

Figure 26. Deep uniform to gradational soil

7. Pasture types

7.1 Pasture elements

If livestock production is one of the primary objectives for your property, grazing paddocks will be much more productive if they contain pasture plants and few weeds. Pastures with a significant proportion of desirable pastures species will provide higher levels of livestock production and lower levels of animal health and land management issues.

The compostion of an ideal pasture can vary according to seasons, soil type and the purpose for which it is being used.

However pastures should always:

- be productive and meet the nutritional needs of stock
- withstand grazing and persist
- resist disease and weed invasion
- provide good ground cover throughout the year
- not cause livestock health problems.

Figure 27. Well balanced pastures contain a mix of legumes and grasses

Legumes and grasses

Nitrogen fixation

Low soil nitrogen is one of the most widespread nutrient problems in South Australia because it is easily leached from the soil. Legumes add nitrogen to soil naturally through a process known as 'nitrogen fixation' which occurs when Rhizobia bacteria in root nodules convert atmospheric nitrogen into soluble nitrogen to assists plant growth. On average, irrigated lucerne can add up to 225 kg/Ha of nitrogen to the soil each year, whilst clover can add approximately 60 to 100 kg/Ha. To see these nodules, carefully dig up any legume plant such as a clover, bean or pea. Gently wash off the soil to reveal small swellings on the roots. When they are pink in colour, the plant is fixing nitrogen.

Most pastures are made up of grasses and legumes (e.g. clovers). Grasses produce the bulk of pasture growth during the year, while legumes are important for producing high levels of digestible protein and greater amounts of calcium than grasses. All legumes are pod bearing plants which add nitrogen to the soil which is then utilised by grasses.

Ruminant (cattle and sheep) pastures should contain approximately 70% grass and 30% legume. Where the legume content is lower than 30%, the nutritional value of the pasture declines and dry matter production can decrease. However, when a mixed grass and legume pasture is dominant in legumes, the production level declines and animal health issues can arise.

The most common legume grown in the high rainfall areas of the region is subterranean clover (*Trifolium subterraneum*) (Figure 28).

Figure 28. Subterranean clover (*Trifolium subterraneum*)

Annuals and perennials

Pasture plants can be described as either 'annual' or 'perennial'. Annual plants survive for only one year and reproduce by setting seed in spring which germinates the following autumn e.g. subterranean clover (*Trifolium subterranean*).

Perennial plants have deeper root systems, live from year to year, and have the capacity to grow all year if water is available. Perennial ryegrass (*Lolium perenne*), phalaris (*Phalaris aquatica*) and cocksfoot (*Dactylis glomerata*) are common introduced perennial pasture grasses. One of the most productive introduced perennial legume is lucerne (*Medicago sativa*) which can be grown in a dryland situation, but is more commonly grown under irrigation.

Where annual legumes are germinating amongst perennial grasses, they can find themselves competing for water, light and nutrients with well-established grasses. This normally occurs at the break of the season in autumn. At this time it is important to ensure that grasses are grazed down to 5 cm avoid shading out the emerging legume seedlings.

Rainfall and soil type will play an important part in determining whether perennial or annual pastures are sown (or in some cases a mixture of both).

7.2 Pasture plants

Variability in rainfall, soil type, topography, salinity, acidity, rocks, erosion potential and limitations due to waterlogging will directly influence the nature of pastures found on small properties. In addition, the long term goals of individual landholders will play an important part in how pastures are maintained.

When deciding on how pastures are to be grown and managed, landholders should always consider the protection of natural resources. Ideally these decisions should be part of a whole of property planning approach which recognises different land classes and addresses long term sustainability issues.

Implementing any property plan should also be compatible with the broad aims of the Adelaide and Mount Lofty Ranges Natural Resources Management Board which promotes the importance of sustainable land management.

A range of different pasture types are found on small properties.

- Degraded pastures which have a high proportion of weed species, including broad leaf weeds (e.g. capeweed) and annual grasses (e.g. barley grass and brome grass). In general fertiliser inputs are low and pastures are set stocked.
- Summer growing native plants such as kangaroo grass (*Themeda triandra*) and brushwire grass (*Aristida behriana*) with no fertiliser or legume and are mainly found in lower rainfall areas.
- Native perennial species which normally grow through autumn to early summer such as wallaby grass (*Rytidosperma* spp. previously *Austrodanthonia* spp.) and weeping rice grass (*Microlaena stipoides*), along with introduced annual introduced legumes, some weeds and limited fertiliser applications.
- Older introduced improved pastures that have some perennial grass and legume but also have a weed burden. These pastures have had a fertiliser and weed control history but are currently not managed for high production.
- Highly productive introduced pastures with perennial grasses such as perennial ryegrass (*Lolium perenne*), phalaris (*Phalaris aquatica*), cocksfoot (*Dactylis glomerata*) in association with annual legumes. Weed content is low but fertiliser, weed control and grazing management inputs are high.

The following section highlights some of the characteristics of different pasture species and explains where they might suitably be grown.

Introduced pasture species

Perennial ryegrass (*Lolium perenne*)

A perennial grass which is native to Europe, Asia and North Africa, it was brought to Australia on the First Fleet and remains one of the most important grasses in high rainfall and irrigation areas. It is easy to establish, has good nutritional value and is highly digestible. Older cultivars contain an endophyte fungus which can affect the nervous systems of animals causing 'grass staggers'. Newly developed cultivars, which are labelled as AR1, do not affect grazing livestock.

Available cultivars differ greatly in maturity, growth habit, and resistance to disease and moisture requirements. Minimum rainfall is approximately 600 mm p.a. for dryland pasture cultivars. However as this plant does not have an extensive root system, its persistence under 750 mm p.a. rainfall is questionable especially when spring rainfall is poor. In a seeding mix, it is not compatible with other perennial grasses as it outcompetes the other grass seedlings. Perennial ryegrass is also ideal under irrigation where it can be sown with white clover. Sowing rates range from 8 to 30 kg/Ha depending on seed size, rainfall and irrigation.

Figure 29. Perennial ryegrass (*Lolium perenne*)

Phalaris (*Phalaris aquatica*)

Phalaris is a deep-rooted perennial grass native to the Mediterranean region, which requires at least 450 mm rainfall p.a. It is relatively drought tolerant and should persist, provided pastures are not overgrazed during spring. There are two types of phalaris; prostrate semi winter dormant types such as Australian and more upright winter active types such as Holdfast. Phalaris has a lower seedling vigour than perennial rye grass, so care should be taken at establishment. It will persist on a wide range of soil types including heavy waterlogged soils, but it is the most sensitive of the temperate grasses to acid soils, where aluminium toxicity can severely reduce growth. New varieties such as Holdfast GT and Advance AT have been breed to tolerate lower acidity and higher aluminium. In general it performs best on neutral soils. Although the risk is small, livestock may experience staggers when grazing phalaris dominant pastures that contain older varieties such as Australian. In some cases sudden death may occur during autumn and early winter. Animals should be moved to a non-toxic pasture and veterinarian advice sought. Newer varieties do not cause staggers as they have much lower levels of the alkaloid that causes this condition. Sowing rates are generally 2 to 4 kg/Ha when mixed with other cultivars, or 4 to 6 kg/Ha when sown as a sole grass.

Figure 30. Phalaris (*Phalaris aquatica*)

Figure 31. Cocksfoot (*Dactylis glomerata*)

Figure 32. Italian Ryegrass (*Lolium multiflorum*)
Photo: Will Hannaford

Cocksfoot (*Dactylis glomerata*)

Cocksfoot is a deep-rooted perennial grass of high to moderate drought tolerance (depending on the cultivar). Native to Northern Europe and the Mediterranean region, it requires a minimum of 450 mm rainfall. Cocksfoot varieties vary in their summer dormancy and the appropriate variety should be chosen depending on rainfall zone. High summer dormancy is suited to lower rainfall rains.

Cocksfoot will not tolerate waterlogged soils, but does grow well on more acidic soils. The quality, or perceived lack of quality, of cocksfoot has for some time been an issue, however, new cultivars are of a higher quality. Persistence and quality can be further improved by attention to grazing management. Cocksfoot does not contain animal toxins and is often recommended as a suitable pasture for alpacas and horses due to its lower sugar content.

Italian ryegrass (*Lolium multiflorum*)

Similar in appearance to perennial ryegrass, this pasture is suited to lower rainfall areas where perennial ryegrass will not survive. It is native to Europe and comprises both biennial and annual cultivars. Italian ryegrasses are generally used in short-term pastures for the production of quality hay or silage, but are sometimes used as a minor component of a perennial pasture. They are quick to establish and are of high nutritional value. Minimum rainfall requirement is 450 mm, unless irrigated cultivars are being used. Sowing rate is generally 15 to 30 kg/Ha depending on seed size, rainfall or irrigation.

Figure 33. White clover (*Trifolium repens*)

Figure 34. Subterranean clover (*Trifolium subterraneum*)

White clover (*Trifolium repens*)

White clover is a perennial clover native to Europe which is suited to regions which have at least 750 mm of rainfall p.a. or where irrigation is available. It is easy to establish and produces surface runners which form roots at the nodes. It will grow on a wide range of soil types, but is most highly productive on fertile soils. One method of differentiating white clovers is by its large leaf size, another by stolon density. Persistence in pasture is usually in those cultivars whose stolen density is highest, although some persistence can be attributed to seed set. When sowing irrigated pastures white clover is often mixed with perennial ryegrass or tall fescue. Sowing rates vary from 1 to 2 kg/Ha dryland, and 3 to 5 kg/Ha in high rainfall areas or where irrigation is available.

Subterranean clover (*Trifolium subterraneum*)

Native to the Mediterranean region, subterranean clovers grow on a wide range of soil types. Rainfall requirements vary from 250 mm p.a. to in excess of 750 mm p.a. depending on the variety. Subterranean clover is a self-regenerating annual which buries its seed in the ground. Some of the seed produced is 'hard seed' which is desirable where persistence is needed in drier parts of the subterranean clover zone. They add considerable quantities of nitrogen to the soil which benefit the growth of pasture grasses. Recently new varieties have been bred that are more resistant to red-legged earth mites. Together with a Time-Right spray strategy in spring that times the spray to reduce subsequent populations, reliance on broad spectrum insecticides in managing red-legged earth mite can be reduced. Sowing rates are generally 4 to 12 kg/Ha when mixed with perennial grasses. If irrigated, rates may be as high as 15 to 25 kg/Ha.

Table 7. Characteristics of some subterranean clover varieties

Sub species	Variety	Maturity	Hard seed levels	Disease resistance
Subterraneum	Denmark	mid to late	low	partially resistant to root rot; resistant to clover scorch
Subterraneium	Goulburn	mid to late	moderate	partially resistant to root rot; resistant to clover scorch
Subterraneium	Seaton Park	early to mid	moderate	resistant to root rot; susceptible to clover scorch
Yaninnicum	Gosse	mid	moderate	resistant to root rot; resistant to clover scorch
Yaninnicum	Riverina	mid	moderate	resistant to root rot; resistant to clover scorch
Yaninnicum	Trikkala	early to mid	moderate	resistant to root rot; resistant to clover scorch
Brachycalycinum	Antas	mid to late	low	partially resistant to root rot; resistant to clover scorch
Brachycalycinum	Clare	mid	moderate	partially resistant to root rot; resistant to clover scorch

Lucerne (*Medicago sativa*)

Lucerne is a deep tap rooted perennial legume. It is one of the oldest cultivated plants in the world and is prized for its drought tolerance and high quality as an animal feed. With proper establishment and management lucerne has the ability to survive for over 20 years. It requires well-drained fertile soils with a pH ranging from neutral to alkaline. All lucernes are summer active, but are rated on a scale of 1–10 by their amount of winter activity (1 is winter dormant, 10 is highly winter active). The choice of cultivar should, as a general rule, depend on its intended use and the area where it will be sown. Lucerne is most productive under irrigation where it can be rotationally grazed or cut for hay. It can also be sown into a dryland pasture mix where a 5–6 winter activity level is most suitable. Lucerne requires at least 250 mm of rain during the growing season. Sowing rates vary from 6 to10 kg/Ha for Dryland production, and 8 to 15 kg/Ha under irrigation.

Figure 35. Lucerne (*Medicago sativa*)

Tall fescue (*Festuca arundinacea*)

Tall fescue is a deep-rooted perennial grass native to Europe, the Mediterranean region, and Asia. Tall fescue is suited to soils of medium to high fertility and will tolerate some waterlogging and moderately saline conditions. There are now two distinctively different types, summer active and summer dormant. Summer active tall fescues have the ability to out produce perennial ryegrass during summer and require periodic summer rainfall or irrigation. Summer dormant types have the ability to persist in areas of very low rainfall. Older varieties such as Demeter are not that palatable but new varieties have been substantially improved. Tall fescue is most productive under irrigation, but can be included in dryland pasture mixes where rainfall is at least 450 mm p.a. The sowing rate is generally 10–20 kg/Ha.

Figure 36. Tall fescue (*Festuca arundinacea*)

Annual medics (*Medicago* spp.)

The term 'Medics' describes a particular group of annual legumes. They are predominantly suited to alkaline soils in medium to low rainfall areas. Medic species originated in Europe and are generally yellow flowered, and named according to pod appearance (i.e. snail, barrel, burr). The pods of most medics generally hold between 4 and 10 seeds per pod. Persistence and resistance to pests and diseases make them ideally suited to many areas. Generally sown in autumn, the seed should be sown to a depth of no more than 10 mm. The sowing rate, when blended with selected grass species, is usually between 5 and 10 kg/Ha depending on the variety.

Salt tolerant pastures

A soil test may reveal high salinity levels which preclude the sowing of many pasture species. In this case, the use of salt tolerant plant species is advised. Puccinellia (*Puccinellia ciliata*) and tall wheat grass (*Thinopyrum ponticum*) are suitable perennial grasses, while strawberry clover (*Trifolium fragiferum*) and balansa clover (*Trifolium michelanium*) are both tolerant of moderately saline soils.

Figure 37. Annual medic (*Medicago* spp.)

Native pasture species

In much of the Mount Lofty Ranges where rainfall is above 600 mm, native pastures are no longer present as they have been removed over the last 100 years through native vegetation clearance and the establishment of introduced pastures. If native grass pasture is present on your property, it is very important to preserve it as it provides valuable habitat for our native wildlife. Before considering any management changes to these pastures, contact Natural Resources Adelaide and Mount Lofty Ranges for advice.

Wallaby grass (*Rytidosperma* spp. previously *Austrodanthonia*)

There are over 30 different wallaby grass species with 14 of them found in South Australia. The main flowering time is spring with some flowering in autumn. They are drought tolerant, palatable and provide valuable year round green feed for livestock. Wallaby grass has a low sugar level and is suitable for horses. Pastures should be rotationally grazed to avoid dry leaf material which will lower feed utilisation.

They will tolerate frosts and a wide range of soil types provided they are not waterlogged.

Figure 38. Wallaby grass (*Rytidosperma* spp.)

Weeping rice grass (*Microlaena stipoides*)

A tufted low growing perennial with short rhizomes that can remain green all year. Microlaena is a competitive species and will respond to rotational grazing. It tolerates acid soils and is productive when rainfall exceeds 650 mm. It has a characteristic fine arching or weeping seed-head. Flowering time is summer to autumn.

Kangaroo grass (*Themeda triandra*)

Widespread across Australia, this tall (up to 90 cm) tufted summer active perennial grass does not tolerate continuous grazing, soil acidity, or increasing soil fertility. It is rare to find these grasses on properties which have a medium to high stocking rate.

It has a deep root system and is drought tolerant. Normal flowering time is early summer to mid autumn.

Figure 39. Weeping rice grass (*Microlaena stipoides*)

Figure 40. Kangaroo grass (*Themeda triandra*)

Spear grass (*Austrostipa* spp.)

Austrostipa species are common throughout the region with 39 species being located in South Australia. Most species grow actively in spring and early summer, while others make active growth in late autumn/winter. Nutritional value for stock is only medium and palatability can be a problem. The sharp seeds enter fleeces to downgrade wool quality.

Applications of fertiliser will cause spear grass to decline in numbers.

Windmill grass (*Chloris truncata*)

This tussocky plant is relatively short lived (2 to 3 years). The most rapid growth is made in spring and early summer. It has a low tolerance to frost and is only moderately drought tolerant. It regenerates from seed but is not generally noted as a productive pasture grass.

Figure 41. Spear grass (*Austrostipa* spp.)

Figure 42. Wndmill grass (*Chloris truncata*)
Photo: SARDI Entomology

Figure 43. Brush wire-grass seed head (*Aristida behriana*)

Brush wire-grass (*Aristida behriana*)

Brush wire-grass is a very common species of grass in low rainfall areas. A summer growing grass, it forms a low, compact tussock and has many flowering heads. Seeds can contaminate wool, although they do not have the strength to drive into skins. Brush wire-grass is very palatable and can form an important component of pastures in lower rainfall areas.

7.3 Pasture mixes

Before purchasing any pasture seed it is imperative to consider the four Evergraze principles to ensure successful pasture establishment and persistence; "Right plant (and variety) in the right place for the right purpose with the right sustainable grazing management". Rainfall, drainage, soil depth and soil acidity are an important part of this "right place" philosophy.

For example, lucerne requires deep, well drained soils which are neutral to alkaline with low aluminium levels, while subterranean clover prefers neutral to acidic soils. Phalaris will tolerate waterlogged soils but not highly acidic soils where aluminium toxicity can be a problem. Cocksfoot on the other hand, will grow well in acidic soils but not in waterlogged soils where fescue or perennial ryegrass is preferred. Sowing with a diverse mixture of different grasses used to be the preferred option but using the Evergraze principle of "right plant/variety in the right place" is now best practice in achieving maximum pasture production and sustainability.

Thinking about the "purpose" is also very important. How will the extra feed be utilised on a small property? Is the extra time and resources needed to establish new pastures worth it? Is it a lot easier to keep stocking rates low to just "keep the grass down"? In many cases, new owners of small properties jump into pasture improvement thinking it is necessary and will allow them to run many more livestock. However, more thought is needed prior to making this important decision as in many cases, the economics of pasture establishment on small properties do not stack up.

However, if pasture improvement is needed, the following examples represent a range of suitable mixes which could be used in particular circumstances. Professional advice should always be sought before choosing seed mixes, since improvements to pasture varieties are continuously being made. For further information go to **www.evergraze.com.au**.

Permanent introduced pastures

Options for dryland (non-irrigated) situations

Example 1. Rainfall >800 mm p.a.

Perennial ryegrass 20 kg/Ha

Subterranean clover 10 kg/Ha

Example 2. Rainfall >650 mm p.a.

Cocksfoot (summer active) 2 kg/Ha

Phalaris (winter active) 4 kg/Ha

Subterranean clover 6 kg/Ha

Where pH and fertility are at good levels chicory and Lucerne can be added to this mix

Example 3. Rainfall 500 – 650 mm p.a.

Cocksfoot 2 kg/Ha

Phalaris 4 kg/Ha

Subterranean clover 6 kg/Ha

Example 4. Rainfall 425 – 500 mm p.a.

Cocksfoot 2 kg/Ha

Phalaris 3 kg/Ha

Subterranean clover 6 kg/Ha

Note: In alkaline soils subterranean clover can be replaced with medics.

Option for dryland (non-irrigated) situation with poorly drained waterlogged soils

Example 5. Rainfall 550 – 700 mm p.a.

Phalaris 5 kg/Ha

Tall fescue 10 kg/Ha

Balansa clover 2 kg/Ha

Strawberry clover 3 kg/Ha

Options for dryland (non-irrigated) situations with saline soils

Example 6. Rainfall > 450 mm p.a.

Tall wheat grass 10 – 15 kg/Ha (slightly saline areas)

Balansa clover 1 kg/Ha

Strawberry clover 1 kg/Ha

Note: Tall wheat grass can spread and become invasive. It can also become very clumpy, so careful management is required for environmental protection, and to maintain feed quality.

Example 7. Rainfall > 350 mm p.a.

Puccinellia 6 – 10 kg/Ha (highly saline areas)

Balansa clover 1 kg/Ha

Strawberry clover 1 kg/Ha

For more information on suitable pasture for saline areas go to **www.saltlandgenie.org.au**.

Options for irrigated pastures

Landholders on small properties may have a licence to irrigate, however, using this precious resource is questionable when a well-managed dryland pasture will usually enable all of their lifestyle goals to be achieved.

In most cases, lifestyle landholders who wish to increase their livestock carrying capacity, could invest in a dryland pasture improvement program rather than irrigate, especially when many of these pastures have not been sown as recognised irrigation mixes.

However, for those who wish to maximise their production, a mixture of perennial ryegrass and white clover is commonly used to produce high quality feed under irrigation. The following pasture is ideal for grazing, hay and silage production.

Example 8.

Perennial ryegrass 25 kg/Ha

White clover 6 kg/ha

Annual pastures

Some areas with low rainfall do not support permanent pastures, unless irrigation is available. This can create problems for small landholders who do not possess the machinery to undertake sowing of short term annual pastures each year. Contractors or local farmers can provide support in these circumstances, however the key objective should always be to ensure enough ground cover is maintained to avoid any soil erosion.

Sowing annual ryegrasses for hay, silage or grazing is common in low rainfall areas. However, these pastures, known as short term Italian ryegrasses, will only last one or two years. They are often sown with annual medics (or clovers) to lift the protein value in hay.

Where an annual pasture is required which will eliminate the need to sow each year it is best to choose a species which is self regenerating from the seed it produces each spring. 'Safeguard' annual ryegrass is recommended as a self regenerating vigorous variety which is resistant to annual ryegrass toxicity (ARGT).

Safeguard ryegrass will crossbreed with the local ryegrass species such as Wimmera, to produce ARGT resistant seeds which germinate the following year.

This has been developed for the drier regions of South Australia and has excellent winter pasture production and is resistant to the root disease Take-all. This is an option for small horse properties where grazing in spring can be controlled to allow adequate seed set for germination the following autumn.

It is necessary to sow only certified seed of Safeguard to ensure the pasture remains free of ARGT.

Options for dryland (non-irrigated) situations with low rainfall e.g. Adelaide Plains

Example 1. Self regenerating annual ryegrass (no ARGT) Rainfall 350 – 500 mm p.a.

Annual ryegrass 10 to 15 kg/Ha (Safeguard)

Medics 5 kg/Ha

Lucerne 2 kg/Ha

Example 2. Grazing, silage or hay mix. Rainfall 350 – 500 mm p.a.

Oats 40 kg/Ha

Annual Italian ryegrass 17 kg/Ha

Medics 5 kg/Ha

Example 3. Grazing, silage or hay mix. Rainfall 350 – 500 mm p.a.

Annual Italian ryegrass 17 kg/Ha

Balansa clover 3 kg/Ha

Example 4. Grazing, silage or hay mix. Rainfall 350 – 500 mm p.a.

Annual Italian ryegrass 15 kg/Ha

Shaftal persian clover 10 kg/Ha

Example 5. Grazing, silage or hay mix. Rainfall 350 – 500 mm p.a.

Annual Italian ryegrass 10 – 15 kg/Ha

Medics 5 kg/Ha

Lucerne 2 kg/Ha

Other pastures

Lucerne

For the better drained soils with neutral to alkaline pH, lucerne has generally performed well.

Sowing rate in 400 to 800 mm rainfall areas is 4 to 8 kg/Ha. If irrigated, the rate is 15 to 20 kg/Ha. If a grass is required for a mixed dryland pasture add 1 to 3 kg/Ha of cocksfoot and phalaris. Over-sowing grasses the following autumn after lucerne is established works well, however, lucerne can be successfully established if sown in late April with cocksfoot, phalaris and clover or in mid September in a La Nina year.

Kikuyu

Kikuyu is a perennial prostrate grass which spreads by runners, rhizomes and seed. Late spring, summer and early autumn are the main growing season. It is generally managed as a dryland pasture if rainfall is >500 mm per annum.

On medium input horse properties, where paddocks are generally small and grazing is restricted to a few hours each day, kikuyu is an option provided it is managed well. If no legumes are present in the pasture, consideration will need to be given to applications of nitrogen and in low rainfall areas (<500 mm p.a.) limited irrigation during summer will encourage production and help to maintain good ground cover.

It will tolerate a range of soil types (both alkaline and acid), and is best established by seed sown in spring. A suitable sowing rate is 2 kg/Ha. If a legume is required use Balansa clover.

However kikuyu is invasive and does not provide any growth in winter. Careful consideration should be used before deciding on using kikuyu.

8. Pasture establishment

8.1 Permanent pasture in medium to high rainfall areas (>450 mm p.a.)

8.1.1 Deciding to re-seed

In many cases pastures that are weedy and unproductive may not have to be re-seeded if enough desirable pasture species are present. Re-seeding is expensive and careful attention to soil fertility, weed control and appropriate grazing can restore paddock health and productivity without the need to spray out the old pasture and start again. Some paddocks that look unproductive may have native grasses and other native broadleaf species present. These paddocks may provide valuable habitat for our native wildlife. Advice should be sought from Natural Resources Adelaide and Mount Lofty Ranges prior to any management changes in these types of paddocks.

Degraded introduced pastures which contain very few good pasture species and are dominated by weeds, may need to be re-sown. In these circumstances it is important that clear benefits will be observed, because the process can be expensive and is not without risks. The presence of weeds alone is not necessarily a good reason to start again with a new pasture. Before making the decision to re-sow, thought needs to go into the four principles of Evergraze; "Right plant (and variety) in the right place for the right purpose with the right sustainable grazing management".

Some pastures may only require additional seed and could be 'over-sown' to improve the density. If unsure, landholders should seek professional advice before embarking on the process of 'pasture renovation' (i.e. sowing a new pasture).

The first step when deciding if a pasture needs to be re-seeded is to undertake an assessment of good pasture species. As a guide, a minimum of 20 perennial grass plants and 60 clover plants per square metre should be present to avoid re-seeding the pasture. This figure may be higher for intensively grazed properties. A professional and experienced consultant can provide help if necessary.

Figure 44. Fence off difficult sites for conservation purposes

Landholders should also be aware that no grazing will be possible during the first 3 months of a newly sown pasture, and only limited grazing will be available for another 9 months, so the feed requirements of all livestock on the property will need to be considered for that year.

Unless paddocks need to be levelled (i.e. the surface smoothed), the recommended technique for re-seeding is 'direct drilling'. This involves the use of non-selective herbicides to control weed growth during autumn, after which the pasture seed is drilled into the soil with minimum soil disturbance.

Cultivation of highly erodible soils on steep slopes poses a high erosion risk, particularly when carried out over summer and autumn during the high intensity rainfall period. In these circumstances landholders should seek professional advice to avoid the risk of environmental damage.

Paddocks with severe limitations for sowing pasture seed, such as rocks, steep slopes and erodible soils, may be better fenced off for conservation purposes. These areas can be revegetated with native trees and shrubs which will create shelter for livestock.

Landholders should also be aware that native grass pastures on steep land which is difficult to manage, can provide good grazing. Attempts to re-seed these areas is not wise and can result in degraded sites at risk of erosion.

If a pasture is to be re-seeded, landholders require a detailed seasonal action plan covering two years. Inexperienced landholders should consider engaging a professional land management consultant, or agronomist, who will be able to consider local conditions when developing the plan.

8.1.2 Developing a two year plan

It is important to ensure that good weed control is carried out in the year prior to seeding. Many failures can be attributed to pasture seedlings not being able to compete with stronger more vigorous weed seedlings during autumn.

The plan should consider:

- control of pests
- appropriate pasture varieties
- sowing rate
- requirements for inoculation of legume seed
- soil preparation
- time of seeding
- soil testing and fertiliser applications
- correcting soil acidity
- grazing management.

Figure 45. Direct drill pastures in high rainfall areas

Checklist

It is important for landholders not to rush into re-seeding. Follow a two year plan to establish a new pasture and do not omit any steps in the process. The following checklist is suitable for establishing pastures in high rainfall areas of the Mount Lofty Ranges.

1. Assess, select and plan early

- Assess existing pasture, weeds and soil fertility.
- Seek independent professional advice if unsure whether to re-sow.
- Check on the availability of equipment and/or contractors.

2. Control weeds/pests the year before sowing

- Spray or spray-graze to control broadleaf weeds.
- Spray metsulfuron-methyl to control Guilford Grass or Dock (late July).
- Spraytop, slash or graze to control annual pasture weeds.

3. Check soil fertility

- Soil test over summer to check fertility levels.
- Apply lime (if required) anytime up to sowing.
- Seek advice on a suitable fertiliser program.

4. Graze prior to sowing

- Graze well over summer to remove residues.

5. Control weeds and pests in autumn

- Allow a full weed germination after the autumn break (normally 3 weeks after opening rains).
- Spray appropriate herbicides/insecticides to control weeds and pests (e.g. redlegged earth mite).
- Harrow paddock only if surface has to be made even. Cultivate to achieve a firm, fine weed-free seedbed.

6. Ensure adequate soil moisture

- Don't sow on the first autumn rains.
- Sow into moist soil after weeds have been controlled.
- Sowing can commence if significant rain (> 12 mm) is likely soon afterwards.

7. Place seeds accurately when sowing

- Direct seed to achieve 5 to 10 mm soil cover over seed.
- As a guide, around 5% of the seed should be visible after sowing.

8. Monitor weeds and pests

- Check weekly for any pasture pests and weeds.
- Treat problems promptly.

9. Strategically graze new pastures

- First graze when plants are 10 cm tall and well anchored.
- Graze heavily but quickly down to around 3 cm.
- Re-graze when plants again reach 10 cm tall.
- Reduce grazing pressure in the first spring (allow cocksfoot and phalaris to set seed).
- Do not graze with horses in the first year of a new pasture.
- Do not cut hay in the first year of a new pasture.

8.1.3 Sowing techniques

The risk of soil erosion is significant in parts of the Adelaide and Mount Lofty Ranges region. Steep slopes and light textured soils are most likely to be at risk during high intensity rainfall events. Consequently choosing an appropriate sowing method should be determined after considering:

- soil erodibility
- the slope of the paddock
- the nature of vegetation cover
- availability of appropriate machinery.

There are several techniques that can be used.

Direct drilling

This is the most appropriate technique for sowing pastures in this region and involves sowing seed directly into undisturbed soil after paddock weeds have been treated with a non-selective herbicide (Figure 46).

The use of narrow points on sowing machinery contributes to successful sowing and helps with the correct depth of seed placement.

Figure 46. Apply glyphosate herbicide prior to direct drilling a new pasture

Minimum tillage (harrowing and sowing)

This technique involves limited cultivation, often with a harrow, and usually in combination with one or more herbicide applications (Figure 47). It is generally not recommended in high rainfall areas on steep slopes due to the risk of soil erosion. However there may be cases where heavier textures soils with gentle slopes can be treated this way to clean up the surface and smooth areas which have become pugged due to livestock trampling.

Landholders should note that any disturbance of the soil can lift weed seeds to the surface which will compete with sown pasture seeds. Excessive harrowing can also destroy the structure of soils and lead to surface crusting.

Broadcast sowing

Broadcasting can be carried out using a fertiliser spreader and combining the seed with the fertiliser. The success of this technique depends upon how clean the paddock surface is, so landholders are advised to use livestock to graze down pastures during summer before sowing in autumn.

Hand broadcasting is another alternative for landholders who have small paddocks, limited machinery and cannot engage contractors. To improve establishment of seedlings, the sowing rate should be higher than normal recommendations.

Aerial sowing

This is only recommended where ground sowing is not possible. The technique involves using aircraft to apply herbicides followed later by pasture seed and fertiliser. It is costly and nowhere near as successful as other ground based techniques.

Figure 47. Paddocks may have to be lightly harrowed before sowing

8.1.4 Pasture management calendar

The following calendar is a guide only, since management will vary according to average rainfall, seasonal conditions, soil types, slopes, aspects, pasture species and the type of stock grazing. On small lifestyle properties, hay cutting will depend upon the availability of machinery and or contractors. If it is not possible to cut hay, overgrown paddocks may need to be slashed, or grazed by additional livestock brought into the property. If left untouched during late spring and summer, overgrown pastures may become rank and unpalatable to livestock, and also create a fire hazard.

Table 8. High rainfall permanent pasture management calendar (e.g. perennial ryegrass and subterranean clover)

Month	Activity
January to March	Graze down dry residues to 3 cm. Do not overgraze, and maintain a minimum 70% cover. Supplementary feed livestock. Soil test paddocks to determine fertiliser and lime application rates. Lime paddocks in March, if necessary.
April	Fertilise according to soil test reports. If fertilising close to watercourses, split applications are recommended (half in autumn and the remainder in early spring). Control redlegged earth mite, lucerne flea and pasture cockchafer, if present.
May	Inspect for weeds, spray early for annual broadleaf weeds, if necessary. Control insect pests, if necessary. Graze paddocks in rotation.
June and July	Inspect for weeds, spray for perennial broadleaf weeds, if necessary, and follow instructions for safe applications and livestock withholding periods. Spray for Guildford Grass in late July if dense infestations present. (If spraying for Guildford grass in late July with metsulfuron-methyl, pastures may need to be re-sown the following year). Apply 10 to 20 kg/Ha of nitrogen to grass dominant pastures.
August	Apply NPK fertiliser in late august to hay paddocks. Close these paddocks off in mid-august if cutting hay.
September and October	Watch for insect pests (e.g. lucerne flea and redlegged earth mite) and control if there is a problem. Refer to Timerite website: **www.timerite.com.au**. 'Spray top' annual grasses in weedy paddocks (seek professional advice). Hard graze paddocks not cut for hay, especially if weedy.
October and November	Cut pasture for hay or silage. (It is important **not** to cut hay off the same paddock year after year since this will encourage the build-up of annual weeds and reduce the quality of pasture. Hay paddocks should be rotated over a 3 to 4 year cycle). Continue to rotationally graze. Aim to have 10 cm of pasture cover by the end of December.
December	Continue to rotationally graze. Always keep a minimum of 70% cover.

8.2 Pasture in low rainfall areas (250 to 450 mm p.a.)

Maintaining perennial grass pastures in low rainfall areas is difficult. In sandy soils perennial veldt grass may have established, or landholders may be fortunate enough to have native grasses. However, relying on annual pastures each year is common. These may need to be re-seeded each year depending on the cultivars used. A range of cultivars for low rainfall areas is outlined in Chapter 7.

8.2.1 Sowing annual pastures

- Conduct a soil test to determine fertiliser requirements.
- Graze down dry residues to 3 cm in autumn prior to sowing the seed.
- Allow weeds to germinate following the opening rains (usually late April) and spray out with Glyphosate.
- Sowing can be undertaken during May or early June provided it is not too cold.
- Seed is best sown by direct drilling, however on small paddocks broadcasting seed may be appropriate. It is important to run a light chain or a piece of weldmesh over the paddock if broadcasting seed.
- Ensure fertiliser is applied when the seed is sown.
- Watch for weeds and pests after the pasture has germinated and apply appropriate chemical sprays if necessary.
- Allow the plants to establish before grazing. This usually when the roots are firmly held in the ground and plants cannot be pulled out by livestock.
- Once the pasture is approximately 12 cm in height graze down to 5 cm and rest the pasture. Graze again when 12 cm and rest when plants reach 5 cm. This rotational grazing approach is important to best utilise the pasture.
- It is important not to graze annual pastures too heavily in spring, since it is a time when you should be encouraging seed production which will germinate again next autumn.
- These pastures can also be sown to produce good hay to feed out during summer and autumn when paddock feed is low.

9. Soil testing, fertilisers and liming

Soils are dynamic ecosystems containing vast numbers of living organisms, mineral particles and organic matter which provide water, nutrients and air for plant growth.

Appropriate management of soils is critical to avoid degrading them to the point where plant growth suffers. The continued removal of plant products without the addition of fertilisers will result in a loss of crucial soil nutrients. The physical condition of a soil, together with its chemical and biological status is used to measure soil health. Nutrient levels, soil acidity and erosion can all impact on the health of a soil.

Correcting soil nutrient levels is important, however overuse of fertiliser can be a source of water pollution. This is an important issue to consider throughout the high rainfall areas of the Mount Lofty Ranges. Where fertiliser applications are being made near a watercourse it can be beneficial to split the applications so that half is applied in autumn and the other half in spring.

If soil nutrient levels are low it is important to apply fertiliser to counter poor plant growth which can often lead to a lack of ground cover, increased weed growth and erosion.

Figure 48. Shallow soils over rock are common in some parts of the region

9.1 Soil testing

Laboratory tests on soil samples will measure the nutrient status of soils and indicate the level of soil acidity (pH). From this information the type and amount of fertiliser for each paddock can be determined, and if lime is required, to correct soil acidity, an accurate application rate can be calculated.

Spring and summer is the best time to test soils, once they are dry, since this is when the nutrient levels are the most stable and the test results most reliable.

Leaf tissue tests are sometimes required to accurately measure trace element deficiencies e.g. copper, zinc and manganese. Foliar sprays can be used to rectify these deficiencies. Test kits should provide details of sampling procedures.

A soil test is essential prior to liming, or when re-seeding pastures, or when sowing a new crop. It is also important to test soils on a regular basis (every three to four years) to monitor the effect of management on soil fertility and pH.

Different soil types should be sampled separately. Aim to take a representative sample of a relatively uniform area, avoiding stock camps, tracks, headlands, etc. where conditions may not be representative. If testing pasture or cropping paddocks, approximately 30 cores to a depth of 10 cm (if possible 15 cm) should be collected and mixed thoroughly for laboratory testing. Soil samplers can be borrowed from most natural resource centres.

Figure 49. Collecting a soil sample for testing

Soil test results will identify nutrient deficiencies, but if assistance is required, when calculating the level of fertiliser or lime to apply, always seek independent professional advice.

An important principle to keep in mind when applying fertilisers is that production is linked to the most deficient nutrient. For example, an application of phosphorus can be wasted if another element is limiting plant growth, so ensure that all nutrients levels are adequate and represent the correct balance of plant nutrients.

9.2 Soil acidity

Acid soils predominate in the higher rainfall areas of the region which includes the Mount Lofty Ranges and the Fleurieu Peninsula, while alkaline soils are generally found on the Adelaide Plains.

Pasture production from soils which are highly acidic, or highly alkaline, can decline resulting in economic losses for landholders. Soils are often characterised as being acidic, or alkaline, and measured using the term pH. The pH scale covers a range from zero to 14.0 with 7.0 being neutral (Figure 50). If soils are measured at less than pH 7.0 (in water) they are considered to be acidic. If they are less than pH 5.0 (in water) they are considered to be strongly acidic. The ideal pH range for most plants is from 6.5 to 8.5 (in water).

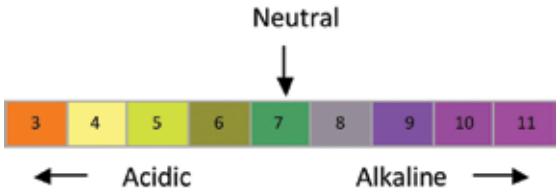


Figure 50. Soil pH scale

Figure 52. Field pH testing kit

A field kit, consisting of barium sulphate, universal indicator and a colour chart, can give an indication of soil pH (Figure 52).

Small hand held meters are also available to measure soil pH.

However, a laboratory soil test should be undertaken to measure the precise pH reading. Most laboratories measure pH by two methods (pHwater and $pHCaCl_2$). Typically $pHCaCl_2$, (i.e. pH calcium chloride) is about 0.8 units lower than pHwater, but gives a more accurate measurement in acidic soils.

Causes

Acidification is caused by:

- organic matter decomposing and producing organic acids
- nitrogen compounds being added to soils e.g. fertilisers and legumes such as clovers, lucerne and lupins
- removal of alkaline elements in crops and hay.

Figure 51. Plants indicating soil acidity

51a: Guildford grass (*Romulea rosea*)

51b: Sorrel (*Rumex acetosella*)

51c: Fog grass (*Holcus lanatus*)

In high rainfall areas, such as the Mount Lofty Ranges, nitrogen compounds are naturally leached from the soil profile, leaving acid conditions behind. However, land management practices, such as pasture production and removal of nutrients in farm products (e.g. hay and silage) can accelerate this process.

The addition of urea, ammonium sulphate and ammonium nitrate fertilisers have a major acidifying effect.

Some soils can be naturally alkaline, such as parts of the Adelaide Plains, with some being caused by the presence of calcium carbonate.

Consequences of soil acidity

Most of the detrimental effects of soil acidity are due to plant nutrients becoming less available (Figure 53). For example, phosphorus which is needed by all plants for good root development, can become tied up with other nutrients at low pH and become insoluble and therefore less available to plants. In addition, nutrients such as iron, aluminium and manganese can become toxic to plants.

When this occurs, plant growth slows and dry matter production declines which can result in poor vegetative cover and exposed soil.

Phalaris and lucerne, are especially susceptible to aluminium toxicity at low pH, and overall production can be severely reduced.

Significant economic losses can also occur in agricultural production systems if soil acidity is not recognised and treated.

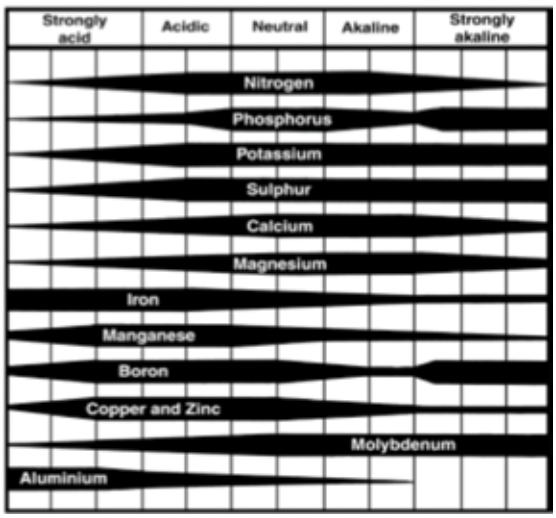


Figure 53. Nutrient availability

Correcting soil acidity

Acidity is a form of soil degradation which can be corrected by the addition of lime (calcium carbonate). The lime neutralises the acid and raises the pH.

There are a number of different lime materials such as:

- calcium carbonate
- hydrated lime
- burnt lime.

These, and various other liming materials, vary in their neutralising capacity. Good lime should have a neutralising value of at least 80 (i.e. 80% as effective as pure calcium carbonate) but should not be so fine that it blows away when spread, or too coarse that it reacts extremely slowly in the soil (Figure 54).

Dolomite lime (calcium magnesium carbonate) should be used where soil test indicates a deficiency in magnesium.

Figure 54. Particle size varies with different lime products

Figure 55. Lime spreading on pasture
Photo: PIRSA Rural Solutions SA

Lime requirements

The amount of lime required to reduce acidity will depend upon:

- soil texture
- initial pH
- target pH.

In all situations lime should be added to prevent the pH from falling below 5.0 ($CaCl_2$). The target range for extensive grazing on small properties will depend to some extent on the stocking rate, but an acceptable range is pH 5.0 to pH 5.5. In intensive grazing situations aim for the ideal pH of 5.5.

Table 9. Lime requirements to raise soil pH by approximately 1 unit (e.g. raise pH ($CaCl_2$) from 5.0 to 6.0)

Soil texture	Average (tonnes/ha)
Sand, loamy sand	2.0
Sandy loam	3.25
Loam, sandy clay loam	4.5
Loamy clay	5.0

There is a range of soil acidity information and decision tools available:

Ag Excellence Alliance: Soil acidity – **http://agex.org.au/project/soil-acidity**

Natural Resources Adelaide Mount Lofty Ranges: Small Talk Autumn 2017 – **www.naturalresources.sa.gov.au/adelaidemtloftyranges**

Agriculture Victoria: Soil acidity monitoring tools – **http://agriculture.vic.gov.au/**

Soil quality: Soil acidity – **www.soilquality.org.au/factsheets/soil-acidity**

PIRSA: Action on acid soils – **http://pir.sa.gov.au**

The following map (Figure 56) illustrates the distribution of acidic topsoil in the AMLR NRM region. Those shown as neutral to alkaline have pH (in water) of 7.0 to 14.0. Where soils are acidic with moderate to high buffering capacity (i.e. soils which contain clay particles that resist changes to soil acidity), high amounts of lime are often required to correct soil acidity. The pH (water) range of these soils can be 6.5 to 6.9. Acidic soils with low buffering capacity can have a pH (water) range of 5.5 to 6.4, while strongly acidic soils with low buffering capacity are often less than 5.4.

Table 10. Preferred ranges of pH (water) for some agricultural crops

Crops	Preferred pH (water) range
Barley	6.0 to 8.5
Oats	4.5 to 8.0
Wheat	5.5 to 8.5
Triticale	4.5 to 8.5
Lupins	5.0 to 7.0
Strawberry	6.5 to 7.5
Apple	6.0 to 7.0
Bean	5.5 to 7.5
Brussel sprouts	6.5 to 7.5
Clovers	5.5 to 7.0
Cocksfoot	5.0 to 7.5
Ryegrass	5.5 to 7.0
Lucerne	6.0 to 8.0
Phalaris	6.0 to 8.0

Correcting alkaline soils

Alkalinity can be reduced by adding sulphur, however few soils show an economic response due to excessive amounts of free limestone which counters the impact of sulphur. Growing legume based crops, such as field peas, lucerne and annual medics, may help to reduce pH to some extent, but to avoid poor plant growth it is important to grow crops which tolerate a high pH.

In alkaline soils (high pH) phosphorus can become tied up and less available to plants, and molybdenum can become toxic in some soils. Boron may also be toxic in soils with high pH, but be deficient in acid soils (low pH). Soils which are higher than pH 8.5 can also have significant levels of the element sodium. These soils are known as 'sodic' soils and can limit plant growth.

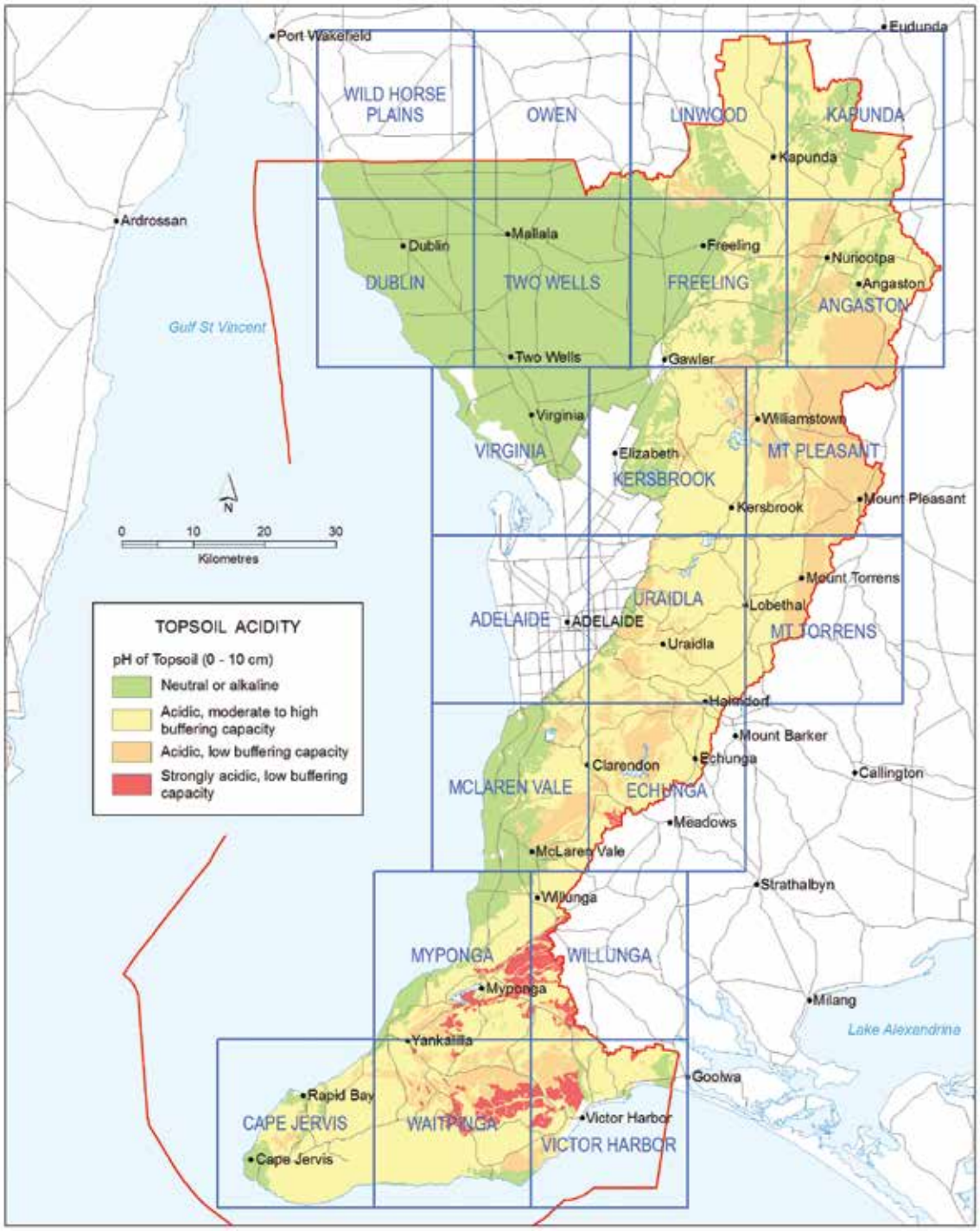


Figure 56. Topsoil acidity in the Adelaide and Mount Lofty Ranges NRM region
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

9.3 Nutrient requirements

Plants require a range of nutrients to grow successfully and if levels of these are not adequate in soil, production will decline and animal health may be affected. The most common nutrients applied to soils in South Australia are phosphorus and nitrogen.

Nitrogen (N)

Plants require nitrogen to make protein, and require large amounts for normal leaf growth. It can be one of the most widespread nutrient deficiency problems in South Australia because it is easily leached from the soil. Fortunately, legumes add nitrogen to soil naturally through a process known as 'nitrogen fixation'. On average, lucerne can add approximately 225 kg/Ha of nitrogen to the soil each year, whilst clover can add up to approximately 100 kg/Ha.

Phosphorus (P)

Most Australian soils, in their natural state, suffer from phosphorus deficiency. Available phosphorus in soil encourages good root growth. Plants suffering from stunted growth may be lacking phosphorus.

Potassium (K)

Potassium deficiencies are generally rare in South Australian soils, however, continual cutting of hay will remove large quantities of this nutrient. Potassium is required by flowers and seeds.

Sulphur (S)

Sulphur deficiencies are generally not widespread in soils containing sulphate compounds and reasonable levels of organic matter. Common high analysis fertilisers were often low in sulphur, but this nutrient is now being added to improve soil nutrient levels. Gypsum is a good source of sulphur.

Calcium (Ca)

Most Australian soils have sufficient calcium in the form of limestone, calcrete, and 'soft' lime. However, some soils can be low in calcium which leads to plant disorders, especially in horticulture.

Magnesium (Mg)

Sandy soils in high rainfall areas can be heavily leached resulting in a deficiency of magnesium. These soils can also be quite acidic, in which case dolomite lime may need to be spread. This type of lime will not only correct the level of the acidity, but it will also add magnesium to help correct deficiencies.

Trace elements

Trace elements are required by plants in only small quantities, but they still have the capacity to severely impede the growth of plants.

Examples include:

- copper (Cu)
- manganese (Mn)
- zinc (Zn)
- molybdenum (Mo)
- iron (Fe)
- boron (B)
- cobalt (Co)
- selenium (Se).

Any product removal from paddocks, be it hay, milk, meat, wool, depletes the nutrient "bank" in the soil (Table 11). These nutrients need to be replaced, and this is best determined from the results of a soil test. From this analysis suitable fertilisers can be applied to lift nutrient levels.

Table 11. Nutrient loss from a paddock

Statistics	Kg of nutrient/ha/year		
	Phosphorus	Potassium	Sulphur
Hay (4.5 t/ha meadow hay)	11	45	9
Milk (irrigated, 3 cows/ha)	14	27	8
Meat (7.5 crossbred lambs/ha)	2	1	2
Cereal Crop (barley, 2.5 t/ha)	7	13	4
Legume Crop (peas, 2.5 t/ha)	11	25	6
Wool (30 kg/Ha)	0.2	0.4	1.4

Table 12. Nutrient content of particular fertilisers

Fertiliser	N:P:K:S
Conventional	
Super phosphate – low analysis	0:8.8:0:11
Triple superphosphate	0:20:0:0
Urea	46:0:0:0
Sulphate of Ammonia	21:0:0:23
Blends	
Super potash 4/1	0:7:10:8.8
Hayboosta	12:5:24:5
Blends with trace elements	
Superfect (Cu 1.0%, Zn 1.0%)	1:10:0:10
Organic	
Blood and bone	5:5:0.5:4
Fertico organic	3:4:2:3
Sheep manure	1.7:0.8:0.63:0.24
Slow release	
Reactive rock phosphate (acid soluble)	0:12.5:0:1.4

Choosing fertilisers can be confusing, so in order to determine how much of a particular product to add, the 'nutrient analysis' for each fertiliser should be known (see Table 12). This is usually expressed as a ratio e.g. DAP (di-ammonium phosphate) has a ratio of 18:20:0:1.6 where the nutrients are N:P:K:S.

Hence DAP contains 18% nitrogen, 20% phosphorus, 0% potassium and 1.6% sulphur.

10. Stocking rates, grazing pressure and dry sheep equivalents

For lifestyle landholders, the type and numbers of livestock they run on their individual property will often vary widely depending on why they chose to purchase land in the first place.

The region is home to numerous recreational horse properties, often with no agricultural pursuits at all. On the other hand, sheep, cattle and alpacas are the chosen livestock for many other property owners. In nearly all cases there is a reliance on pasture production to manage a particular number of animals, so getting the numbers right is paramount for animal welfare and to manage our natural resources.

Under-grazed properties can pose a risk of fire and promote weed infestations, while over-grazed properties can lead to serious environmental damage and land degradation.

Soil type and rainfall are two important environmental factors which influence stocking rate determinations. For example, pasture production from a highly leached sandy soil with a rainfall of 450 mm p.a. will be considerably less than the pasture production from a deep uniform red brown earth in a 800 mm p.a. rainfall zone. As a consequence the number of stock that can be carried on these two properties will vary significantly.

Management is also a critical part of the equation. Good managers can generally carry more livestock and still protect, and in many cases improve, the condition of natural resources by:

- improving pasture
- controlling weeds
- improving grazing strategies
- increasing soil fertility
- combating soil acidity
- matching livestock numbers to pasture productivity.

How much stock can be carried on a single property can vary throughout the year since the level of pasture feed will vary from season to season. Hence, calculating the initial overall 'stocking rate' will only give landholders a 'ball park' figure which should be used as a guideline when stocking a grazing property. Management practices, variability in rainfall and soil fertility all play an important part in how much feed is ultimately available and therefore how much stock can be run at any one time.

The term 'carrying capacity' is sometimes used when discussing stocking rates. This refers to the number of animals which can be run on the property at times of low feed production. This is likely to be in winter.

It is important to distinguish between the overall stocking rate for the property and 'grazing pressure' (i.e. stocking density). Grazing pressure refers to the number of animals grazing a particular area of pasture for a limited time. For example, a small property may be able run a maximum of 20 head of cattle. If the area to be grazed is 20 hectares, the grazing pressure will be 1 animal per hectare. However, if the property is divided into two paddocks of equal size and all animals graze in one paddock, the grazing pressure in this paddock is now two animals per hectare (Figure 57).

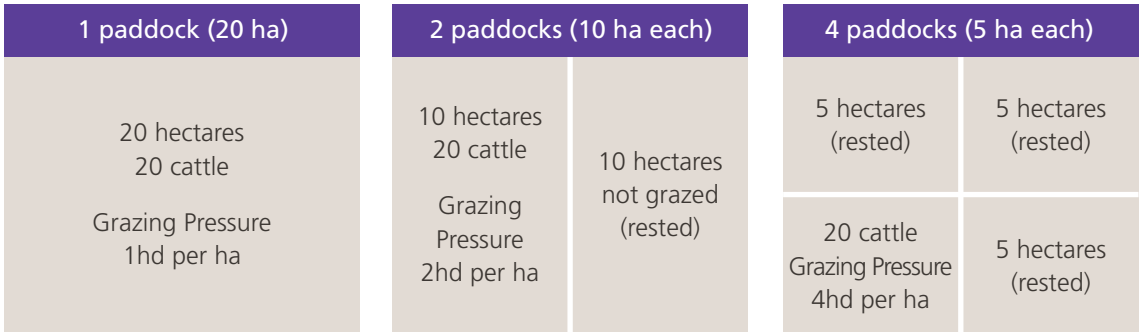


Figure 57. Relationship between livestock numbers, paddock area and grazing pressure on a 20 hectare property

Adopting effective grazing pressures, and rotating animals through a series of paddocks, can increase pasture production, give better weed control and increase livestock production. Consequently dividing a small grazing property into four to six paddocks is recommended.

The challenge for landholders is to determine a suitable stocking rate for the property and apply grazing pressures which have a positive impact and do not degrade the land.

If the overall stocking rate is too high or grazing pressure is excessive:

- pasture production is reduced
- pasture quality declines
- the proportion of weeds can increase
- soil erosion can occur, particularly during a drought
- livestock can be stressed or suffer health problems.

10.1 Dry sheep equivalents (DSE)

When discussing stocking rates the term dry sheep equivalents (DSE) is generally used. This is a standard unit frequently used to assess the carrying capacity of a given area of farmland. The standard DSE unit is the amount of feed required by a two year old, 50 kg sheep (wether or non-lactating, non-pregnant ewe) to maintain its weight. Using this as the standard allows comparisons to be made between different classes of livestock (Table 13). For example, an adult dry cow or steer has a DSE value of 7.0 to 8.0 and would therefore require the same amount of feed as 8.0 or 10.0 dry sheep. If 10 hectares of good pasture were available in a region with a stocking rate of approximately 10 DSE, either 8.0 or 10 cattle could be carried, or 80 to 100 dry sheep.

Figure 58. One standard dry sheep is used as a benchmark to compare feed requirements of stock

Table 13. Dry sheep equivalents (DSE) values for different classes of sheep and beef cattle based on daily energy requirements
Source: Agriculture Victoria, formerly Victorian Department of Primary Industries 2007

Class of livestock	DSE at specified liveweights	
Sheep (Merino)		
Weaned lambs	15 kg	25 kg
– gaining 100 g/day	0.9	1.2
– gaining 200 g/day	1.4	1.8
Mature sheep	45 kg	50 kg
Dry ewes, wethers (store)	0.9	1.1
– gaining 50 g/day	1.2	1.4
– gaining 100 g/day	1.5	1.7
Pregnant ewes last 6 weeks (single lamb)	1.4	1.6
Pregnant ewes last 6 weeks (twin lambs)	1.8	2.0
Ewes with single lamb at foot	2.4	3.1
Ewes with twin lambs at foot	2.8	3.3

Table 13. continued

Class of livestock	DSE at specified liveweights	
Beef cattle (British breeds)		
Weaned calves	200 kg	250 kg
– gaining 0.25 kg/day	5.5	6.5
– gaining 0.75 kg/day	8.0	9.0
Yearling	300 kg	350 kg
– gaining 0.25 kg/day	7.0	8.0
– gaining 0.75 kg/day	10.0	11.0
Mature cattle	400 kg	500 kg
Dry cows, steers (store)	7.0	8.0
– gaining 0.25 kg/day	8.0	9.0
Bullocks (store)	8.0	9.0
– gaining 0.75 kg/day	12.0	14.0
Pregnant cows last 3 months	9.0	11.0
Cows with 0 to 3 month calf	14.0	18.0
Cows with 4 to 6 month calf	18.0	22.0
Cows with 7 to 10 month calf	22.0	25.0

When using DSE values it is important to remember that they are only approximations and are based on the energy requirements of livestock. They do not account for differences in protein and mineral requirements of different animals, or requirements due to genetic variations. Livestock feed requirements vary according to liveweight, level of production, physiological state and climatic conditions.

Landholders should also be aware that the carrying capacity of land is greatly reduced when animals are infected by large numbers of parasites.

Table 14. Dry sheep equivalents (DSE) values for horses, deer and goats

Class of livestock	DSE value
Horses	
Light horse	10.0
Draught horse	14.0
Pony	6.0
Horse – light work	13.5
Horse – heavy work	18.7
Deer	
Fallow dry female or castrate	1.5
Fallow breeding female with fawn	2.2
Red dry female or castrate	2.2
Red breeding female with young	3.0
Red buck	3.1
Weaner doe	1.4
Weaner buck	1.9
Goats	
Dry angora	1.0
Breeding angora	1.6
Dry milk or meat goat	1.5
Milk or meat goat lactating	3.0

Table 15. Dry sheep equivalents (DSE) for alpacas

Class of livestock	DSE at specified liveweights		
Alpacas	35 kg	55 kg	65 kg
Dry adult (non lactating, non pregnant)	0.6	0.8	0.9
Hembra	0.9	1.2	1.3
Macho	0.7	0.9	1.1
Growth 50 grams/day	1.1	1.5	1.7
Growth 100 grams/day	1.2	1.7	2.0
Growth 150 grams/day	1.4	2.0	2.2

10.2 Using DSE values to initially stock a property

In order to estimate how much stock your property can run, without reducing pasture quality or degrading land, a DSE rating (i.e. indicative baseline stocking rate/ha) for the location of your property will need to be known. These are often regarded as 'regional stocking rates'. This is the subject of the next chapter which will take into account key factors including: soil type, average annual rainfall, slope of the land and pasture quality. For the example below it is assumed that the regional DSE/ha is 10.

Estimating a total stocking rate for a small property

Example: Firstly, determine how much land is available for grazing. Eliminate non grazing areas such as house, sheds etc. Take account of restricted seasonal grazing due to waterlogging.

Available grazing land:
Area 1: (grazing all year) = 6 ha
Area 2: (restricted for 3 months in winter) = 2 ha
Area 3: (only available for 6 months) = 4 ha

Assume the regional stocking rate for the region is 10DSE/ha and the pasture is good.

Maximum stocking rate for the property:
Area 1: 6 ha × 12/12 × 10DSE = 60 DSE
Area 2: 2 ha × 9/12 × 10DSE = 15 DSE
Area 3: 4 ha × 6/12 × 10DSE = 20 DSE
Total for the property = 95 DSE
(i.e. 95 dry sheep can be run on this property without degrading the land)

If running steers; divide 95 by the DSE for steers (9) i.e. 95/9 = 10.5 steers.

If running lambing ewes; divide 95 by the DSE for this class i.e. 95/1.5 = 63 ewes.

Note: All calculations of this nature are approximate. Land managers will need to monitor pasture and livestock condition regularly to avoid any land degradation or loss of livestock condition.

10.3 Are you overstocked?

Thankfully most landholders in the Region are responsible and endeavour to look after their properties. Even so, for inexperienced landholders it can be difficult to judge appropriate stock numbers in the early days of managing a property for the first time.

If your property stands out from others in the district because paddock feed always seems low, or you have enormous feed bills, or your animals are not in good condition, or summer and autumn bring bare paddocks, you are most likely overstocked.

Following the above method to estimate your stocking rate will provide you with an overall 'ball park' figure given in DSEs. The following example will enable you to determine if your current stock numbers are comparable.

Example: Assume that the overall stocking rate for this property was calculated to be 120 DSE. The current actual stocking rate can be calculated using the following table.

In this case the property is clearly overstocked at 262 DSE. Buying extra feed will not protect paddocks from being overgrazed. Bare soil and degraded pastures are a likely consequence.

Table 16. Calculating current stocking rate

Number	Livestock	DSE rating	Total DSEs
2	Horses (light)	10	20
25	Yearly steers (350 kg)	8.0	200
6	Alpacas (dry adult 55 kg)	0.8	4.8
12	Ewes (single lamb at foot 50 kg)	3.1	37.2
Total DSE			262

10.4 Excess grazing pressure can create bare soil

One of the most common causes of bare soil is excess grazing pressure, even though in many cases landholders have determined a realistic stocking rate for the property.

For example, consider a small property which has an overall stocking rate of 40 DSE, which may well just be 5 yearling steers. If these animals are given free run of the property there should be no major problems with overgrazing. However, if the property is divided into four paddock of equal size and all animals graze together in a single paddock at any one time, they have only one quarter of the total feed available. So it is important to move these animals on to the next paddock when pasture feed is low. Leaving animals in individual paddocks for too long leads to overgrazing, and once again, bare soil and degraded pastures are a likely consequence.

Figure 59. Excess grazing pressure can expose surface soil

11. Regional stocking rates

Most landholders make use of regional stocking rate estimates to help them determine how much stock they can run on their property, and for the most part they can be a necessary and useful guide. However, the variability in stock numbers per hectare, between farms in the same location, can be significant despite similar annual rainfall.

While rainfall has the biggest influence on pasture production, other factors play an important part, such as soil type, soil fertility, length of growing season, pasture quality and grazing management.

11.1 Dryland pasture (non-irrigated)

Many field trials have been conducted over recent years which have enabled agronomists to produce a range of formulae to help calculate how much stock a landholder can run on a property. The key principle which allows a formula to be used, is the amount of dry matter a pasture produces during the growing season. What underpins this approach is the understanding that 1 kg/day of dry matter is required to maintain one DSE (dry sheep equivalents). So the amount of dry matter per mm of rainfall often becomes the starting point to calculate an overall stocking rate. This value can vary markedly depending on dryland pasture quality, with 20 kgDM/Ha/mm regarded as high compared with 6 kg DM/Ha/mm which is regarded as poor.

1 kg/day of dry matter is required to maintain one dry sheep (50 kg dry ewe or wether)

A good average farmer will probably be around the 1.5 to 2.0 DSE/Ha/100 mm rainfall. However, it is important that landholders regard regional stocking rate values as 'indicative baseline stocking rates' only. They may be improved upon in some situations by better management, or on the other hand, landholders may find themselves reducing stock numbers to better match feed production and protect the environment.

Table 18 contains values for 'indicative baseline stocking rates' for a range of pasture and soil qualities and are intended as a guide to help landholders match stock numbers with pasture production.

Basic assumptions were made to calculate these figures. They are:

- 10% of rainfall is lost as runoff
- evaporation is 70 mm during the growing season
- poor pasture produced approximately 6 kgDM/Ha/mm rainfall
- high quality pasture produced approximately 20 kgDM/Ha/mm rainfall
- only 50% of the dry matter produced is utilisable
- 400 kg of pasture dry matter production is lost due to trampling and the impact of dung.

Since pasture quality varies so much from property to property, estimating regional stocking rates is difficult unless this variability is taken into account. The following four pasture descriptors (Table 17) represent poor, moderate, good and high quality pastures and are differentiated on the basis of pasture type, soil fertility, management and limitations due to slope and rocks. These qualities were used to help determine regional stocking rate values. Average annual rainfall was then considered to arrive at the final baseline stocking rate estimates (Table 18).

Table 17. Categories describing pasture quality and soil limitations

Quality	Pasture quality, soil limitations and management
Poor (Figure 60)	Primarily annual weeds e.g. guildford grass, barley grass, brome grass, capeweed. No rotational grazing, no liming or fertiliser treatments. Soils are usually leached sand o/clay, deep sands, highly-acidic soils. Rocks and slope may be limiting at some sites. Regional soil groups 7, 8, 9 and 11.
Moderate (Figure 61)	< 15% perennial grass, some clover or medic, annual grass weeds and broadleaf weeds obvious. Set stocking, occasional liming and fertiliser treatments. Soils are usually sandy loams o/clay, ironstone soils. Minor limitations due to slope and rocks at some sites. Regional soil groups 1, 2, 10 and 12.
Good (Figure 62)	30% perennial grasses e.g. phalaris, cocksfoot, ryegrass, 20% clover. Annual grass weeds and broadleaf weeds make up the rest. Set stocking with some rotational grazing, regular fertiliser, liming and weed control. Soils are usually sandy loams o/clay, ironstone soils. No limitations due to slope and rocks. Regional soil groups 1, 2, 4, 10 and 12.
High (Figure 63)	> 60% introduced perennial grasses, 30% clover, 10% weeds. Rotationally grazed, fodder conserved. Annual fertiliser, insect and weed control. Renovation program implemented. Soils are usually highly fertile, deep well drained loams. No limitations due to rocks or slope. Regional Soil Groups: 3, 5, 6 and 13.

Figure 60. Poor quality pasture, salvation Jane and annual brome grass only

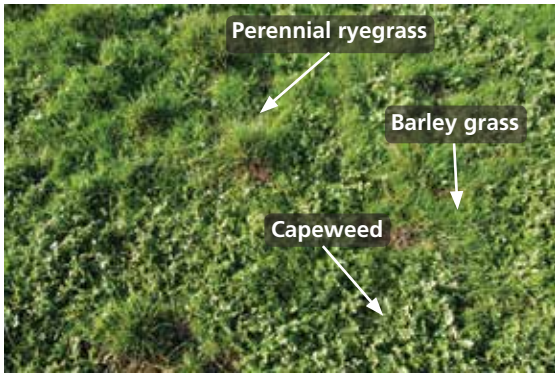


Figure 61. Moderate quality pasture, <15% perennial grass, capeweed and barley grass dominate

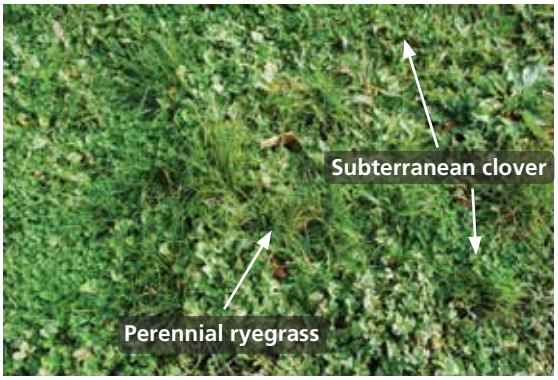


Figure 62. Good quality pasture, 50% perennial grass and clover

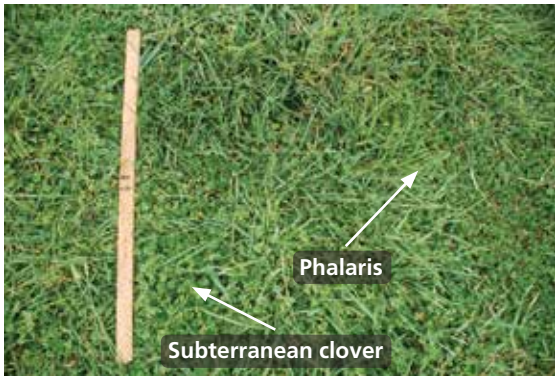


Figure 63. High quality pasture, 60% phalaris, 40% subterranean clover

Table 18. Indicative baseline stocking rates (DSE/ha) for varying rainfall, pasture and soil qualities in the AMLR NRM region (refer to Table 17 for descriptors)

Average annual rainfall mm	Pasture quality and management (Table 17)			
	Poor	Moderate	Good	High
1000	6	10	15	22
950	6	9	15	21
900	6	9	14	20
850	5	8	13	18
800	5	7	12	17
750	4	7	11	16
700	4	6	10	15
650	4	6	9	14
600	3	5	8	12
550	3	5	8	11
500	3	4	7	10
450	2	4	6	9
400	2	3	5	7
350	1	2	4	5

Table 19 provides indicative baseline stocking rates for specific locations. One column of figures are given for pasture quality which is 'good', and where soil fertility, rocks and slope are not limiting for production. The other set of figures 'poor' assume that pastures are unimproved, of poor quality, and soil fertility, rocks and slope are limiting for production. Average annual rainfall values have been taken from the past 30 years, since these values are likely to better represent potential annual rainfall in a drying climate.

Table 19. Indicative baseline stocking rates for locations in AMLR NRM region

Location	Average annual rainfall mm (1980 – 2009)	Indicative baseline stocking rate (DSE/ha)	
		Good pasture, no limitations for soil, rock and slope	Poor pasture, weeds dominate, soil, rock and slope limitations
Lenswood Research Centre	1007	15	6
Longwood	969	15	6
Cleland Conservation Park	966	15	6
Parawa	927	14 to 15	6
Second Valley Forest	909	14	6
Cherry Gardens	893	14	6
Lobethal	888	13 to 14	6
Cudlee Creek	837	12 to 13	5
Belair (State Flora Nursery)	834	12 to 13	5
Hahndorf	780	11 to 12	5
Clarendon	774	11 to 12	4 to 5
Echunga	768	11 to 12	4 to 5
Gumeracha	762	11 to 12	4 to 5
Kersbrook	737	10 to 11	4
Yankalilla	733	10 to 11	4

Table 19. continued

Location	Average annual rainfall mm (1980 – 2009)	Indicative baseline stocking rate (DSE/ha)	
		Good pasture, no limitations for soil, rock and slope	Poor pasture, weeds dominate, soil, rock and slope limitations
Woodside	710	10 to 11	4
Blackwood	707	10	4
Birdwood	694	10	4
Myponga	681	9 to 10	4
Williamstown	675	9 to 10	4
Upper Hermitage	639	9	4
Mount Pleasant	616	8 to 9	3 to 4
Willunga	604	8	3
Second Valley	602	8	3
Angaston	549	8	3
Tanunda	532	7 to 8	3
Lyndoch	530	7 to 8	3
Victor Harbor	528	7 to 8	3
Normanville	517	7 to 8	3
Greenock	511	7 to 8	3
Truro	505	7	3
Keyneton	496	7	3
Kapunda	484	6 to 7	2 to 3
Port Elliot	483	6 to 7	2 to 3
Freeling	483	6 to 7	2 to 3
Eudunda	466	6 to 7	2 to 3
Tarlee	464	6 to 7	2 to 3
Hamley Bridge	450	6	2
Roseworthy	440	5 to 6	2
Gawler	424	5 to 6	2
Bolivar	408	5	2
Owen	404	5	2
Two Wells	391	5	2
Mallala	387	4 to 5	1 to 2
Lower Light	382	4 to 5	1 to 2

11.2 Irrigated pasture

Available water is the greatest factor influencing the overall stocking rate on small grazing properties, and since most of these properties do not irrigate, seasonal rainfall alone will determine how much pasture is produced each year.

However, where irrigation is practised a greater level of dry matter can be produced and more stock can be carried. Up to 46 DSE/ha is possible where regular irrigation and fertilising of improved pasture occurs.

This figure may will drop if landholders are only watering occasionally and/or the pasture does not contain appropriate species for irrigation (refer to Chapter 7).

12. Principles of grazing management

Developing a suitable grazing strategy for a small property, so that the needs of the animals and pastures are met, is not difficult as long as a few basic principles are followed. Rotational grazing, set stocking, resting pastures for seed production, and supplementary feeding, all need to be considered when deciding on the best tactical approach for grazing.

The benefits of implementing an effective grazing strategy are considerable and include:

- improved pasture quality
- increased livestock production
- better control of weeds
- less environmental damage.

12.1 Set stocking

Set stocking involves grazing livestock for a set period of time in a particular paddock without any resting phase. This is quite common on small properties where landholders have low stock numbers and production is not a major objective.

Where a property consists only of one main grazing area, and has not been subdivided into smaller paddocks, the landholder often has no choice but to apply set stocking. In this case the overall stocking rate is generally calculated so that area of land will carry a set number of livestock for the year.

Rotational grazing is also not possible on small properties where all paddocks are occupied by different groups of animals. These landholders operate a set stocking regime.

A common problem with this approach is the build-up of weeds and a decline in pasture quality. Livestock tend to consume palatable pasture species and leave the unpalatable species, which in many cases are weeds. This is known as 'selective feeding'. In this situation, the seed set of weeds increases and the balance of the pasture changes as weeds begin to dominate the pasture.

Feed shortages can be managed by supplementary feeding with hay, silage or grain.

12.2 Rotational grazing

Rotational grazing is a practice where livestock are grouped together and rotated through a number of paddocks in order to rest pastures. Resting pastures is a vital practice if landholders wish to improve pasture quality, reduce weeds, and increase productivity. This process relies on the rest period being long enough to allow sufficient pasture growth so that grazing can begin again.

Rotational grazing can increase stocking rates by up to 20% compared with set stocking.

Under these circumstances grazing pressure is higher than under set stocking and relies on more intensive grazing of the vegetative pasture phase. Livestock graze less selectively when grazing pressure is high which helps to keep weeds under control.

Figure 64. Set stocking can occur when a property has only a single paddock

Figure 65. Paddock division is important for rotational grazing

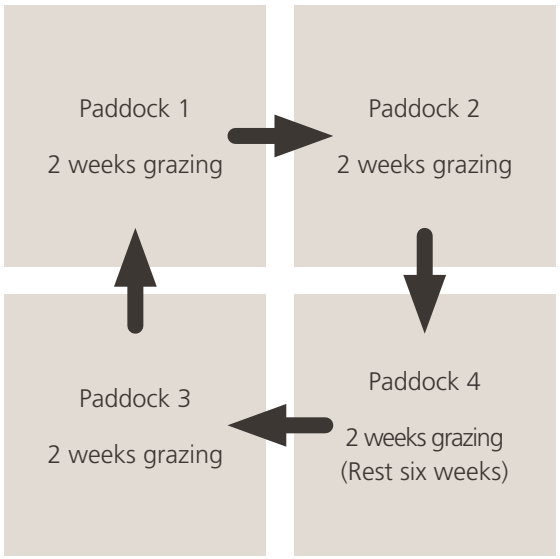


Figure 66. Paddock rotation during moderate growth – six week rest

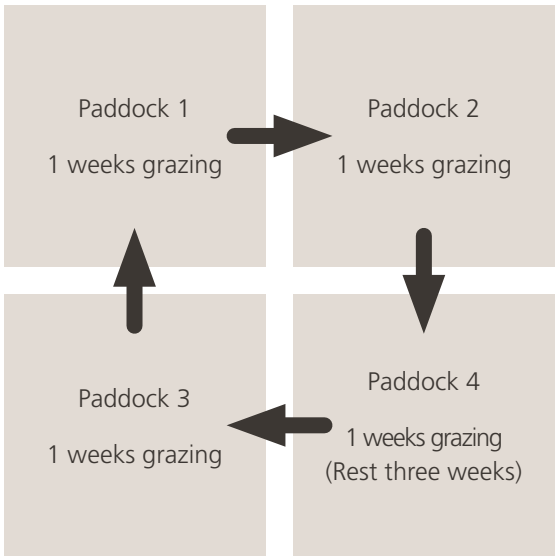


Figure 67. Paddock rotation during rapid growth in spring – three weeks rest

Small properties should be divided into at least four paddocks (ideally four to six paddocks). This enables a simple four paddock rotation for a single group of animals to be quite easily managed. Temporary electric tape can be used for horses and cattle if landholders do not want permanent fences. However, five or six wire internal electric fences are very effective for these classes of animals.

To operate a simple four-paddock rotation during moderate pasture growth, combine animals together and run as one herd or flock on the property. Rotate these animals around the four paddocks following a program of approximately two weeks grazing and six weeks rest.

During **rapid** pasture growth in spring graze for approximately one week and then rest for approximately three weeks. This will help to keep the pasture in the vegetative (or growth phase).

Rotational grazing helps to reduce 'patch' grazing and livestock camps, minimises broadleaf weeds and annual grasses. It also provides a more even distribution of manure and urine to the pasture. If managed appropriately ground cover over summer will be improved.

It is essential that paddocks are not grazed for too long since this will result in plants not recovering as quickly as they should. The height at which pastures are grazed is a critical part of the success of this grazing strategy. Pasture utilisation is best when plant are growing between 5 cm and 12 cm. The use of a pasture ruler is helpful when estimating pasture height (Figure 68).

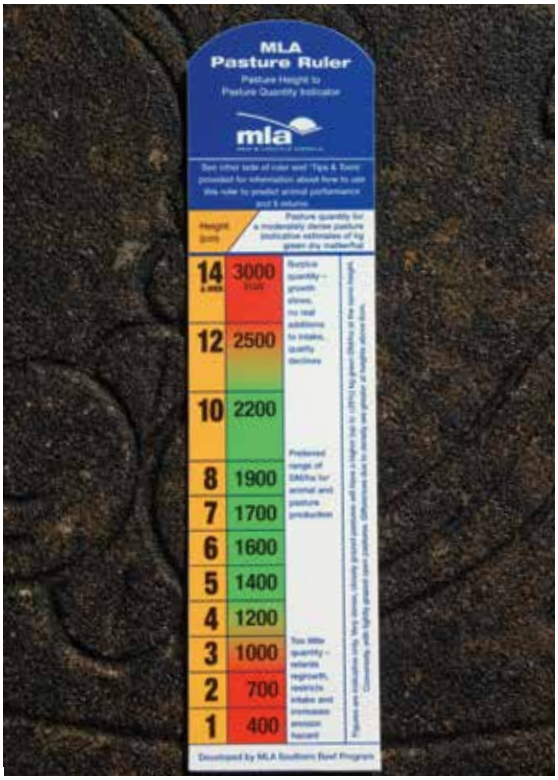


Figure 68. Pastures should be grazed in the green zone

Paddocks should be rested when pastures have been eaten down to 5 cm during pasture growth phases, and animals re-introduced when pastures have grown to 12 cm

When livestock are moved out of a paddock it is advisable to monitor pasture height to estimate the degree of under, or overgrazing. Overgrazed pastures will take longer to recover, result in less pasture production over the year, and often create bare patches which become invaded by weeds.

Figure 70. Strip grazing on a dairy farm – Fleurieu Peninsula

12.3 Intensive rotational grazing

This grazing system involves stock being rotated frequently (every 1–3 days) through a large number of paddocks (up to 20 or 30). Intensive rotational grazing systems are also referred to as:

- high density grazing
- short duration grazing
- block grazing
- strip grazing
- cell grazing.

Intensive grazing is a very efficient method of utilizing pasture and relies on rotations being planned around the most desirable plant species in the pasture which grow actively in different seasons.

Stocking densities are very high and so grazing periods are short. They can be as low as one day depending on pasture growth rates and stock numbers. Stocking densities of 100DSE per hectare and higher are manageable provided paddock numbers and resting periods are carefully determined.

Dairy farmers have used strip grazing as an efficient grazing strategy for decades. The use of electric tape is effective and animals quickly adapt to the system.

Figure 69. High stocking densities are required for intensive rotational grazing

Speeding up the rotation when growth is rapid is important to ensure pasture can be maintained in the vegetative state with plenty of leafy grasses and a high legume content.

During spring some paddocks will need to be dropped out of the rotation and used for silage or hay production if they cannot be kept to below 14 cm in height. Avoid grazing pastures lower than 4 cm if using this system, and monitor pastures to avoid overgrazing.

12.4 Supplementary feeding

The usual spring flush results in extra pasture growth which can be conserved as fodder in the form of hay or silage.

Silage is made from green pasture or fodder crops and is cut earlier than normal hay. The plant material is preserved by a process of bacterial fermentation where sugars are converted to lactic acid. This usually takes about two weeks.

Traditionally silage was placed in large heaps on the ground and rolled by a tractor to push out all the air, then covered by a plastic sheet held down by recycled tyres. However, storing silage as individual bales has become more popular (see Figure 71). In this case pastures are cut when plant dry matter is around 60 to 70%. The bales are wrapped tightly in plastic wrappers to exclude oxygen, and the material then goes through a limited fermentation.

Figure 71. Silage conserved as summer feed

Feeding out hay or silage to livestock when paddock feed is low will help to support all grazing strategies and help match feed requirements with feed supply.

If fodder has to be purchased the benefits will need to weighed against the costs.

Matching livestock numbers with available paddock feed and fodder cut from the property, will help to avoid baring out paddocks in summer and autumn. However, in particularly dry seasons, or in times of drought, confinement paddocks may need to be considered to avoid damage to pastures and possible erosion.

12.5 Confinement paddocks

Confining livestock to a single paddock, sometimes referred to as a 'sacrifice paddock', is a drought feeding strategy where animals receive supplementary feed while ground cover and land condition is preserved across the majority of the property.

This paddock should be well fenced and provide animals with adequate room, water, feed, and shelter from wind and sun. In addition, manure management will need to be considered in line with Environmental Protection Agency requirements. The site chosen for a sacrificial paddock should have a low erosion risk, be at least 50 metres from any watercourse (wet or dry) and have a slope of no more than 8%. A sacrificial paddock should not be used more than two years in five. Monitoring the condition of all stock is important when hand feeding.

Feed ration tables are available for all classes of livestock to assist landholders maintain stock in appropriate condition. Visit: **www.dpi.nsw.gov.au/animals-and-livestock** for more detail.

Daily water requirements should be based upon peak consumption at all times (Table 20).

Table 20. Livestock daily water requirements
Source: Agriculture Victoria, formerly Victorian Department of Primary Industries 2007

Type of livestock	Average daily consumption (litres per head)	Peak daily consumption (litres per head)
Sheep		
Lactating ewes on dry feed	9	11.5
Mature sheep on dry pastures	7	8.5
Mature sheep on green pastures	3.5	4.5
Fattening lambs on dry pasture	2.2	3
Fattening lambs on green pasture	1.1	1.1
Cattle		
Dairy cows in milk	70	250
Dairy cows – dry	45	60
Adult beef cattle	45	60
Calves	22	30
Horses		
Working	55	70
Grazing	35	45
Pigs		
Breeding sows	22	30
Mature adult	11	15

Table 20. continued

Type of livestock	Average daily consumption (litres per head)	Peak daily consumption (litres per head)
Alpacas		
Mature adult	5.5	7.0
Lactating adult	10.0	12.0
Poultry	(litres/100birds)	(litres/100birds)
Laying hens	32	40
Non-laying hens	18	23
Turkeys	55	70

12.6 Grazing to manage pasture species

Most perennial grass based pastures should not have to be re-sown unless they become degraded for some reason, which can sometimes be the result of poor management. Landholders should be especially careful during flowering and seed set, and during establishment because pastures are particularly vulnerable to overgrazing at these stages.

Grazing undesirable species to prevent seed set, or resting desirable species to encourage seed production are two key strategies to maintain pasture quality.

Perennial ryegrass is a common pasture grass used in high rainfall areas of this region. Its persistence depends on how it is grazed during spring. Allowing ryegrass to flower and set seed during spring and summer will increase the density of a stand of perennial ryegrass. Significantly more new tillers are produced from plants which have flowered than those kept in a vegetative state by grazing. In addition further seed will germinate in autumn to help thicken up the pasture. So resting these pastures occasionally will have noticeable benefits.

For newly established phalaris and cocksfoot pastures it is important to allow seed set before grazing.

Inexperienced landholders should seek independent professional advice to ensure their grazing strategy is appropriate for the pasture species mix on the property.

12.7 Grazing native pastures

Some of the common native grasses found in the Adelaide and Mount Lofty Ranges region include:

- weeping grass (*Microlaena stipoides*)
- wallaby grass (*Rytidosperma* spp.)
- kangaroo grass (*Themeda triandra*)
- windmill grass (*Chloris truncata*)
- spear grass (*Austrostipa* spp.)
- brush wire-grass (*Aristida* spp.)
- black-head grass (*Enneapogon nigricans*)
- tussock grasses (*Poa* spp.).

Wallaby grass and weeping rice grass in particular are regarded as significant pasture species and should be carefully grazed to ensure long term production. (Refer to Chapter 7 for identification).

Native grass pastures should be rotationally grazed or stocked at low rates to maintain productivity.

Figure 72. Productive wallaby grass pasture, Meadows

After the autumn break defer grazing for 6 to 8 weeks to allow the native plants to grow and become competitive. In spring grazing pressure can be increased which will encourage shorter species such as wallaby grass, and help to reduce competition from annual grasses. Once seed heads emerge reduce the grazing pressure or defer grazing to encourage seed production.

While low levels of phosphorus will be beneficial for some native pastures, for example, wallaby grass and weeping rice grass, others such as kangaroo grass will not respond as well. Applying 0.5 kg P/DSE/ha to a responsive native grass pasture should promote significant pasture growth.

Legumes, in particular clover, can be an important component of native grass pastures provided that they do not exceed more than 20%. Values higher than this can lead to excess nitrogen resulting in more weeds and less native grass.

13. Soil conservation

13.1 Soil erosion

Soil erosion events can be significant. A loss of 1 mm of topsoil represents 10 to 12 tonnes per hectare, with the loss of approximately 10 kg/Ha of nitrogen and 2 kg/Ha of phosphorus.

Large tracks of primary production land can be lost due to gully erosion (Figure 73), while silt in watercourses and dams can damage aquatic habitats and interfere with the respiration of fish and other biota.

Furthermore the functioning dynamics of a watercourse can be dramatically changed to the point where specific plants become a problem. Bulrushes (*Typha* spp.) thrive and spread rapidly in shallow water caused by siltation.

Silt in water supplies can also damage infrastructure, slow flow rates and reduce water quality.

(a) Cereal cropping areas (rainfall <450 mm p.a.)

Light sandy soils in particular are very susceptible to both wind and water erosion once the surface is loose, whether by cultivation or grazing animals.

The keys to minimising the risk of erosion are:

- maintain adequate surface cover of native vegetation, pasture or stubble (Table 21)
- minimise the time that cultivated land is exposed and without cover
- use conservation farming practices (i.e. no-till and stubble retention)
- fence off sand dunes and permanently stabilise by planting perennial vegetation
- establish windbreaks to reduce surface velocity and reduce the erosive forces of the wind
- construct contour banks in cereal paddocks with 4% to 12% slope to reduce the risk of water erosion.

Figure 73. Severe gully erosion on prime agricultural land

Figure 74. Grain legume stubble

Grain legume stubble is far less effective than cereal stubble in holding soil together and is easily blown away. Careful management is required.

Maintaining surface cover is particularly important in cereal growing areas of the region. In the past it was common practice, once the grain was harvested, for livestock to graze the remaining stubble. In some cases insufficient cover was left resulting in disturbed soil being blown, or washed away. A better understanding of soil conservation practices, coupled with a move to continuous cropping, has now resulted in stubble being retained to reduce the risk of erosion.

Light soils on steeper slopes pose the highest risk, while heavier soils on flat land have a much lower erosion risk.

Table 21. Surface cover needed to protect soil from wind and water erosion in cropping land
Source: Fact sheet 89, DWLBC 2008

Erosion	Minimum vegetative surface cover		Desirable vegetative surface cover	
	%	tonnes/ ha	%	tonnes/ ha
Wind				
Loam	15	0.5	35	1.0
Sandy loam	20	0.6	50	1.5
Sand	50	1.5	70	2.5
Water				
Level land	60	2.0	75	3.0
Sloping land	75	3.0	85	4.0

Figure 75. Light textured sandy soils are vulnerable to erosion if cover is insufficient

(b) High rainfall areas (>450 mm p.a.)

High rainfall areas of the Adelaide and Mount Lofty Ranges are at risk of water erosion if land management practices are not appropriate.

To reduce the likelihood of erosion:

- aim for 100% cover, but do not let this fall below 70% at all times
- do not overstock
- adopt appropriate grazing management strategies
- avoid cultivation of steep land
- direct drill new pastures
- stabilise watercourses by planting appropriate native vegetation.

Figure 76. Erosion due to overstocking

13.2 Pasture ground cover

Maintaining adequate ground cover is an important consideration when managing a grazing property. Soil erosion is often the result of insufficient ground cover. (Figure 77).

Variations in seasonal rainfall, stock numbers and pasture type will impact on how much cover there is at any one time, however, landholders have a responsibility to ensure that paddocks are not overgrazed to the point where soil erosion occurs.

Apart from any environmental considerations, it is important to avoid bare soil because in most cases this will result in weed infested pastures and low feed production (Figure 80).

The best form of ground cover is dense pasture, however, living or dead plants also provide ground cover along with any parts that fall ground, such as leaves, stalks, seed pods (Figure 78). Pebbles and rocks, mosses, lichens and fungi also protect soil.

In cereal growing areas cover is provided by crops and the stubble that remains after harvest.

Maintaining adequate ground cover on pasture paddocks will:

- help to prevent water erosion
- reduce the risk of wind erosion
- moderate the temperature on the soil surface and help to reduce evaporation
- provide food for livestock
- aid recycling of nutrients as plant products decompose and return nutrients to the soil.

Figure 77. Erosion caused by insufficient ground cover

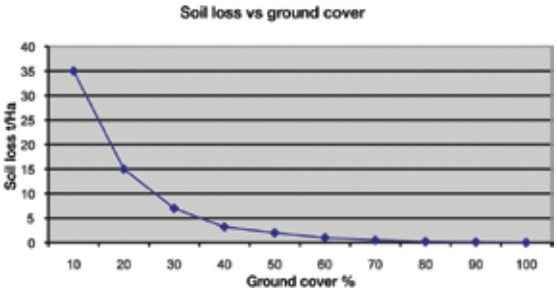


Figure 79. Relationship between ground cover % and average annual soil loss (t/Ha)

Figure 78. Ground cover includes leaf litter which protects soil

Figure 80. Severe overgrazing promotes weeds and soil loss

13.3 How much ground cover is sufficient?

In farming situations in particular, the amount of ground cover can vary considerably throughout a year and is dependent on a range of factors including:

Plant type – plants have different growth habits and can be annuals or perennials. Perennial pasture grasses (introduced or native) are ideal to hold soil together, while the stubble of annual cereal crops can provide soil protection for up to 12 months. On the other hand, grain legume stubble will rapidly break down and expose soil to wind and rain thereby increasing the risk of erosion.

Growth rates – soil moisture, fertility levels and seasonal conditions all affect plant growth.

Land management – grazing, cropping and fire management practices have a major impact on ground cover levels. In vulnerable cereal growing areas of the region, no-till farming practices, along with stubble retention, is now an established conservation practice.

Soil type, slope and intensity of rainfall play an important part in determining the potential for erosion to occur. To reduce the risk of this form of land degradation, adequate ground cover levels should be maintained. 100% ground cover, of at least 3 cm in height, is ideal. However, this is not always possible, especially during a long hot dry summer, consequently a figure of 70% ground cover throughout the driest seasons is often used to provide an absolute minimum benchmark. During winter and spring landholders should aim for total cover.

Benchmarks for pasture:

Extremely poor levels of ground cover

In all cases the cause was overgrazing due to poor management. The risk of erosion is high to very high for an average rainfall event.

Figure 81. Ground cover 5% in winter

Figure 82. Ground cover 20% in summer

Insufficient ground cover

In all cases the cause was overgrazing due to poor management. There is a high risk of erosion for an average rainfall event.

Figure 83. Ground cover 50% in winter

Figure 84. Ground cover 50% in summer

Marginal ground cover

The following photographs are examples of a minimum 70% ground cover. There is still a risk of erosion with an average rainfall event.

Figure 85. Ground cover 70% in autumn

Figure 86. Ground cover 70% in summer

Sufficient ground cover

The risk of erosion is low.

Figure 87. Ground cover 80% in autumn

Figure 88. Ground cover 80% in summer

Optimum ground cover

Erosion is unlikely.

Figure 89. Ground cover 100% in summer

Figure 90. Ground cover 100% in spring

When assessing the percentage ground cover for the situations above, all surface cover was considered, provided it contributed to protecting the soil from an intense rainfall event. This included dead annual plants, plant stalks, leaves, twigs, pebbles and dung. Consequently some percentage values may appear to be overestimated on initial viewing.

13.4 Improving soil structure

Structure refers to the way that soil particles (sand, silt and clay) clump together into aggregates. A well-structured soil relies on the formation of small soil aggregates which remain stable when wet and contain pore spaces which allow water and air to penetrate (Figure 5 in section 4.3).

Soil structure is generally a product of inherent soil characteristics. However, land management practices, such as continuous cultivation, can contribute to the destruction of good soil aggregates.

Most soils will benefit from the addition of organic matter, which not only encourages good aggregation, but also releases nutrients to assist plant growth, and improves water holding capacity. The structure of some heavy clay soils may also be improved by the addition of gypsum (calcium sulphate) which helps soil particles to aggregate.

14. Property management planning

Property management planning is a process supporting sustainable land management which considers the personal goals of landholders, environmental issues and economic returns. Good management can lift productivity and at the same time improve the condition of natural resources.

Developing a property management plan will assist landholders to:

- identify clear goals
- solve problems
- budget
- allocate time.

Most properties contain a range of soil types, topographical features, each with individual productive potential and management needs, so landholders will need to apply some form of classification when conducting an initial assessment of the characteristics of the property. This classification system is known as land capability.

Figure 91. Slope pays an important part in how land is managed within its capability

14.1 Land capability

Land capability describes the ability of the land to accept a type and intensity of use with minimal risk of damage to the soil. Understanding land capability is at the core of responsible land management and land use. Land use decisions should only be made on the basis of adequate information about the land itself.

Land capability is based on the physical attributes of the land which is called land quality. A range of limitations (potential for land degradation) exist for different land qualities, which will influence land use. These include:

- water erosion – steep slopes create a high potential for degradation if soil cover is not adequate
- wind erosion – deep sandy soils in low rainfall cropping areas have the potential to erode, particularly with intense rainfall events
- soil acidity – highly acidic soils have the potential to reduce productivity

Figure 92. Steep land cleared of native vegetation has resulted in severe gully erosion

- water absorption – some low lying areas may become waterlogged in the wetter months and will reduce the amount of land available to stock; others are highly water repellent and can affect the quality of pasture, crop and horticultural production
- rockiness – the degree of stoniness will affect the purpose to which the land can be used, particularly where machinery is involved
- inherent fertility – some soils are poorer in nutrients than others. While nutrients can be added to soil, it is important to decide whether the cost of fertiliser outweighs the value of the enterprise as a whole.

An assessment of all the attributes of the land will decide its limitations. These limitations can then be used to assign the land to particular 'land classes' (Table 22).

Table 22. Generalised land class definitions

Land class	Description
1	Land with little risk of degradation and able to support a wide range of uses. Suitable for all types of agricultural production on a permanent basis.
2	Land with some risk of degradation but still able to support a wide range of uses. Some conservation practices required if used for cropping e.g. broad rotations and/or some special cultivation practices.
3	Land with moderate risk of degradation. Special conservation practices required if used for cropping.
4	Land with moderately severe risk of degradation. Regular cropping would constitute an unacceptable risk.
5	Land with little risk of degradation but unsuitable for cropping because of soil, topography, wetness or salinity. Suitable for cultivation associated with pasture development.
6	Land with severe risk of degradation. Suitable for grazing but good management needed to preserve vegetative cover. Specialised equipment is necessary for establishment of improved pasture.
7	Land with very severe risk of degradation. Suitable for controlled grazing. Good vegetative cover is essential for protection of the land.
8	Land incapable of sustaining any form of agricultural production.

Individual properties can have a range of land classes which will place limitations on how the land is managed.

Steep slopes have the potential to create severe water erosion if sufficient ground cover is not maintained. Cropping land is particularly vulnerable. In high rainfall areas, extreme slopes which prohibit the use of machinery and are dangerous to livestock, should be reserved for native vegetation.

Rockiness reduces the ability to use machinery and can indicate a shallow soil depth rendering the land unsuitable for improved pasture or perennial horticulture (Figure 93). Rocky areas which have little agricultural value can be fenced off and revegetated.

Figure 93. Rocks severely limit land capability

Watercourses are fragile ecosystems which can be severely degraded by livestock. Water quality and biodiversity assets decline under these circumstances, so all watercourses (including dams) should be fenced off from livestock. Rehabilitation of degraded watercourses is an important process which contributes to the improvement of our natural resources.

Deep sand dunes are at risk of eroding if used for agricultural purposes. This land should be fenced off from stock and stabilised with appropriate native vegetation, or cereals such as cereal rye or triticale. Perennial veldt grass has the capacity to stabilise these dunes, however it can become invasive if not controlled.

Land class system for grazing

Using a simplified land capability approach for particular enterprises can be used as an alternative to the more complex eight-class system. For example, grazing can use a three class system (Table 23).

Table 23. Simplified land class system for grazing on small properties

Land class	Description
All year access areas	Gentle to moderate slopes, well drained, loamy to clayey soils. All year access except when conditions become too wet or when vegetation cover becomes sparse (cover should be >70%)
Restricted access areas	Winter waterlogged, poorly drained, steep slopes, highly erosive and/or poorly structured soils. Access is restricted during the year when certain areas experience waterlogging or when vegetation cover is too sparse.
Prohibited areas	Extreme slopes, area affected by or prone to landslips, gullying, tunnelling, salinity, areas of native vegetation or highly sensitive areas.

The 'prohibited areas' classification needs to be considered when assessing stocking rates and the type of management required. Identifying whether your property has any limitations (such as waterlogging, extreme slopes or rockiness) will enable the property owner to achieve a more realistic assessment of the amount of grazing land available. Allowing stock to graze waterlogged land will damage soil and pasture.

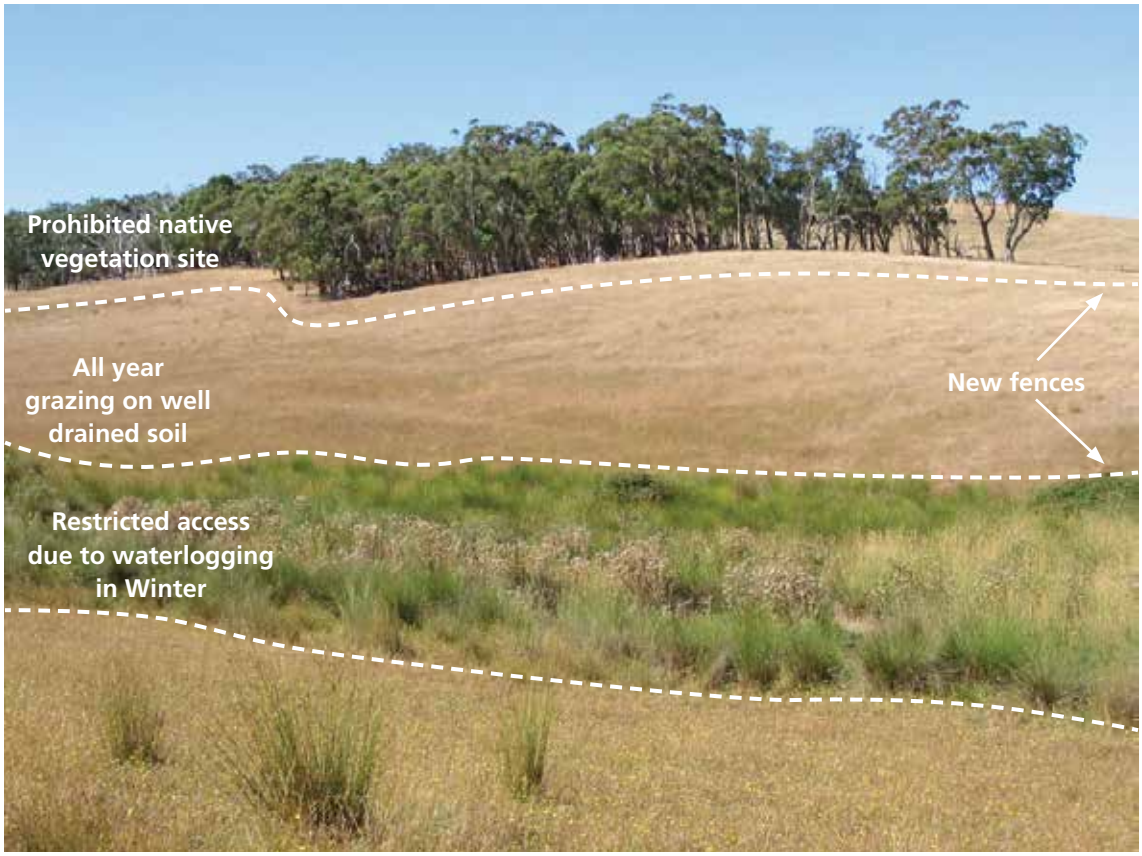


Figure 94. Grazing areas should be fenced off from different land classes such as native vegetation and waterlogged areas

14.2 Mapping land classes

Why map land classes?

1. Show where you can or cannot graze.
2. Allows fencing to land class which separates productive areas from non-productive areas.
3. Separating areas enables a more accurate assessment of carrying capacity.
4. Determines the area available for grazing.
5. Shows limitations for other enterprises e.g.
   Vines: need well drained soils and avoid frosts.
   Farm forestry: maximum slope of 35%.
   Cropping: avoid land over 12% slope.
   Grazing: avoid waterlogged soils.
   Strawberries: avoid saline soils.
   Phalaris: highly acidic soils can cause aluminium toxicity.

Figure 95. Land class mapping

14.3 Four steps to develop a successful property plan

Step 1 – Identify your goals and visions

Having a clear vision for your property is important if you are to achieve your hopes and aspirations. You will need to consider goals for:

- the property and its resources
- the business
- your family
- your lifestyle.

For most small property owners' lifestyle counts for a lot, however, particular enterprises can be a source of income if managed effectively. Whatever your priorities, appropriate management is critical to maximise your land's potential, or minimise any negative impacts on your resources.

Step 2 – Assess the natural resources of your property

To write a property plan effectively, you will need to gather information about the property.

This includes:

- natural resources – soil type, rainfall, native vegetation, water quality, water quantity
- physical geography – slope, rocky outcrops, drainage lines
- limitations of the property – waterlogging, weeds, erosion, salinity
- financial and human resources – what are the requirements of the enterprises to be run? Do these match the attributes of the property?

It is important to understand that the property assessment cannot be done in a short period of time. Landholders need to observe how the property reacts to weather events and seasons (dry, wet, prevailing winds, frost etc.).

Obtaining an aerial photograph of the property (Figure 96) will help by providing an overview of the existing layout, topography, native vegetation and watercourses. Land classes and existing infrastructure can be drawn on a clear overlay.

Figure 96. An aerial photograph will provide an overview of your property

Landholders can obtain an aerial photograph from a range of sources including:

- the internet
  – Google Earth: **http://maps.google.com.au/**
  – Nearmap: **www.nearmap.com.au**
- private businesses
- Mapland: **www.environment.sa.gov.au/Science/mapland**.

Step 3 – Develop the plan

Using a series of clear overlays will enable a realistic plan to be drawn up (Figure 97).

Figure 97. Overlays are used to draw up a realistic plan

Overlay 1 includes all the physical and permanent features of the property which will impact on its management (i.e. saline sites, rocky areas, steep slopes, native vegetation and watercourses etc.).

Overlay 2 includes the existing layout of the property (including fences, stock troughs, raceways, etc.).

Overlay 3 is the realistic plan based upon best practice land management principles and includes future plans such as new fence lines, revegetation areas or permanent structures.

The following should be considered when drawing up your realistic farm plan:

- location of the house
- location of sheds and yards
- location and types of fences
- water resources including stock watering points
- trees and vegetation
- surface water management
- names or numbers of paddocks
- raceways
- number and types of enterprises
- new fences
- livestock movement plan.

Step 4 – Write a detailed action plan

The success of any property management plan will depend upon the amount of resources needed to implement the changes. Most landholders will be limited by time, money and technical knowledge, so a feasible action plan should be drawn up which includes appropriate management strategies to accomplish specific tasks.

The action plan will need to address the following:

- prioritising issues
- location or area
- desired outcomes
- management strategies
- costs
- practical actions
- start and completion dates
- monitoring and evaluation.

14.4 Other planning considerations

Property management planning should lead to improvements in farm design which may result in a number of changes to infrastructure.

Fences

Horse properties

A permanent conventional fence of ringlock and three plain wires would be appropriate as a boundary fence to keep horses in and other animals out. Height should be approximately 1.4 metres. The top wire can be a sighter wire. To reduce the impact of horses damaging their hooves in the netting, a single electric offset wire is often used (Figure 98). Alternative horse fencing such as 'post and rail' is another possibility although for some people the cost is prohibitive.

Figure 98. A single offset electric wire can be used to keep horses well away from ringlock fencing

Painting them can also create time consuming maintenance issues. Barbed wire is likely to injure horses or damage horse rugs, and so should not be used.

Internal electric fences are less expensive than permanent conventional fences, but are very effective. Four or five wire electric with a top sighter wire is usually appropriate.

For temporary fences the use of electro-braid or tape is equally effective and can be correctly located in the paddock by using simple tread-ins.

There is a huge range of fences for horses so good research is recommended to decide on the most suitable fence for your property.

Cattle

Mature cattle are large animals which require adequate fences and yards to be managed appropriately. If the property will only ever run cattle, five or six strands of barbed wire will be adequate to keep cattle in (Figure 99). However, dogs will often penetrate these and can be a nuisance to young calves. If at any time sheep are introduced to the property these fences will be inadequate, especially for young lambs.

Where both sheep and cattle are being managed on the same property, a conventional fence of ringlock and three barbed wires would be appropriate (Figure 100). As a rule electric fences are generally not used for boundary fences, but are ideal as an internal cattle fence (Figure 101).

Figure 99. Six barbed wire boundary or internal fence

Figure 100. Conventional ringlock and barbed wire boundary or internal fence

Figure 101. Internal electric fence

Sheep

A boundary fence of ringlock and three plain wires (or barbed) is generally required. It is possible to use internal electric fencing but sheep are well insulated against electric shocks, and so should be introduced to this type of fencing after they are shorn. More strands of wire, usually six to eight are required to effectively hold sheep and lambs compared with cattle. Internal fences of ringlock and three plain wires are more commonly used as internal fences.

Alpacas

Provided adequate paddock feed is available, alpacas will respect fences, and prefer to remain with the herd rather than jump fences. Fencing which is suitable for sheep will also be appropriate for alpacas. Ringlock with three plain wire strands, or five to seven plain wire strands is generally adequate. Electric fencing can work, but is not always recommended since the animals fleece will often insulate them against the shock. Barbed wire is not recommended since it can cause serious injuries.

Yards

Placement of yards is an important consideration when re-designing a property. Yards need to be situated where large trucks can manoeuvre on solid ground (Figure 102). A flat, well drained area will avoid a quagmire during the wetter months of winter. If constructing a new yard it is well worth a few hours research to ensure that the facility meets your requirements and does not represent a danger to people or livestock.

Figure 102. Well-constructed cattle yards with road access

Stock water

Ideally dams and watercourses should be fenced off from livestock which will no longer be able to access water directly from these sources. A reticulated watering system (Figure 103) is generally accepted as the most efficient way to provide stock water. This system relies on water from dams (or bores) being pumped to a header tank which then allows water to flow through underground polypipe, by the force of gravity, into stock troughs strategically placed in each paddock. A series of pressure valves and ball floats will ensure that water troughs are always full. However, these should be checked regularly to avoid any problems. Water trough should be placed on higher well drained ground away from fences and 'at risk' areas of the paddock.

And where possible these troughs should be placed adjacent to shade trees. They should not be placed through a fence, which tends to encourage bare areas susceptible to erosion.

There are many types and sizes of water troughs. Whether landholders use troughs which are all polyethylene construction, or made of concrete, will depend largely on circumstances and personal preference. Concrete troughs are solid and will resist damage from large animals, especially if the ball float is protected, but they can crack in time and are generally heavy and difficult to move around.

Polyethylene troughs are light and animals are less likely to injure themselves. They can also be shifted easily to provide a short term water supply when creating temporary paddocks.

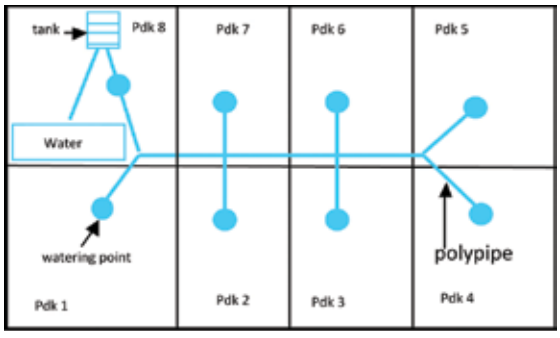


Figure 103. Example of a reticulated watering system

Figure 104. Round concrete troughs are popular on small horse properties

Figure 105. Round polyethylene troughs are light and easily moved

Figure 106. A basic trough suitable for a small flock of up to 300 sheep

Figure 107. Poorly designed troughs can lead to erosion
Photo: Will Hannaford

In either case, troughs should be deep and large enough to supply the needs of all the animals in the paddock. Round troughs are quite popular for small horse properties since they allow good access by a number of horses at any one time.

Raceways

Raceways can be an efficient way of accessing paddocks. Planning and careful positioning of raceways contribute to safe and easy livestock movement, and moving machinery around the property is less time consuming since fewer gates need to be opened. In the event of fire, livestock can be moved quickly to safer areas, and fire authorities will have better access to deal with any threats caused by bushfires.

Shelterbelts

Livestock require shelter from intense summer sun and severe winter winds. New paddocks may not have adequate shelter, so it may be necessary to erect an artificial shelter from plastic netting or wooden slatting, while newly planted shelterbelts are becoming established. Shelterbelts are a potential fire hazard, so when planning their location, landholders need to assess the risk to property, livestock and family. Species selection can be important in managing this risk.

Figure 108. Shelterbelts provide good protection for livestock

Fire

In planning for fire protection, consider the total property as well as buildings, and consider the situation in relation to known hazards. For example, the proximity of native vegetation. Assess the fire hazard when locating new buildings, hay sheds, water supply points, access tracks, yards, fence lines and livestock. Remember ambient heat from an intense bushfire can kill livestock held in yards. And always prepare a bushfire survival plan.

15. Livestock feed requirements

Using regional stocking rate figures (Chapter 11) is a helpful guide to matching livestock numbers with anticipated annual pasture production each year. However, a much more accurate approach is possible if the dry matter (DM) produced by a pasture can be estimated (or measured) at different times of the year. Seasonal conditions will have a significant influence on dry matter production. For example, an average dryland pasture in the Mount Lofty Ranges may produce 20 kg DM/ha/day during June, but in October this can jump to 50 kg DM/ha/day. Therefore, knowing how much feed is in a paddock will enable landholders to be more precise when determining how many animals can graze a particular paddock, and for how long.

This is referred to as feed budgeting, which allows livestock productivity to be maximised, and helps to ensure enough cover is maintained in paddocks to prevent erosion. How much feed is available for livestock over a particular time period is referred to as 'food on offer' or 'herbage mass'.

15.1 Pasture productivity

Annual rainfall will impact strongly on pasture growth along with the quality of pastures. However, it is important for landholders to recognise that not all pasture growth is consumed by livestock, therefore pasture utilization is a better measure of actual productivity from a pasture (Table 24). For intensive strip, or cell grazing, where stocking rates are high, pasture utilisation is likely to be around 60 to 70%. Where stocking rates are average, and a four paddock rotational grazing system operates, this figure is more likely to be 45 to 55%. Utilisation can drop to 25% where set stocking is the only grazing strategy and stocking rates are below the district average.

Table 24. Pasture utilisation (tonnes DM/ha/year) on dairy farms in the Mount Lofty Ranges

	Dryland pasture	Irrigated pasture
Poor	< 3.0	< 9.0
Average	3.0 to 4.5	9.0 to 12.0
Good	4.5 to 8.0	12.0 to 18.0

Pasture growth will vary according to the seasons of the year with most growth of dryland pastures occurring during spring, while for irrigated pastures this period of high production extends through to summer and early autumn.

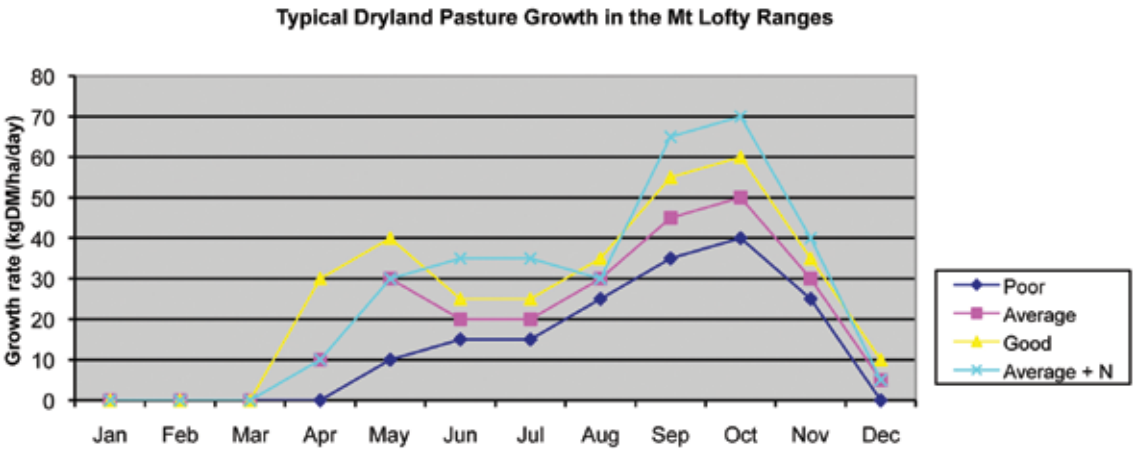


Figure 109. Typical dryland pasture growth in the Mount Lofty Ranges

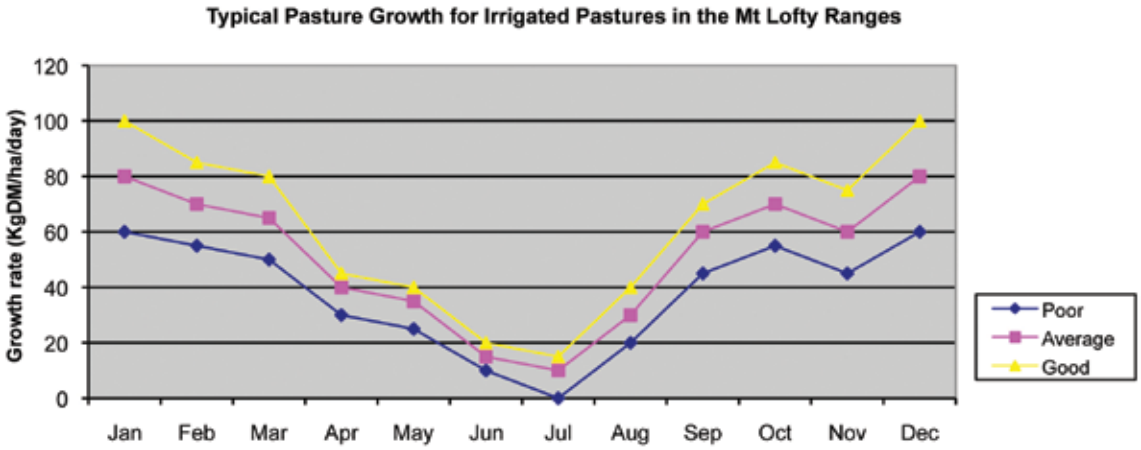


Figure 110. Typical irrigated pasture growth in the Mount Lofty Ranges

15.2 Food on offer (herbage mass)

Pasture availability in a paddock can be determined by:

- visually estimating
- measuring plant height
- cutting, drying and weighing sample quadrants.

The latter method is accurate but time consuming since a number of samples need to be taken from each paddock to be accurate. Visually assessing the paddock is less accurate but quicker, so where pasture heights can be measured the final result can be more reliable (Table 25). Note: 1500 kg of dry matter (DM) per hectare is regarded as the minimum pasture height to maintain good pastures and protect soil from erosion.

Table 25. Generalised relationship between green pasture height and pasture availability

Average pasture height cm	Pasture availability kg DM/ha
1	500
2	800
3	1100
4	1400
5	1700
6	2000

Estimating pasture availability relies on individuals refining their skills to the point where they can reliably predict herbage mass. Where clover makes up a significant proportion of the pasture, herbage mass tends to be overestimated, when using height alone, while estimating pasture density can be problematic.

Prograze training courses which focus on developing these field techniques are offered to landholders. Enquiries can be made with the Adelaide and Mount Lofty Ranges NRM Board or Meat and Livestock Australia.

Another useful technique is to use photographic benchmarks when assessing herbage mass (food on offer) in the field. The following photographs have taken into account pasture height, legume content and plant density and were sourced courtesy of Primary Industries and Resources SA and the Appila Bundaleer Pasture Group.

Legume grass mixes

Figure 111. Legume grass pasture showing 0.5 tonne/hectare of dry matter

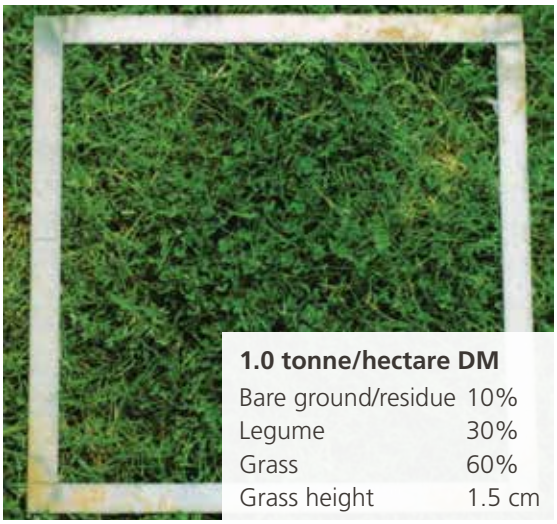


Figure 112. Legume grass pasture showing 1.0 tonne/hectare of dry matter

Figure 113. Legume grass pasture showing 1.8 tonnes/hectare of dry matter

Figure 114. Legume grass pasture showing 2.8 tonnes/hectare of dry matter

Figure 115. Legume grass pasture showing 3.7 tonnes/hectare of dry matter

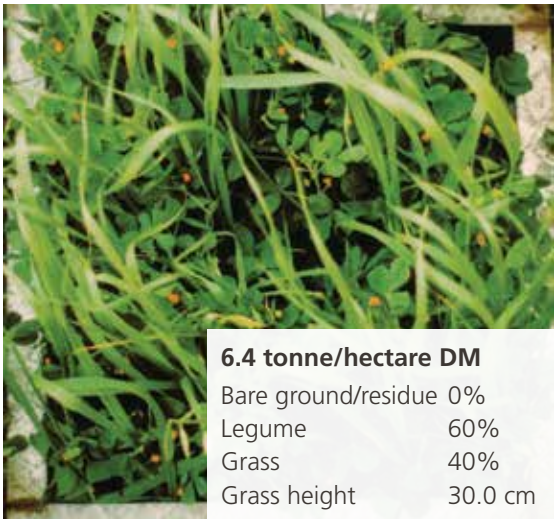


Figure 116. Legume grass pasture showing 6.4 tonnes/hectare of dry matter

15.3 Feed budgeting

Balancing livestock numbers with pasture availability to ensure the nutritional needs of animals are met and paddocks are not overgrazed is a fundamental responsibility of any landholder managing a grazing property.

Observing pastures to ensure paddock feed levels do not fall beyond 1500 kg DM/ha (approximately 4 to 5 cm) during the growing seasons is one way of encouraging efficient pasture re-growth, and avoiding bare ground which can lead to soil erosion. This approach can be very successful provided the stocking rate for the property matches pasture production and fodder is being conserved in spring (hay making).

However, there are situations where simple feed budgeting can be helpful, such as deciding whether to increase livestock numbers or when it may be necessary to sell. The following is an example of a simple feed budget.

How long will a 5 ha paddock last if stocked with 40 yearling steers (weighing 400 kg and gaining 0.5 kg per day), ensuring pasture is kept above a minimum level to meet livestock requirements?

Herbage mass currently in the paddock (use photographs above)	2800 kg DM/ha
Minus required minimum pasture mass	1500 kg DM/ha
Available pasture	1300 kg DM/ha
Daily growth rate of pasture (Table 26)	25 kg DM/ha
Stocking density (40 steers divided by 5 hectares)	8 steers/ha
Daily livestock requirements (Table 28) (9.6 kg dry matter/ hd/day × 8 steers/ha + spoilage 15%)	88 kg DM/ha
Net pasture loss (88 kg DM/ha minus 25 kg DM/ha)	63 kg DM/ha
How long will the paddock last? (1300 kg DM/ha divided by 63 kg DM/ha)	21 days

In this example, if livestock are allowed to remain in the paddock for any substantial period after 21 days, paddock feed will fall below 1500 kg/Ha dry matter (i.e. approximately 4 to 5 cm in height). As a consequence, not only is the condition of animals likely to decline, but ground cover will become less, and the risk of soil erosion will increase.

Pasture growth rates will vary according to the composition of the pasture, the location and whether they are being irrigated. The following tables provide some generalised figures for daily pasture growth in the Mount Lofty Ranges and Fleurieu Peninsula.

Table 26. Estimated daily dryland pasture growth rate (mid month) kg DM/ha/day for specific pasture types

Pasture type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Perennial grass and sub. clover, Mount Lofty Ranges	0	0	0	10	30	15	15	30	60	65	20	10
Perennial grass and sub. clover, Fleurieu Peninsula (good quality)	0	0	0	30	25	25	25	35	55	60	35	10
Perennial grass and sub. clover, Fleurieu Peninsula (average quality)	0	0	0	10	20	20	20	30	45	50	30	5
Perennial grass and sub. clover, Fleurieu Peninsula (poor quality)	0	0	0	0	15	15	15	25	35	40	25	0

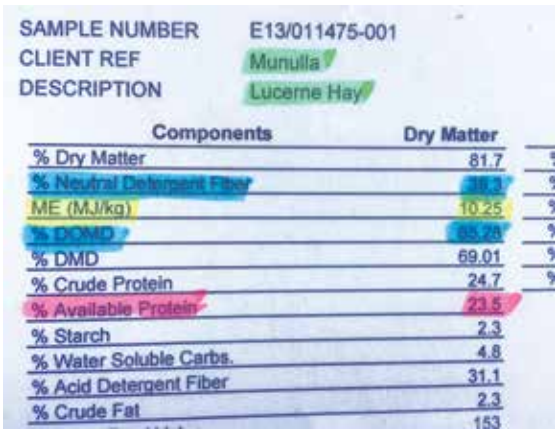
15.4 Energy and protein content of various feeds

While benchmark figures are available for how much to feed particular classes of animals, knowing the energy and protein values of specific types of feed will enable landholders to calculate how much of a particular feed type is required to meet the all the nutritional requirements of different livestock classes. The cost of feed can then be considered and a more economic approach to supplementary feeding can be adopted.

Table 27. Metabolisable energy and crude protein contents of feeds

Feed	Dry matter %	Energy MJ/kg DM	Crude protein % DM
Oaten hay	90	9.0	6.0
Wheaten hay	90	8.0	6.0
Pasture hay (mainly grass)	90	8.5	8.0
Pasture hay (good quality)	90	9.8	18.0
Pasture hay (average quality)	90	9.0	12.0
Pasture hay (poor quality)	90	7.8	8.0
Lucerne hay	90	9.0	15.0 to 25.0
Clover hay	90	9.0	13.o to16.0
Oat/vetch hay	90	9.5	13.0
Silage (good quality)	40	10.0	18.0
Dry paddock pasture	90	5.0	5.0 to 8.0
Barley grain	90	13.0	11.0
Oats grain	90	12.5	10.5
Lupin grain	90	12.5	30.0
Faba beans grain	90	12.5	25.0
Field peas grain	90	13.0	25.0
Barley straw/stubble	90	6.5	5.0
Pea straw/stubble	90	7.0	7.0

Figure 117. Lucerne Hay
Photo: Will Hannaford



SAMPLE NUMBER	E13/011475-001
CLIENT REF	Munulla
DESCRIPTION	Lucerne Hay

Components	Dry Matter
% Dry Matter	81.7
% Neutral Detergent Fiber	38.3
ME (MJ/kg)	10.25
% DOMD	65.28
% DMD	69.01
% Crude Protein	24.7
% Available Protein	23.5
% Starch	2.3
% Water Soluble Carbs.	4.8
% Acid Detergent Fiber	31.1
% Crude Fat	2.3

Figure 118. Lucerne Hay nutrition
Photo: Will Hannaford

Figure 119. Meadow Hay
Photo: Will Hannaford

SAMPLE NUMBER	E13/011541-002
CLIENT REF	Yankalilla Meadow Hay
DESCRIPTION	Mixed Mostly Grass

Components	Dry Matter
% Dry Matter	81.9
% Neutral Detergent Fiber	62.2
ME (MJ/kg)	8.30
% DOMD	55.87
% DMD	57.66
% Crude Protein	12.4
% Available Protein	11.2
% Starch	1.4
% Water Soluble Carbs.	9.1
% Acid Detergent Fiber	40.6
% Crude Fat	2.7

Figure 120. Meadow Hay nutrition
Photo: Will Hannaford

The quality of hay can vary significantly, depending on the quality of the pasture and how the cutting and baling process was carried out, so for the inexperienced landholder what seems good feed may well be low in both protein and energy. One way of reducing the risk of purchasing poor quality feed is to conduct a visual assessment of the hay.

Good quality hay should:

- be green in colour – not yellow
- be sweet smelling
- have good legume leaf (avoid too much stalk in lucerne)
- be free of weeds and weed seed heads
- be pliable but not brittle
- have pasture grass seed heads which are flowering, and do not contain mature seed
- have the seeds at the watery ripe stage for cereal oaten hay.

However, if an accurate nutritional value is required hay must be tested in a laboratory. As well as crude protein % and energy MJ/kg DM, dry matter digestibility (DMD) is also measured. Once digestibility (DMD) declines below 65% for lactating stock and 55% for dry stock, then, no matter how much pasture is available, these animals are likely to experience unsatisfactory performance levels, i.e. increasing weight loss.

15.5 Livestock nutritional requirements

Most small farms rely on hay supplements when paddock feed is low, but there are a variety of feed types which can be given to livestock which will provide animals with the necessary daily energy and protein levels. In order to determine how much to feed, the energy and protein requirements for different classes of animals need to be known. The following tables provide some of this information.

Table 28. Energy and protein requirements – sheep and cattle

Class of animal	Energy needed (MJ per day)	Protein %	Maximum daily dry matter intake (% of live weight)
Adult dry sheep (60 kg)	8.0	8.0	2.0
Adult dry sheep (40 kg)	6.5	8.0	2.0
Pregnant ewes (last 6 weeks)	8.5	13.0	2.8
Lactating ewes (first 2 months)	14.5	14.0	4.2
Weaner sheep (< 35 kg)	5.5	15.0	3.8
Dry cows	41.0	8.0	1.8
Lactating cows (first 3 months)	97.0	14.0	3.5
Lactating cows (4–7 months)	105.0	14.0	3.5
Weaned calves	50.0	15.0	2.5
Steer (300 kg gaining 0.5 kg/day)	57.0	10.0	2.5
Steer (400 kg gaining 0.5 kg/day)	71.0	7.6	2.4

Table 29. Energy requirements for horses at various levels of work

Weight	400 kg	500 kg	600 kg
Maintenance energy requirements MJ/day	58.0	68.0	79.0
Additional energy required per hour for:			
Walking	0.84	1.05	1.26
Slow trotting, some cantering	8.4	10.5	12.6
Fast trotting, cantering, some jumping	21.0	26.2	31.4
Cantering, galloping, jumping	38.5	48.1	57.8
Strenuous activity (polo, racing at full speed)	65.3	81.6	97.9
Steer (400 kg gaining 0.5 kg/day)	71.0	7.6	2.4

Table 30. Daily energy and protein requirements for different categories of horses
Source: 'Grazing and feeding', Agriculture Victoria, formerly Victorian DPI

Class of horse	Mature weight (kg)	Live weight gain (kg/day)	Energy MJ/ day	Crude protein (grams/day)
Weanling (4 months)	400 500 600	0.85 0.85 1.00	56.5 60.2 69.0	675 720 825
Weanling (6 months, moderate growth)	400 500 600	0.55 0.65 0.75	54.0 62.8 71.1	643 750 850
Weanling (6 months, rapid growth)	400 500 600	0.70 0.85 0.95	60.7 72.0 80.3	725 860 960
Yearling (12 months, moderate growth)	400 500 600	0.40 0.50 0.65	65.3 71.9 95.0	700 851 1023

Table 30. continued

Class of horse	Mature weight (kg)	Live weight gain (kg/day)	Energy MJ/ day	Crude protein (grams/day)
Yearling (12 months, rapid growth)	400 500 600	0.50 0.65 0.80	71.5 89.1 105.0	770 956 1127
18 months	400 500 600	0.25 0.35 0.45	66.5 82.8 100.00	716 893 1077
2 years	400 500 600	0.15 0.20 0.30	64.0 78.7 98.3	650 800 998
Maintenance	400 500 600		56.1 68.6 81.2	563 656 766
Pregnant (9 months)	400 500 600		62.3 76.1 90.0	654 801 947
Pregnant (11 months)	400 500 600		67.4 82.4 97.5	708 866 1024
Lactating (foaling to 3 months)	400 500 600		95.8 118.4 141.0	1141 1427 1711
Lactating (3 months to weaning)	400 500 600		82.4 101.7 120.9	839 1048 1258

Alpacas consume 2% of their body weight in feed per day and prefer to graze shorter pastures. Ideally the fibre or roughage component of their diets should not fall below 25%.

The energy requirements for alpacas are generally 30% less than those of sheep, because fibre provides a significant amount of additional energy. A dry hembra, or wether, weighing 65 kg requires approximately 7 MJ of energy each day which can be supplied by 1.3 kg of hay each day.

Protein requirements for alpacas are relatively low compared with other animals.

The following protein levels are provided as a guide:

- maintenance 8% to10% crude protein
- rapid growth from weaning 16% crude protein
- pregnancy and lactation 12% to 14.5% crude protein.

15.6 Livestock feed consumption

A dryland pasture comprised of grasses and legumes will usually provide a balanced diet for livestock while paddock feed is available. However, during the dry seasons of summer and early autumn landholders will usually have to consider supplementary feeding with hays or grains.

When feeding grain, animal health problems can be encountered if grain is not introduced gradually after livestock have been grazing on pasture. If feeding grain to sheep, start with only 50 grams per head per day, increasing to 430 grams per head per day by the 14th day.

Further information on supplementary sheep feeding can be found in F*eeding and managing sheep in dry times*, visit: **www.wool.com** and search for 'Feeding and managing sheep in dry times'.

Meat and Livestock Australia provide information and feed calculators on the feeding and finishing section of their website: **www.mla.com.au** and search for 'Feed caluculators'.

16. Weed and pest control

16.1 Weed management

Good land management remains the key to controlling most weeds in pastures. There are a number of pasture management techniques which will help to keep weeds from becoming a serious problem.

These include:

- soil testing and adding appropriate fertilisers
- liming acid soils
- rotational grazing
- keeping good ground cover
- over-sowing with perennial grass and clover
- hard grazing in spring to reduce seed set of annual grasses
- rotating hay paddocks to avoid a build-up of annual grasses
- using low toxicity herbicides, if necessary
- integrating biological control measures where possible.

Annual broadleaf pasture weeds (e.g. capeweed, geranium and salvation Jane)

Most landholders think of using herbicides when confronted with paddocks full of capeweed (*Arctotheca calendula*), storksbill (*Erodium* spp.) or salvation Jane (*Echium plantagineum*). Whilst herbicide use is an important tool for controlling these plants, it is only one of the management options available.

If paddocks becomes bare, weed seeds present in the soil are likely to germinate – especially in autumn. Establishing and maintaining a perennial pasture in high rainfall areas will help to combat this problem. Perennial pastures consisting of cocksfoot, phalaris, ryegrass and clover will allow grazing, and provide competition for germinating broad leaf weeds, as well as reduce the reliance on herbicide use.

If using herbicides to control annual broadleaf weeds, spraying should occur early in the season when plants are small and lower rates can be applied. Early spraying encourages more desirable plants to grow without competition from aggressive weeds. Selective herbicides are available to help control these weeds.

A technique known as 'spray-grazing' can be effective in reducing weeds. This involves applying MCPA* or 24D amine and then grazing sheep and cattle at four to five times the normal stocking rate. This is not recommended for horses because it can be detrimental to the health of these animals.

Metsulfuron-methyl can be used to control flowering salvation Jane in early spring.

***Warning: Do not use products with MCPA (or similar volatile chemicals) before mid-May or after end of August within 1 km of vineyards or horticultural crops etc. since damage to these crop can occur.**

Figure 121. Common annual broadleaf pasture weeds
Capeweed, storksbill and salvation Jane

Biological control can be used as part of an integrated weed management program. In the case of salvation Jane there are four main insects that are the focus of biological control. The **crown weevil** larvae attack the growing crown of the plant, whilst the **root weevil** larvae feed on the taproot, effectively 'ring-barking' the root. The **flea beetle** larvae also attack the primary and secondary roots. The impact of the **pollen beetle** is to reduce the amount of seed set.

If herbicides need to be used to control particular weeds, it is important that landholders investigate the impact of these chemicals on useful insects. In some circumstances it may be necessary to leave untreated strips so the biological control agents are not wiped out.

For advice on biological control agents and their possible availability, contact your local natural resources centre.

Perennial broadleaf pasture weeds (e.g. catsear and dock)

Perennial broadleaf weeds can be difficult to control. They often have well established roots systems and very effective seed dispersal mechanisms. The light seeds of catsear (*Hypochoeris radicata*), which are distributed by wind, make this a very common weed in high rainfall areas. Dock plants (*Rumex* spp.) generally have a very deep tap root which seeks out sub soil moisture at depth, while the variegated thistle (*Silybum marianum*) is unlikely to be eaten by stock and so freely sets seed. Good pasture management and improved soil fertility will help to keep these weeds under control, but if herbicides are required, Dicamba/MCPA and Metsulfuron-methyl are effective if sprayed when plants are actively growing. It is important to seek professional advice before selecting and using chemicals, and to ensure label directions are followed.

Figure 122. Common perennial broadleaf pasture weeds Dock and catsear

Bulbous weeds (e.g. guildford grass, cape tulip and watsonia)

Despite its name guildford grass is not a grass. It belongs to the family Iridaceae and is a bulb. Guildford grass (*Romulea rosea*), sometimes referred to as 'onion grass', has long, tough leaves up to 12.5 cm and thrives in low fertility soils found throughout the high rainfall areas of the Mount Lofty Ranges. Landholders may also discover lesser guildford grass (*Romulea minutiflora*) which has a similar distribution.

It has been known to create problems for livestock (especially horses and cattle) when it forms a tough fibrous ball, blocking the animals digestive tract. In some cases this can be fatal.

Poor pasture management, coupled with low fertility soils, encourages the spread of this 'allelopathic' weed, and as a result, pasture growth is suppressed. Studies in Victoria have shown that adding 10–15 kg/Ha of phosphorus, depending on soil type, can prevent it from invading perennial grass/subterranean clover pastures.

Herbicide applications may be necessary where this weed has become dominant. Metsulfuron-methyl applied at 15 g/ha is effective in controlling Guildford grass, provided it is applied in late July. It may be necessary to re-seed pastures in autumn if applying this chemical because it will kill subterranean clover and can damage or kill perennial ryegrass. Professional advice should be sought for particular situations.

Figure 123. Guildford grass (*Romulea rosea*)
Seeds, bulb and flower (pale to bright pink)

Figure 124. Cape tulip (*Homeris* spp.)

Figure 125. Watsonia (*Watsonis bulbilifera*)

Other bulb weeds include watsonia and cape tulip which can become quite invasive. Digging out the bulbs before they have time to flower can be effective for small patches, however, if landholders need to rely on chemical control, metsulfuron methyl is effective against cape tulip while Glyphosate is effective against watsonia.

Annual grass weeds (e.g. barley grass, silver grass and wild oats)

These types of weeds can be a problem in pastures which have been overgrazed, so it is important not to graze pastures below 5 cm while they are growing, and 3 cm over summer. In high rainfall areas, a dense permanent pasture with a good percentage of perennial grasses will make it hard for annual grasses to become established. However, once established, these weeds are difficult to eradicate and landholders will need to employ a range of tactics in order to control them. The following section on 'barley grass control' includes a range of management options which can be employed.

Barley grass control

Some barley grass seed can remain viable for 2 or 3 years, so landholders should be watchful during this period when dealing with badly-infested pastures. However, usually over 90% germination occurs during the autumn break, so after a two year period significant control should be observed. If this weed is a problem across the whole of the property it may be prudent not to target all paddocks in one year since a lot of paddock feed will be lost and reduced livestock carrying capacity will need to be addressed. A staged program over 2 or 3 years may be preferable.

Figure 126. Use a range of techniques to control barley grass in permanent pastures

Using post emergent herbicides

Post emergent herbicides are available which will control barley grass if sprayed 4 to 6 weeks after the opening rains in autumn. Landholders should seek professional advice when using these herbicides since damage to perennial grasses can occur in some situations.

Patch spraying

In paddocks where the barley grass is patchy, these areas can be sprayed out with glyphosate in spring before seeds have formed. New pasture can then be re-sown in autumn provided livestock can be excluded from the site while the pasture becomes established.

Deferred grazing

When grazing is deferred for a period of 20 days after the autumn break, and the paddock heavily stocked continuously throughout the rest of the growing season, many plants will be eradicated before setting seed. If deferred grazing occurs earlier, or later, than the 20 day period, selective grazing of livestock may reduce the effectiveness of this type of control.

Spray topping

This process involves spraying the barley grass with a low rate of Glyphosate or Gramoxone after seed head emergence. The plant is not killed, but a small amount of the herbicide is absorbed by the seed which dies. If embarking on this approach, it is important to heavily graze pastures during early spring (September) to ensure an even crop of barley grass seed heads. Livestock should be removed 2 to 3 weeks before target weed has set seed, but seed heads have emerged. Spraying should be delayed until the last seed heads at the bottom of the plant have emerged and initial signs of yellowing appear. If spraying with Glyphosate 450 the rate is 240 ml to 360 ml per hectare.

Using herbicides

If the use of chemicals is necessary, the application of appropriate herbicides at the correct time of the year will be better for the environment, be more effective and help to reduce costs.

Effective control of weeds will avoid the necessity to apply more chemicals at a later stage to eradicate larger plants. The following chart outlines the most appropriate times to control weeds.

Table 33. Calendar of chemical control of weeds

Weeds	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blackberry, Broom												
Gorse												
Boneseed												
Hawthorn												
Olive (wild)												
Salvation Jane and Thistles												
Broadleaf pasture weeds												
Cape Tulip												
Bridal creeper												
Watsonia												
Water dropwort												

Legend — Optimum | Suitable | Seek advice | Not suitable

When using herbicides landholders should always read the label carefully to ensure that chemicals are being applied as directed. Application of chemicals must comply with the registered use as specified on the label or the Material Safety Data Sheet (MSDS).

The MSDS describes the properties of a material and provides advice on safe handling and use of the material. In Australia chemical manufacturers and importers must produce an MSDS for any chemical that is a hazardous substance and make it freely available to workers handling the substance. The MSDS for each chemical product is generally available at the point of sale. The manufacturer of the product can be contacted if these are not available.

In addition, equipment should be calibrated so that the rate of application matches the manufacturers' recommendations. If assistance is required contact staff at your local natural resources centre or your local land management consultant, who will be able to explain the process.

Declared weeds

Declared plants are those that are regulated under the *Natural Resources Management Act 2004*. They have been assessed as significant weed threats to South Australia's primary production industries, natural environments and public safety. Every landowner in South Australia has a legal responsibility to manage declared plants

Plant species can be declared under various sections of the NRM Act, relating to:

Movement – Some declared plants must not be moved on a public road (e.g. as a cutting, seed or potted specimen). Inadvertent movement of the plant on animals, soil, vehicles, machinery or produce may also be illegal.

Sale – Many declared plants must not be sold at any outlet including nurseries, pet shops and market stalls. Sale of items contaminated with the plant may also be illegal.

Notification – The presence and locations of some declared plants on your own land must be reported to your regional NRM board.

Control – Landholders are required to take action to destroy or control many declared plant species which are growing on their property, regardless of whether it is used as a business, residence or for other purposes. The AMLR NRM Board (along with all other NRM boards) will also control certain declared plants found on road reserves. Costs can be recovered from the adjoining landowners.

Some of the more common pasture weeds found in the region are listed in Table 34.

Table 34. Common declared pasture weeds of the region

Common name	Scientific name
Blackberry	*Rubus fruticosus* sp. agg.
Bulbil watsonia	*Watsonia meriana* var. *bulbillifera*
Caltrop	*Tribulus terrestris*
Horehound	*Marrubium vulgare*
Nutgrass	*Cyperus rotundis*
Salvation Jane	*Echium plantagineum*
Soursob	*Oxalis pes-caprae*
Spear thistle	*Cirsium vulgare*
Wild artichoke	*Cynara cardunculus*

For more information on declared weeds contact your local natural resources centre or go to **www.naturalresources.sa.gov.au/adelaidemtloftyranges**

16.2 Pasture pests

Highly productive and persistent pastures can be severely damaged by pests and diseases unless land managers are able to recognise the symptoms and deal with them before they become a problem. Carrying capacity can be reduced when pastures lose vigour, creating a risk of overgrazing and soil erosion.

Pests

The most common pasture pests include red legged earth mite, lucerne flea and blackheaded pasture cockchafer. Severe damage can result from large infestations.

Redlegged earth mite

The redlegged earth mite (*Halotydeus destructor*) is a major pest of pastures, especially subterranean clover, annual medics and lucerne. It thrives in the Adelaide and Mount Lofty Ranges region which experiences cool wet winters and hot dry summers. The use of pesticides is a common method of control, however, alternative non chemical options are being embraced as evidence emerges that mites are exhibiting resistance to chemical sprays. Typical damage from these mites is seen as 'silvering' or 'whitening' of leaves (Figure 127). It is important to kill adult mites before they are able to lay eggs in spring which ultimately hatch in autumn. The optimum dates can be predicted by accessing the TIMERITE website program (**www.timerite.com.au**). Systemic pesticides can be applied to the seed coat when sowing a new pasture, however, it is still necessary to check young pastures to determine the extent of any infestations as these mites have the capacity to destroy the legume component of any pasture. Biological control can play a part in reducing redlegged earth mite numbers. There are a number of predators, in particular a predatory mite (*Anystis wallacei*), however, the dispersal rate for this mite is slow. Controlling weeds, such as thistles and capeweed, which act as host plants for the redlegged earth mite, will reduce breeding sites.

Figure 127. Redlegged earth mite damage

Lucerne flea

Adult lucerne fleas (*Sminthurus viridis*) are approximately 3 mm long, wingless (Figure 128) and lay eggs which remain dormant over summer and hatch during March and April. They can inflict considerable damage to clovers, lucerne and capeweed. They tend to be a problem on loam/clay soils, but generally not on sandy soils. Monitoring the development and spread of these pests is important so that chemical applications can be timed to act on young fleas which have not had a chance to breed. Systemic sprays can be used when damage is first detected. There are known predators of this pest, but these are unlikely to be an effective control measure on their own. A good grazing regime coupled with sound weed control of host plants should be adopted to avoid total reliance on chemicals.

Figure 128. Adult lucerne flea
Photo: Victorian DPI, Agnote 0415

Figure 129. Black Headed Pasture Cockchafer

Blackheaded pasture cockchafer

The larval stage of this insect pest (*Aphodius tasmaniae*) is responsible for damaging pasture. Clovers and ryegrass are particularly susceptible. Larvae can reach 15 to 20 mm in length (Figure 129) while the adult beetles are generally 10 to 11 mm. Eggs are laid in soil and when larvae emerge they feed on pasture plants resulting in bare patches and exposed soil. Eggs hatch in early November with larvae doing considerable damage during April to early August. May and June is the optimum feeding time of larvae. In severe cases insecticides can be used since these insects are surface feeders. The best time to spray is just before rain or when heavy dew is expected. Avoid spraying after July as larvae will be difficult to eradicate. To confirm that bare patches are the result of the pasture cockchafer, holes need to be dug to a depth of 150 mm to identify the insect larvae and determine the density of the infestation.

Diseases

There are a number of diseases of pasture plants including rust, leaf spot, blight and a range of viruses. Young seedlings can also suffer from 'damping off' which occurs when a fungus attacks the stems of newly emerged seedlings. Soil conditions contribute significantly to this problem. It is important to use clean certified seed when sowing new pastures and to ensure that pastures are selected for their resistance to known diseases of the area. Appropriate management of soils and pastures will help to reduce the likelihood of disease becoming a problem. If disease is suspected, seek professional advice.

16.3 Feral animal control

Rabbits

European rabbits (*Oryctolagus cuniculus*) are a declared pest under the *Natural Resources Management Act 2004*, and are regarded as a serious invasive pest throughout the state. They cause millions of dollars in damage to crops and pastures annually, and are detrimental to the natural environment.

There are a number of methods that can be used to control rabbits. To achieve good results it is best to use a range of ongoing approaches.

For example:

- baiting
- warren destruction by ripping
- fumigation.

Biological controls in the form of Myxomatosis and Rabbit Hemorrhagic Disease are present in Australia, but their effectiveness varies considerably from year to year since they are dependent upon a range of environmental factors.

Trapping is generally not regarded as an effective way to reduce high numbers of rabbits quickly, since it requires a significant amount of time and effort. However, some local councils hire out cage traps to residents for the trapping of pest animals.

It is best to adopt a range of strategies for effective control. Technical support and advice is available from Natural Resources Adelaide and Mount Lofty Ranges.

Foxes

The fox (*Vulpes vulpes*) is a declared animal under the NRM Act, and is one of the most successful predators in the world. They are a major threat to livestock and small native mammals, birds and reptiles. It is the responsibility of property owners to control them. It is also illegal to keep foxes as pets.

Fox management and control options include:

- destroying fox shelters
- fumigation using carbon monoxide gas cartridges
- trapping
- poisoning.

Traps are available from your local natural resources centre.

Sodium fluoroacetate, commonly called 1080 (ten-eighty), is the only poison registered for fox control in South Australia. Foxes are extremely susceptible to this poison. However, due to the risk of poisoning other animals, such as dogs, its use is highly regulated. Landholders can only access 1080 through their local natural resources centre.

Deer

Farmed deer (*Family: Cervidae*) which are kept for commercial or non-commercial use, should be permanently identified and confined behind deer fencing in compliance with the *Natural Resource Management Regulations 2005*. These herds need to be registered under the *Livestock Regulations 1998*.

Deer that lack identification, are not confined by appropriate fencing, and are on land without the consent of the owner, are regarded as feral deer.

Landholders are responsible for the satisfactory control of the feral deer on their properties. The AMLR NRM Board requires landholders to eradicate new populations of feral deer that have established as the result of recent escapes or recent migrations. The control of established feral herds on private and public lands is the responsibility of the landholder. The board is also responsible for determining the level of control that will manage the impact of feral deer within the region.

It is an offence to wilfully or negligently release deer into the wild.

For further information on feral animal control contact Natural Resources Adelaide and Mount Lofty Ranges.

17. Enterprise management – specific issues

17.1 Horse management

Horse keeping

Under the *Natural Resources Management Act 2004*, owners and managers of land have a duty of care to protect natural resources and to ensure that land is not degraded. Intensive horse keeping, along with other intensive livestock systems, have the potential to damage natural resources (i.e. soil, water, air and vegetation) so it is important that appropriate management systems are in place to protect the environment.

The term 'horse keeping' is defined in the regulations pertaining to the *Development Act 1993* and refers to situations where landholders keep more than one horse for every three hectares (7.4 acres) of land, or where hand feeding of horses is involved. In these situations approval may be required from your local council.

If you intend to keep two horses on three hectares of land you are undertaking horse keeping.

Local councils have their own zoning regulations, so check with your council before embarking on a horse keeping venture or intensive horse management system, regarding your rights and obligations managing horses.

Horse management systems

Many thousands of land owners in this region have purchased properties to manage horses for recreational purposes. While some landholders have a few hectares for equestrian sports or for family members to ride horses and ponies, others operate a more intensive management system where larger numbers of horses are kept for agistment purposes.

Deciding on the best management system will depend on the number of horses to be kept, as well as how they will be fed and cared for, since managing horses can be quite time consuming compared with raising other livestock.

As a general rule, three management systems are recognised as suitable for managing horses, all of which will ensure that no environmental damage occurs, provided landholders follow a few simple rules with respect to grazing strategies, manure management and hygiene.

These systems include:

- low input (grazing, no yards)
- medium input (controlled grazing, some hand feeding)
- high input (limited grazing, mainly stabled).

Low input (grazing, no yards)

In this situation horses are not hand fed. All feed requirements are provided by pasture. Therefore stocking rates should be in line with district averages and grazing strategies adopted which maximise pasture productivity (Chapters 11 and 12).

Figure 130. A well-designed 'low input' horse management system

Figure 131. Well-designed day yards help to control grazing on a 'medium input' horse management system

No stables or yards are necessary, so shelterbelts become the primary source of protection in the paddock. Good pasture management should be practiced at all times.

Medium input system (controlled grazing, some hand feeding)

Paddock feed alone will not match the nutritional requirements of all the horses on the property in these circumstances. Consequently stables or yards must be used to control how long paddocks are grazed. This approach allows pastures to be rested, ensuring good ground cover and avoiding bare ground with the potential for erosion and dust problems. Some hand feeding will be required.

High input system (limited grazing, mainly stabled)

Hand feeding is the primary means of providing the nutritional requirements of horses. Grazing is limited to only a few hours each day whilst horses spend the majority of their time in stables or yards.

Cleanliness and hygiene of yards become important considerations with this system.

Manure management

Landholders have an obligation to ensure that manure is not a source of off-site pollution. Manure left in paddocks not only poses a risk of environmental pollution, but can result in pastures not being fully utilised, since stock will avoid grazing near manure.

Numbers of harmful intestinal worms can also build up in paddocks and re-infect individuals.

Manure should be removed daily from stables, yards and exercise areas and stored where rain and surface run-off will not leach pollutants into watercourses. On small properties manure can be picked up from paddocks, bagged and used by home gardeners.

Spreading manure using a piece of weldmesh or light harrows is an effective way of recycling nutrients in larger paddocks.

17.2 National livestock identification system

The national livestock identification system (NLIS) is a national database used to identify and track cattle, sheep and goats, and so improves stock identification and traceability.

The NLIS ensures that livestock can be tracked electronically from their property of birth to their place of slaughter. This tracking is important for food safety, disease control and market access. Animals can be traced quickly in the event of a disease outbreak which will minimise possible impacts on the industry.

Further information on NLIS can be found at the Meat and Livestock Australia website **www.mla.com.au**

17.3 Livestock health issues

Poor land management can often contribute to poor animal health. Problems can range from poor condition to severe illness and in some cases fatalities.

A detailed description of these health issues is beyond the scope of this manual, but landholder are advised to become familiar with ways to avoid some of the more common problems.

Horses can be susceptible to:

- annual ryegrass toxicity (ARGT) – caused by a bacterial toxin and can be fatal
- grass staggers – caused by an endophyte fungi in perennial ryegrass
- sand colic – often associated with ingesting sand when fed on bare ground
- greasy heel – an infection of hooves and legs when horses are kept in mud
- founder – inflammation of horses feet caused by feeding on lush pasture
- toxic plant poisoning – e.g. salvation Jane which produces a liver toxin.

Further information can be found at **www.horseslandwater.com**

Cattle are perhaps less prone to diseases and infections compared with horses, but a number of common health issues are worthy of note:

- perennial ryegrass staggers and annual ryegrass toxicity bloat – caused by grazing lush grass or lucerne
- clostridial diseases – e.g. tetanus
- grass tetany – caused by a lack of magnesium in feed often due to low levels in the soil
- internal parasites – e.g. the brown stomach worm
- lice – require chemical treatment.

On the whole, sheep are quite hardy animals, but they do require some basic animal husbandry to ensure they remain healthy.

Landholders should be aware of:

- clostridial diseases – e.g. pulpy kidney (Enterotoxaemia) which can be fatal and often results from sudden changes in nutrition, such as grain feeding or improved lush paddock feed
- flystrike – caused by flies laying eggs in wool
- lameness – due to foot abscess
- phalaris staggers – caused by plant toxins, and can be fatal
- internal parasites – worms.

Further information on cattle and sheep health can be found at **www.mla.com.au**

Alpacas are hardy animals, low maintenance, and do not require crutching, tail docking or mulesing since flystrike is rare. They are resistant to internal parasites, and their soft pads help to prevent outbreaks of foot infections.

However, they are susceptible to:

- perennial ryegrass staggers
- clostridial diseases
- internal parasitic worms in younger animals such as crias and weaners.

Information on alpaca health issues can be found at **www.alpaca.asn.au**

18. Case studies

18.1 Jacqueline and Bob Raphael

Property location:	Kudla, Northern Adelaide Plains
Current enterprises:	Horses (recreational)
Average annual rainfall:	480 mm (approx.)
Soil type:	Red clay loam
Features:	This idyllic property stands out as one of the best examples of an intensive horse keeping property in a low rainfall area of the Adelaide Plains. Day yards, shelterbelts and native pastures are abundant.

Jacqueline and Bob have dedicated much of their time during the last 10 years turning a wasteland of salvation Jane (*Echium plantagineum*) and capeweed (*Arctotheca calendula*), without a single tree to be seen, into one of the most well managed horse properties in the region.

Careful planning, research and a genuine affinity for sustainable land management has been the foundation for their achievements.

After purchasing their 2 hectares of land, Jacqueline and Bob embarked on a search for information and guidance to help them develop the property using sustainable land management practices. Jacqueline enrolled in the Adelaide and Mount Lofty Ranges Natural Resources Management Board's Rural Land Management Course, and attended numerous field days and workshops to understand the importance of good pasture management, rotational grazing, using day yards and incorporating shelterbelts to provide shade and protection. Drawing up a property management plan to incorporate sound environmental principles has been a vital part of their success.

Figure 132. Small horse paddocks can be grazed and still have excellent cover

The property is home to five horses and two Shetland ponies. Internal electric fencing has been used to divide the property into nine small paddocks, and the strategic use of day yards, allows individual paddocks to be rested once pasture levels become low. This often means that horses only graze for a few hours when paddock feed levels are falling. The use of a small sacrifice paddock is carefully managed so that horses can exercise and be hand fed. Consequently ground cover overall is nearly 100% all year round. Despite its size, Jacqueline has incorporated a round yard, arena and exercise yard all strategically positioned with native shelterbelts.

Figure 133. The use of day yards enables pastures to be rested so overgrazing is avoided

Figure 134. Revegetation to create shelterbelts provides shade, protection and a haven for birds

Figure 135. Dense native wallaby grass is a major component of most pastures

Efficient rain capture from all roof areas provides water for horses and newly planted shelterbelts. The property is quite exposed to cold winds during winter and extreme sun in summer so the planting of shelterbelts has become an integral part of the whole design. Researching the appropriate local native trees and shrubs has led to a series of shelterbelts being planted to provide shade and shelter, and create a haven for native birds. Larger trees include river red gums (*Eucalyptus camaldulensis*) and sheoaks (*Allocasuarina* spp.)

One of the biggest challenges confronting Jacqueline and Bob when the property was first purchased was the control of salvation Jane and capeweed. A combination of low toxicity herbicide applications and re-seeding has seen dense pastures establish themselves. Very few broadleaf weeds are now found on the property but if they are, Jacqueline and Bob are quick to grub them out before they seed, or spot spray with a selective herbicide to retain, and encourage the good grasses.

Native grasses form a substantial component of most paddocks. Wallaby grasses (*Rytidosperma* spp.), brush-wire grass (*Aristida behriana*) and windmill grass (*Chloris truncata*) are abundant. Self-seeding of native grasses is encouraged by removing horses from paddocks when grasses are seeding. Slashing then follows to help to spread mature seed.

The careful use of low toxicity sprays, and low fertiliser rates has also contributed to the spread of these native grasses. Horse manure and an organic fertiliser are applied each year, while every few years a soil test is conducted to monitor soil nutrients.

Introduced pasture species include cocksfoot (*Dactylis glomerata*), phalaris (*Phalaris aquatica*), kikuyu (*Pennisetum clandestinum*) and couch (*Cynodon dactylon*). Any bare areas, which occasionally appear, are quickly over-sown with a mixture of annual ryegrass, cocksfoot, phalaris and snail medics, or planted to kikuyu runners. Careful management of these pastures is a key priority for Jacqueline and Bob.

Horse manure is collected weekly from paddocks, and daily from yards, with some being bagged and distributed through the community, while the rest is composted or used as a mulch around native trees and shrubs.

Jacqueline and Bob are proud of what they have achieved and yet they continue to look at ways to improve the property. Jacqueline believes that you are always learning and by attending field days and workshops, as well as searching for information from other sources, further improvements can be made to the property.

The key principles of sustainable land management which Jacqueline and Bob have followed closely include:

- developing a property management plan
- avoiding overgrazing of pastures
- controlling weeds to allow pastures to thrive
- revegetating with native trees and shrubs
- avoiding contamination of the environment through manure and dust
- managing the land to its capability.

18.2 Marc and Alyssa Fox

Property location:	Lobethal, Central Adelaide Hills
Current enterprises:	Beef cattle
Average annual rainfall:	840 mm (approx.)
Soil type:	Acidic sandy loam over brown or red clay with deeper sandy loams near creek flats
Features:	Significant pasture improvement, fencing to land class, plenty of revegetation and reduced stock numbers are all the result of a carefully produced property management plan.

Balancing family life and work can sometimes be a challenge, but when you add managing the family farm of 48 hectares, there has to be commitment and enthusiasm. Fortunately Marc has plenty of both. The farm was established in the early 1900s and like most farms the land was pushed to its limits. When Marc took over managing the farm some 10 years ago he wanted to improve the whole property to the point where it was environmentally and economically sustainable. He brought a fresh approach to land management which recognised the land classes, protected vulnerable areas and increased production off the better land.

Marc enrolled in the Adelaide and Mount Lofty Ranges Natural Resources Management Board's rural land management course, and attended numerous field days and workshops. The result was the development of a property management plan based upon sustainable land management principles. Putting the plan into action has been the result of hard work with some support from the board.

Improving pastures, reducing livestock numbers, and introducing a better grazing strategy have been significant changes. The property now runs 27 breeding cows comfortably, with yearlings sold in early autumn. This enables good ground cover to be maintained throughout the year.

Irrigation is limited to only a few paddocks which are sown to perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and red clover (*Trifolium pratense*). Selecting appropriate pasture species to match soil type and rainfall is a key strategy and Marc places a high value on using perennial grasses such as perennial ryegrass, cocksfoot (*Dactylis glomerata*) and phalaris (*Phalaris aquatica*), especially on steep slopes where the potential for soil erosion is high (Figure 137).

Understanding how pastures respond to rainfall and soil type is important to avoid overgrazing. Some dryland pasture paddocks struggle to hold adequate soil moisture over summer and autumn, and so stock are removed early to rest paddocks and encourage the perennial grasses to persist. The farm is divided into 13 paddocks which supports rotational grazing and allows some paddocks to be cut for hay each year.

Soil testing is a regular activity with one paddock being tested annually. As a result 20 hectares were recently limed at a rate of 3 tonnes per hectare to counter soil acidity.

Careful planning has underpinned a series of positive changes over time. The main watercourse has been fenced off for a number of years now, allowing additional trees and shrubs to be planted where original plantings have struggled to survive.

Figure 136. Fencing to land class is an important land management practice

Figure 137. Establishing perennial grass pastures on steeper slopes helps soil conservation

Figure 138. Revegetation is an integral part of good land management

Steep gullies showing signs of erosion have also been fenced off and revegetated.

Some areas of the property were infested with woody weeds such as blackberry (*Rubus fruticosus*) and broome (*Genista monspessulana*) and while stock used to graze these areas, there was little feed value.

Consequently a woody weed control program was implemented which involved fencing the sites off, using appropriate herbicides and revegetating with local native species (Figure 138).

Marc is convinced that the starting point to transform the farm into a low maintenance and easily managed property was drawing up a property management plan based upon fencing to land class.

Even further improvements are imminent, since Alyssa is in the process of establishing a small flock of Dorper sheep, which she will manage, and which reflects their view that the property is a family farm, now and into the future.

The key principles of sustainable land management which Marc and Alyssa have followed closely include:

- developing a property management plan, based upon fencing to land class
- avoiding overgrazing of pastures
- matching livestock numbers with pasture feed production
- controlling weeds to allow pastures to thrive
- revegetating with native trees and shrubs
- soil conservation.

18.3 Hugh and Yvonne Bygott

Property location:	Kersbrook, Northern Adelaide Hills
Current enterprises:	Dorper sheep stud
Average annual rainfall:	740 mm (approx.)
Soil type:	Acidic sandy loam over brown or red clay
Features:	Situated amongst the gently rolling hills of Kersbrook next to the South Para Reservoir, this ideal grazing property is undergoing a transformation. Shelterbelts are being established and paddock subdivision is well underway to enable efficient rotational grazing. Fencing to land class underpins a sustainable approach to land management.

Hugh and Yvonne moved on to this 32 hectare property with a view to enjoying the lifestyle, improving the land and seeing whether the property could provide some extra income. Having purchased the land a few years earlier there was time to consider a sustainable approach to land management and understand the delicate nature of some areas of the property.

The land classes are distinctly variable. A small watercourse runs through the property which has a large dam, gently rolling hills and some steeper slopes. Lower flat land offers a number of challenges since it is often waterlogged during winter and is mildly saline.

When Hugh and Yvonne took over the property it was quite degraded, pastures were void of perennial grasses due to overgrazing, stocking rates were high and paddock feed low. Delicate areas of the property were not protected from livestock and the dam was unfenced.

Having embraced the concept of sustainable land management, they set about re-designing the property. Some boundary fences needed upgrading as a priority, and revegetation was seen as a must in some areas. The dam and watercourse is now fenced off with significant revegetation established to help stabilise the wet areas below the dam. This has increased the level of rotational grazing which has helped with weed control and pasture improvement.

Shelterbelts have been established with local indigenous species carefully selected to promote biodiversity, provide shade and protection for livestock, and encourage native birds.

Property planning underpins most of what Hugh and Yvonne decide with respect to infrastructure. Hugh's strong belief in good animal husbandry is in keeping with the property being a registered stud. Careful thought is currently being given to dividing the main paddock to enable more rotational grazing, and deciding on the most appropriate location for yards and small paddocks. Ease of vehicle and stock access are key considerations.

The quality of pasture varies, with fog grass (*Holcus lanatus*) and subterranean clover (*Trifolium subterraneum*) isolated to steeper slopes, and phalaris (*Phalaris aquatica*) established on low lying wetter areas. Large areas are in need of pasture improvement and Hugh sees this as an important task before stock numbers can increase.

Soil testing is conducted regularly and as a result the need to apply lime has been identified.

Hugh and Yvonne have a good understanding of the capability of the land and have been quick to stock numbers in line with pasture production.

Figure 139. Fencing of the dam was a top priority

Figure 140. Fencing off the watercourse and establishing native vegetation has helped to protect water quality

Figure 141. Strategic placement of fences and shelter-belts are key improvements

Currently 50 breeding ewes with lambs, plus rams are managed on the property. Being careful not to overstock, many of the young rams are sold before January when paddock feed begins to decline.

Future activities will include establishing more shelterbelts, liming, paddock division and pasture improvement.

Hugh and Yvonne believe they have a responsibility to ensure that their land management practices do not harm the environment, or pollute water draining into the South Para Reservoir. Consequently chemical use is kept to a minimum.

Careful planning, research, attending workshops and field days, and a genuine affinity for sustainable land management has been the foundation for their achievements to date.

Hugh and Yvonne have a strong community focus having worked closely with the South Para Biodiversity Group. Until recently Hugh was President of the Dorper Sheep Society of Australia – Central Region.

Improving their property is a work in progress, but what they have achieved to date is highly significant and with their eagerness to learn more, this property is set to become exemplary.

The key principles of sustainable land management which Hugh and Yvonne have followed closely include:

- strategic planning
- avoiding overgrazing of pastures
- controlling weeds to allow pastures to thrive
- revegetating with native trees and shrubs
- avoiding contamination of the environment by minimum chemical use
- fencing to land class
- positioning of yards and raceways.

18.4 Michele and Robert Wilson

Property location:	Millbrook, Central Adelaide Hills
Current enterprises:	Alpacas
Average annual rainfall:	800 mm (approx.)
Soil type:	Shallow stony sandy loam over brown clay and rock
Features:	This small eight hectare property with its steep rolling hills, isolated Eucalypts and two dams is representative of many lifestyle properties in this location. Managing alpacas has been relatively problem free to date, but subdividing paddocks for better weed control and grazing is now a key element of a recently developed property management plan.

Michele and Robert's alpaca farm could be described as the ideal lifestyle property, and for the most part this is true, however, running alpacas on a small acreage throws up challenges which can be frustrating as well as rewarding.

Before purchasing their Millbrook property Michele and Robert embarked on a process of careful research into managing land and attended various courses, to gather information on rural land management. One of the first things they did on purchasing their property, three years ago, was to enrol in the Adelaide and Mount Lofty Ranges Natural Resources Management Board's Rural Land Management Course. This gave them a good foundation to manage the land sustainably and avoid making decisions which would cost them dearly in the long run.

As a consequence of attending this course, a soil test was carried out to determine fertiliser and liming needs. No lime was required but the paddocks were low in phosphorus prompting them to apply fertiliser in the first year.

Michele was keen not to overstock initially and so information on the potential stocking rate for the property was sought. They now run 34 alpacas and a handful of sheep and goats, which closely matches pasture production.

As new landholders, the initial challenges related to getting a better understanding of livestock husbandry and ensuring the health and welfare of their alpacas, which require annual injections for vitamin D, foot trimming and shearing.

Figure 142. Alpacas are generally hardy and low maintenance

Figure 143. Isolated Eucalypts have suffered from the recent drought and mistletoe has invaded

With this now well in hand Michele and Robert are revisiting their initial property management plan with a view to improving the property. Some of their challenges relate to revegetation, pasture management, weed control and improved grazing.

Isolated Eucalypts have suffered from the recent drought and mistletoe has now invaded with dire consequences for some trees. Whilst some trees have been fenced off from livestock, in the hope they will recover, others will need to be replaced, and so a program of revegetation is underway.

The pasture is essentially unimproved with the main grasses being fog grass (*Holcus lanatus*) and isolated perennial ryegrass (*Lolium perenne*), along with a range of annual grasses. Patches of wallaby grass (*Rytidosperma* spp.) are also present. Subterranean clover (*Trifolium subterraneum*) is widespread in places. The grazing nature of alpacas has created patches of capeweed (*Arctotheca calendula*) and storksbill geranium (*Erodium* spp.) both of which will be the subject of some effective weed control in the near future.

Whilst some spraying may be necessary to keep weeds under control, Michele and Robert acknowledge the need to change from set stocking to rotational grazing so that paddocks can be rested to help improve pastures.

Figure 144. Plans to divide this paddock will assist a change from set stocking to rotational grazing

Figure 145. Steep slopes will make fencing and pasture improvement challenging

This has raised questions about placement of internal fencing to create more paddocks and how to deal with very steep slopes on the southern side of the property. Consideration is also being given to a reticulated watering system as paddock numbers increase. All of this will require careful planning.

Michele and Robert have achieved a great deal in a short space of time, but they have now reached a stage where they want to re-evaluate their initial property management plan so that improvements can be made to their land management practices.

They acknowledge the need for sensible planning with realistic time-lines since at the moment both of them work and finding time is a major hurdle.

The key principles of sustainable land management which Michele and Robert have followed closely include:

- developing a property management plan
- avoiding overgrazing of pastures
- controlling capeweed to allow pastures to thrive
- revegetating with native trees and shrubs
- soil testing and improving soil fertility
- managing the land to its capability.

19. Helpful tools

A range of tools and calculators are available to assist landholders make informed decisions regarding pasture management and stocking rates. Some can be purchased as individual software programs, others can be used online, while trial programs can be located at particular websites.

19.1 Meat and Livestock Australia

Feed budget template

www.makingmorefromsheep.com.au/turn-pasture-into-product/tool_8.4.htm

This program enables landholders to calculate simple feed budgets manually, without using a computer.

To complete the budget template you will need to:

- measure the pasture mass (kg green DM/ha) in the paddock you have allocated to the stock to get your starting point
- estimate pasture quality
- determine the estimated intake of livestock
- look up typical pasture growth rates for your pasture type and soil fertility
- define the minimum target pasture mass (kg green DM/ha) for the class of stock
- convert pasture mass to feed on offer, by adding 300 kg DM/ha.

Stocking rate calculator

www.mla.com.au/publications-tools-and-events/tools-and-calculators/stocking-rate-calculator

This calculator is designed to determine the number of cattle or sheep landholders should put into a paddock based on its carrying capacity.

Feed demand calculator

www.mla.com.au/Publications-tools-and-events/Tools-and-calculators/Feed-demand-calculator

The feed demand calculator allows producers to gain an appreciation of the pattern of feed supply and demand over a twelve-month period, the location of "feed gaps" and the ways in which modifying the livestock enterprise might help to close these gaps. The calculator can be used to assist red meat producers in the planning process of their enterprise.

Rainfall to pasture growth outlook tool

www.mla.com.au/Publications-tools-and-events/Tools-and-calculators/Rainfall-to-pasture-growth-outlook-tool

This outlook tool presents the actual rainfall and indices of soil moisture and pasture growth for the past nine months and an outlook for the next three months for over 3300 locations across southern Australia.

It enables producers to factor this information into enterprise planning. The tool covers a diverse range of soil and pasture types across southern Australia, and provides an index of potential pasture growth.

The pasture growth index should be interpreted in light of local knowledge as to species, soil type, fertiliser history and aspect.

Daily pasture growth estimates

www.makingmorefromsheep.com.au/turn-pasture-into-product/tool_8.2.htm

This tool allows landholders to determine the average pasture supply, and likely variability, based on long-term weather records. The mid-monthly estimates of pasture growth rates (kg DM/ha/day) are for average seasonal conditions for a range of localities and regions across the high rainfall and wheat–sheep zones of Australia. Although there is a large variation in rainfall pattern and feed supply within any year, when put together these monthly values reflect pasture growth in a 'typical' year for the locality or region without reference to growth in the previous month. These estimates provide a basis to assist with the calculations for short to medium term decision making. They are intended as a guide and will assist with the calculations in feed budgets.

19.2 Evergraze tools and calculators

Feed budget and rotational planner

www.evergraze.com.au/library-content/feedbase-planning-and-budgeting-tool/

This program will help landholders to plan rotational grazing systems, determine appropriate stocking rates, calculate pasture growth rates, determine how long paddock feed will last and calculate the most economical ration for stock.

Pasture improvement calculator

www.evergraze.com.au/library-content/pasture-improvement-calculator/

This calculator helps work out the costs and benefits of re-sowing pastures.

It allows inputs of:

- costs of re-sowing
- the benefits of the re-sown pastures to livestock
- soils and the environment at any given financial values.

The tool uses Microsoft Excel and allows a comparison of two different re-sowing options compared with current practice.

19.3 Commonwealth Scientific and Industrial Research Organisation

CSIRO Plant Industry has developed the following successful decision support tools, based on computer modelling of farming systems and validated by research to promote more profitable farm management.

GrassGro

www.hzn.com.au/grassgro.php

GrassGro is a decision support tool developed by CSIRO Plant Industry to examine variability in pasture and animal production and assist decision making in sheep and beef enterprises.

It can be applied to the following range of issues:

- assessment of land capability and production benchmarking
- real time review of management tactics during the current season
- testing long term decisions about herd or flock management
- resource sustainability (ground cover, water balance, nutrient deficiency)
- drought management and climate variability scenarios
- location testing (pasture types, animal bloodlines, enterprise analysis)
- financial testing – tactical and strategic (stocking rate, calving and lambing dates, supplementary feed policy, market specification for livestock)
- supply chain analysis.

Grazfeed

www.hzn.com.au/grazfeed.php

GrazFeed is an easy to use computer program which calculates the energy and protein requirements of sheep and cattle grazing a particular pasture or even being lot fed.

Feed requirements are based on the Australian Feeding Standards. It takes into account the type of animal, the availability and quality of pasture, selective grazing and interaction with supplementary feeds (e.g. the substitution of supplement for pasture).

MetAccess

www.hzn.com.au/metaccess.php

This program analyses historical weather data in a flexible way to quantify variability and assess the likelihood of weather events as it impacts on business, research and everyday life.

AusFarm

www.hzn.com.au/ausfarm.php

AusFarm optimises management strategies for livestock, grassland and cropping operations on a mixed farm or across a variable landscape. The model allows problems to be analysed simulating the physical and biological systems. The software contains powerful facilities for analysing risk over both short and long term.

19.4 Primary Industries and Regions SA – Soil acidity in South Australia

Information, maps, fact sheets, tools and cases studies

agex.org.au/project/soil-acidity

To assist landholders and advisers to make better decisions in treating soil acidity computer decision support tools have been developed. These include the impact of acidification on production (cost of not liming); lime requirement rate; a cost comparison of liming sources; and maintenance rate of lime.

19.5 Australian Wool Innovation Ltd

Timerite

www.timerite.com.au

Redlegged earth mite is an introduced pasture and crop pest in southern Australia. It is estimated that this mite infests 20 million ha of pasture, causing $200 million damage to the wool industry alone. Timerite is a program which predicts the optimal date for spraying in spring to achieve optimal control of the pest the following autumn.

When managing Redlegged earth mites, the first step is to check whether your pastures have it. Once you've checked, it is important, before you spray, to understand the risk level your paddock has for damage next autumn. If you have Redlegged earth mites in spring then spraying on your paddock's Timerite® date is the safest way to minimise the damage to pastures next autumn. Entering your location (latitude and longitude) will enable the program to generate a spring spray date for your property.

20. Glossary

Allelopathic plants – Plants which can inhibit the growth, survival, and reproduction of other plants.

AMLR NRM Board – Adelaide and Mount Lofty Ranges Natural Resources Management Board

Biodiversity – The degree of variation of life forms within a given ecosystem, biome, or an entire planet. Biodiversity is a measure of the health of ecosystems.

Buffering capacity – The ability of a soil to resist changes to pH (a measure of soil acidity and alkalinity).

Contour bank – An earth embankment with a shallow channel on one side which follow the contour of the land with a drain on the up-slope side. It is built with a slight gradient (1–3% only) so that water can drain slowly without causing erosion.

Direct drilling – This involves sowing seed into undisturbed soil following the use of a herbicide to control weeds.

Dry matter pasture production – The amount of feed produced by a pasture (by weight) once the water content has been removed.

Erosion – Natural breakdown and movement of soil and rock by water, wind or ice. The process may be accelerated by human activities.

Hembra – Female alpaca

Land – Whether under water or not, and includes an interest in land and any building or structure fixed to the land.

Land capability – The ability of the land to accept a type and intensity of use without sustaining long-term damage.

Land class – Land classes are based upon the limitations for agricultural production. Land class 1 is assessed as having no significant limitations while class 8 is assessed as having no value for primary production.

Native species – Any animal and plant species originally in Australia.

Natural resources – Natural resources consist of soil; water resources; geological features and landscapes; native vegetation, native animals and other native organisms; and ecosystems.

NRM – Natural Resources Management consists of all activities that involve the use or development of natural resources and/or that impact on the state and condition of natural resources, whether positively or negatively.

Pasture – Grassland used for the production of grazing animals such as sheep and cattle.

PIRSA – Primary Industries and Regions South Australia (Government of South Australia).

SARDI – South Australian Research and Development Institute, a division of PIRSA.

SLMU – Soil landscape mapping unit is an area of land (typically 0.5 to 50 km2 in area) with recognisable and repeating pattern of topographical features and a limited range of soil types.

Sodicity – A term given to the amount of sodium held in a soil. Sodium is a cation (positive ion) that is held loosely on clay particles in soil.

Soil compaction – A process where heavy machinery or livestock cause a loss of soil structure, resulting in air being displaced from the pores between the soil grains. Plant roots find difficulty growing through this dense soil which lacks sufficient air and water.

Soil types – Soil types are determined by the relative proportions of the soil components, sand, silt and clay.

Weaning – Young animals are removed from their mothers and no longer rely on the supply of her milk.

21. Further information

The following publications and websites were referred to when compiling this manual. They provide a useful source of information for those landholders who may wish to investigate particular topics in further detail. A list of local contacts is also provided.

21.1 References

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Adelaide and Mount Lofty Ranges Natural Resources Management Board. *Managing soils for sustainable production*, Fact sheet, AMLR NRM Board

Adelaide and Mount Lofty Ranges Natural Resources Management Board. *Pastures on small properties*, Fact sheet, AMLR NRM Board

Adelaide and Mount Lofty Ranges Natural Resources Management Board. *Property management planning*, Fact sheet, AMLR NRM Board

Adelaide and Mount Lofty Ranges Natural Resources Management Board. *Management of foxes in rural areas*, Fact sheet, AMLR NRM Board

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21.2 Helpful websites

Australian Alpaca Association
www.alpaca.asn.au

Agriculture Victoria
www.agriculture.vic.gov.au

Dorper Sheep Society of Australia
www.dorper.com.au

Environment Protection Authority
www.epa.sa.gov.au

Feed test – analysing the nutritional value of your stock feed
www.feedtest.com.au

Healthy Soils for Sustainable Farms
http://soilhealthknowledge.com.au

Heritage Seeds
www.heritageseeds.com.au

Horses, Land and Water
www.horseslandwater.com

Meat and Livestock Australia
www.mla.com.au/Home

Meat and Livestock Australia / National Livestock Identification System
www.mla.com.au/Meat-safety-and-traceability/Livestock-identification

New South Wales Department of Primary Industries
www.dpi.nsw.gov.au

Pasture Genetics
www.pasture genetics.com

Valley Seeds
www.valleyseeds.com

21.3 Local contacts

Adelaide and Mount Lofty Ranges Natural Resources Management Board

Eastwood Natural Resources Centre
205 Greenhill Road, Eastwood SA 5063
T: 8273 9100

Gawler Natural Resources Centre
8 Adelaide Road, Gawler South SA 5118
T: 8523 7700

Black Hill Natural Resources Centre
115 Maryvale Road, Athelstone SA 5076
T: 8336 0901

Victor Harbor Natural Resources Centre
3 Eyre Terrace, Victor Harbor SA 5211
T: 8552 0300

Willunga Natural Resources Centre
5 Aldinga Road, Willunga SA 5172
T: 8550 3400

www.naturalresources.sa.gov.au/adelaidemtloftyranges

Country Fire Service
Bushfire Information Hotline: 1300 362 361
Mount Lofty Ranges Headquarters: 8391 1866
www.cfs.sa.gov.au

Department of Environment, Water and Natural Resources
T: 8204 1910
www.environment.sa.gov.au

Horse SA
www.horsesa.asn.au

Primary Industries and Regions SA
25 Grenfell Street, Adelaide SA 5000
T: 8226 0900
www.pir.sa.gov.au/

Royal Society for the Prevention of Cruelty to Animals (RSPCA)
T: 1300 477 722
www.rspcasa.org.au

State Flora
Belair nursery: 8278 7777
Murray Bridge nursery: 8539 2105
www.stateflora.sa.gov.au

Trees For Life
T: 8406 0500
www.treesforlife.org.au

21.4 Local government contacts

Adelaide Hills Council
T: 8408 0400
E: mail@ahc.sa.gov.au
www.ahc.sa.gov.au

Alexandrina Council
T: 8555 7000
E: alex@alexandrina.sa.gov.au
www.alexandrina.sa.gov.au

Barossa Council
T: 8563 8444
E: Barossa@barossa.sa.gov.au
www.barossa.sa.gov.au

City of Mitcham
T: 8372 8888
E: mitcham@mitchamcouncil.sa.gov.au
www.mitchamcouncil.sa.gov.au

City of Onkaparinga
T: 8384 0666
E: mail@onkaparinga.sa.gov.au
www.onkaparingacity.com

City of Playford
T: 8256 0333
E: playford@playford.sa.gov.au
www.playford.sa.gov.au

City of Tea Tree Gully
T: 8397 7444
E: cttg@cttg.sa.gov.au
www.teatreegully.sa.gov.au

City of Victor Harbor
T: 8551 0500
E: localgov@victor.sa.gov.au
www.victor.sa.gov.au

District Council of Yankalilla
T: 8558 0200
E: council@yankalilla.sa.gov.au
www.yankalilla.sa.gov.au

Light Regional Council
T: 8525 3200
E: light@light.sa.gov.au
www.light.sa.gov.au

Town of Gawler
T: 8522 9211
E: council@gawler.sa.gov.au
www.gawler.sa.gov.au

Adelaide Plains Council
T: 8527 0200
E: info@apc.sa.gov.au
www.apc.sa.gov.au

Appendix A. Rainfall stations across the region

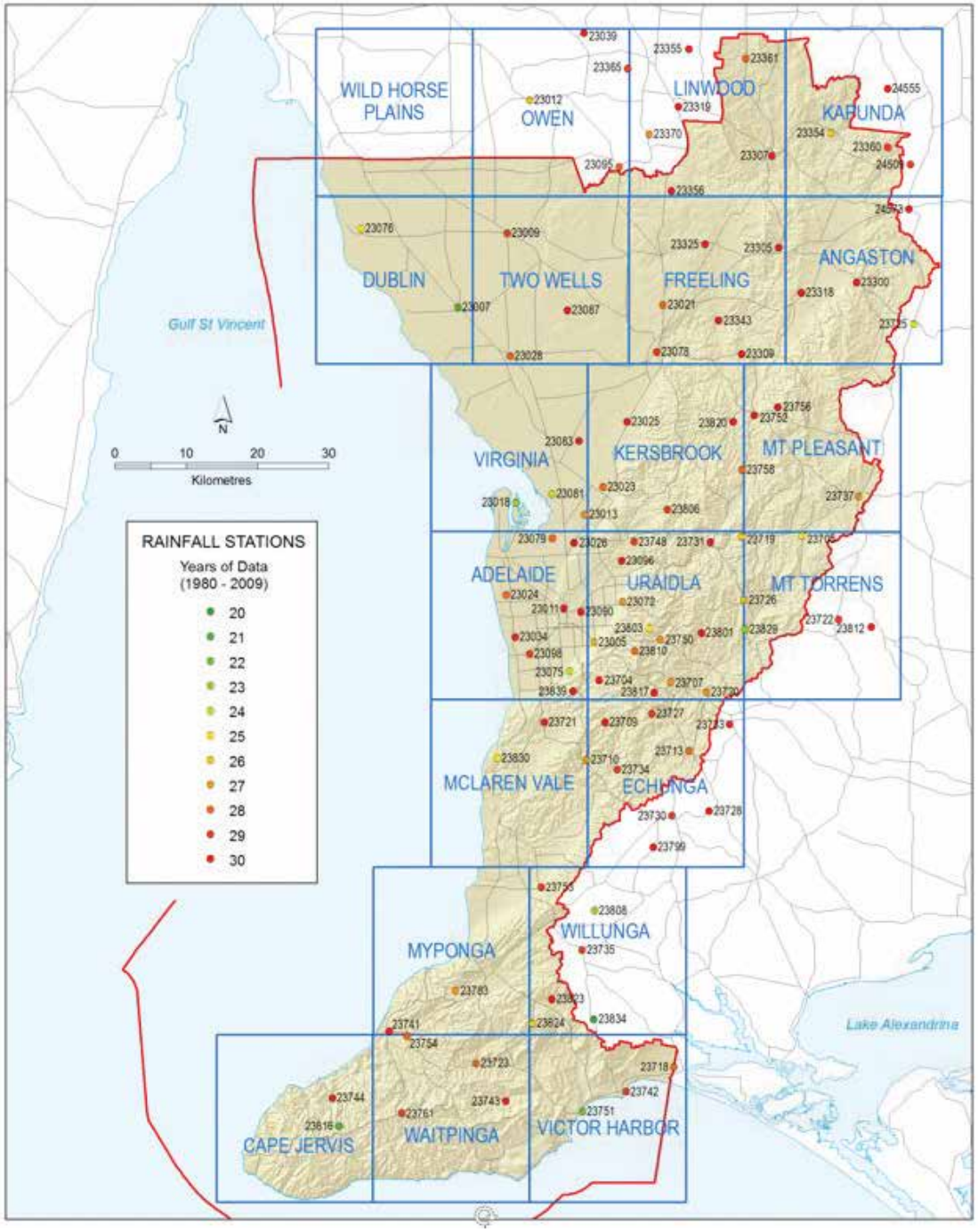

Figure 146. Rainfall stations – numbers relate to Appendix B 'Average annual rainfall across the region'.
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

Appendix B. Average annual rainfall

Table 35. Average annual rainfall for locations in the AMLR NRM Board region
Source: Science Resource Centre, Department of Environment, Water and Natural Resources, formerly DENR 2011

Station number	Station name	1980 to 2009		All records	
		Years of data	Avg. annual rainfall mm	Years of data	Avg. annual rainfall mm
23005	Adelaide (Glen Osmond)	26	603	116	627
23007	Lower Light	21	382	83	386
23009	Mallala	29	387	125	401
23011	North Adelaide	30	497	124	542
23012	Owen	26	404	80	424
23013	Parafield Airport	27	438	60	453
23018	Adelaide (Torrens Island)	23	407	74	434
23021	Roseworthy	28	440	121	444
23023	Salisbury	28	456	134	466
23024	Adelaide (Seaton)	28	460	96	444
23025	Smithfield	30	484	111	473
23026	Adelaide (Pooraka)	30	462	132	486
23028	Two Wells	28	391	127	399
23034	Adelaide Airport	30	435	54	442
23039	Rhynie (Monta Flora)	30	497	52	499
23072	Adelaide (Magill Training Centre)	27	637	38	647
23075	Adelaide (Clapham)	24	617	49	608
23076	Port Parham	25	334	35	356
23078	Gawler Council Depot	29	424	101	468
23079	Dry Creek Saltworks	28	417	48	425
23081	Bolivar Treatment Works	24	408	30	425
23083	Edinburgh RAAF	30	415	37	426
23087	Reeves Plains (Parana Park)	30	403	35	406
23090	Adelaide (Kent Town)	30	544	32	549
23095	Hamley Bridge	28	434	124	428
23096	Adelaide (Hope Valley Reservoir)	30	590	30	590
23098	Adelaide (Morphettville Racecourse)	29	474	58	459
23300	Angaston	30	549	126	558
23306	Greenock	30	511	128	531
23307	Kapunda	30	484	148	494

Table 35. continued

Station number	Station name	1980 to 2009		All records	
		Years of data	Avg. annual rainfall mm	Years of data	Avg. annual rainfall mm
23309	Lyndoch	30	530	123	557
23318	Tanunda	30	532	141	547
23319	Tarlee	30	464	128	470
23325	Freeling	30	483	46	485
23343	Rosedale (Turretfield Research Centre)	30	479	113	468
23354	Kapunda (Bagot Well)	26	478	36	480
23355	Riverton (Leaward)	30	493	41	509
23356	Hamley Bridge (Linwood)	30	450	40	463
23360	St Kitts	29	468	51	480
23361	Kapunda (Hamilton)	28	567	44	576
23365	Tarlee (Hazelton)	29	510	48	512
23370	Stockport (Clifton)	27	473	47	463
23704	Belair (State Flora Nursery)	30	834	123	777
23705	Birdwood Dept. of Transport	25	694	117	722
23707	Bridgewater	27	1030	128	1045
23709	Cherry Gardens	30	893	108	923
23710	Clarendon Post Office	27	774	136	813
23713	Echunga Golf Course	28	768	128	806
23718	Goolwa (Alexandrina Council Depot)	28	474	142	466
23719	Gumeracha	26	762	136	797
23720	Hahndorf Golf Club	27	780	123	850
23721	Happy Valley Reservoir SA Water	30	666	135	633
23722	Harrogate	29	586	111	559
23723	Yankalilla (Inman Valley)	28	733	75	749
23725	Keyneton	25	496	93	533
23726	Lobethal	26	888	121	888
23727	Longwood	29	969	59	967
23728	Macclesfield	30	676	123	731
23730	Meadows	29	821	120	869
23731	Cudlee Creek (Millbrook)	30	837	94	858
23733	Mount Barker	30	711	149	764
23734	Mount Bold Reservoir	29	797	70	766
23735	Mount Compass	29	815	81	841
23737	Mount Pleasant	27	616	129	669
23741	Normanville	30	517	132	522
23742	Port Elliot Caravan Park	29	483	141	500

Table 35. continued

Station number	Station name	1980 to 2009		All records	
		Years of data	Avg. annual rainfall mm	Years of data	Avg. annual rainfall mm
23743	Victor Harbor (Rivington Grange)	30	670	99	699
23744	Second Valley (Poolamacca)	30	602	122	609
23746	Adelaide (Tea Tree Gully Council)	29	583	124	664
23750	Uraidla	27	1053	116	1083
23751	Victor Harbor	22	528	119	536
23752	Williamstown	30	675	128	682
23753	Willunga	29	604	146	646
23754	Yankalilla	28	553	115	574
23756	Williamstown (Glen Gillian)	30	701	58	687
23758	Kersbrook (Mabenjo)	28	737	55	741
23761	Parawa (Sharon)	29	927	67	945
23783	Myponga Reservoir	27	681	43	680
23799	Meadows (Oakland Hills)	30	783	41	830
23801	Lenswood Research Centre	30	1007	42	1022
23803	Ashton Co-op	25	1055	69	1052
23806	Hermitage Upper	29	639	37	645
23808	Yundi	23	831	33	851
23810	Cleland Conservation Park	28	966	38	989
23812	Rockleigh (Black Heath)	30	502	40	519
23816	Second Valley Forest	21	909	31	954
23817	Aldgate	30	1062	40	1077
23820	Williamstown (South Para Reservoir)	30	677	41	683
23823	Hindmarsh Valley (Fernbrook)	30	866	74	862
23824	Hindmarsh valley (Springmount)	26	936	49	917
23829	Woodside	23	710	119	804
23830	Lonsdale	25	483	36	495
23834	Victor Harbor (Berrima)	20	739	22	747
23839	Blackwood (Wittunga)	30	707	30	707
24509	Dutton	29	446	87	444
24555	Eudunda (Moondah)	30	466	40	480
24573	Truro	30	505	130	494

Appendix C. Grid maps of regional soil groups

The following maps illustrate the major soil groups found in the region and are broad representations based on soil landscape mapping units (SLMU). Each unit is an area of land (typically 0.5 to 50 square kms in area) with recognisable topographic features and a limited range of soil types.

Since there are a number of different soil types within each soil group, the name given to each soil group is determined by the dominant soil type.

While these maps can be a useful guide to determine the likelihood of a particular soil type being present on a property, the only certain way to know what soils exist, is to examine the soil on site. Often cuttings can expose soil profiles, or landholders can use an inexpensive hand held auger to raise the various soil horizons. If necessary professional assistance can be sought to characterise the properties of the soil and gain a better understanding of what restrictions there may be to plant growth, and how best to manage that soil.

Descriptions of the major soil types in the region are given in Chapter 6.

Rainfall station numbers are also provided to enable landholders to obtain average annual rainfall data for some locations (refer to Appendix B).

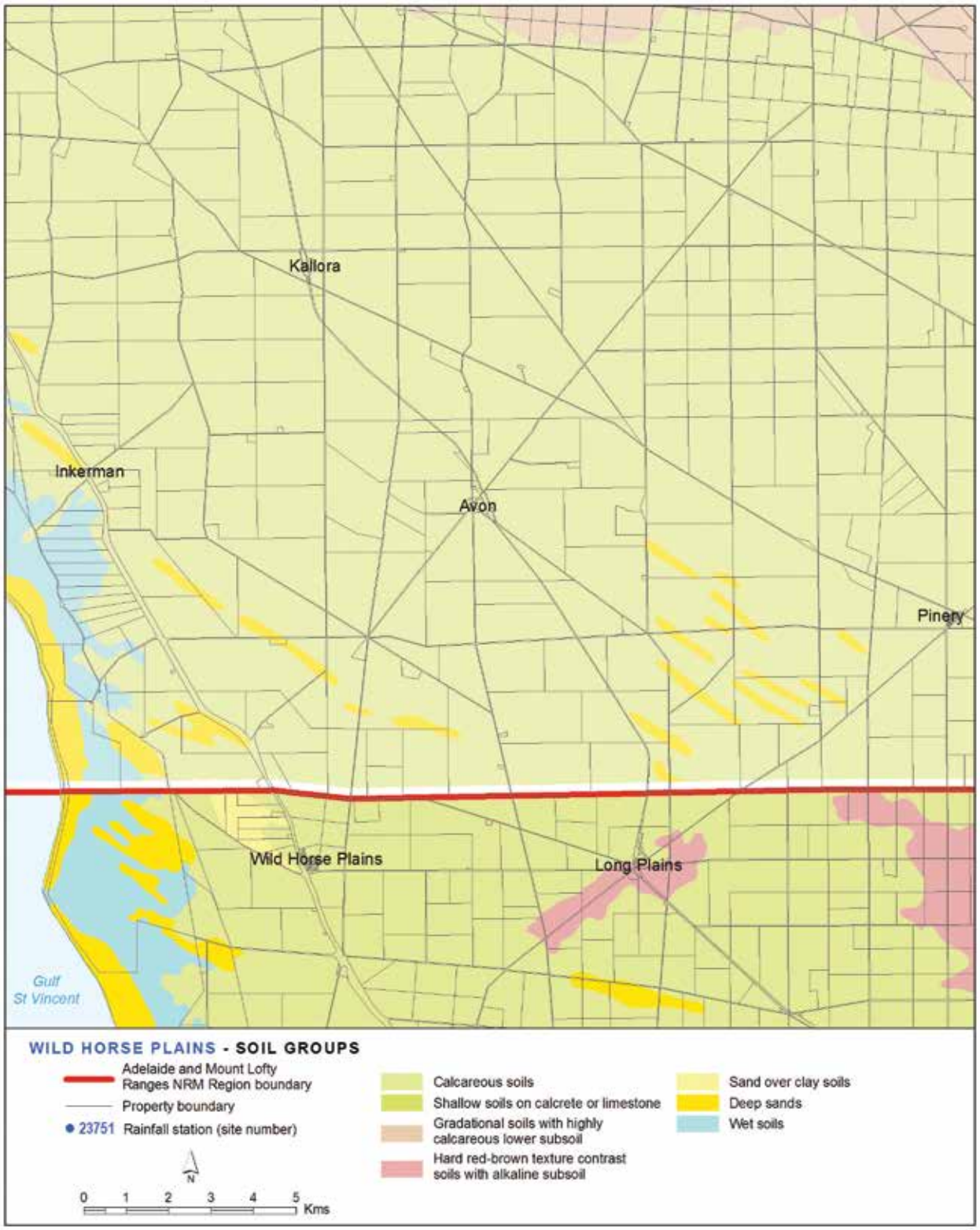

Figure 147. Wild Horse Plains soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

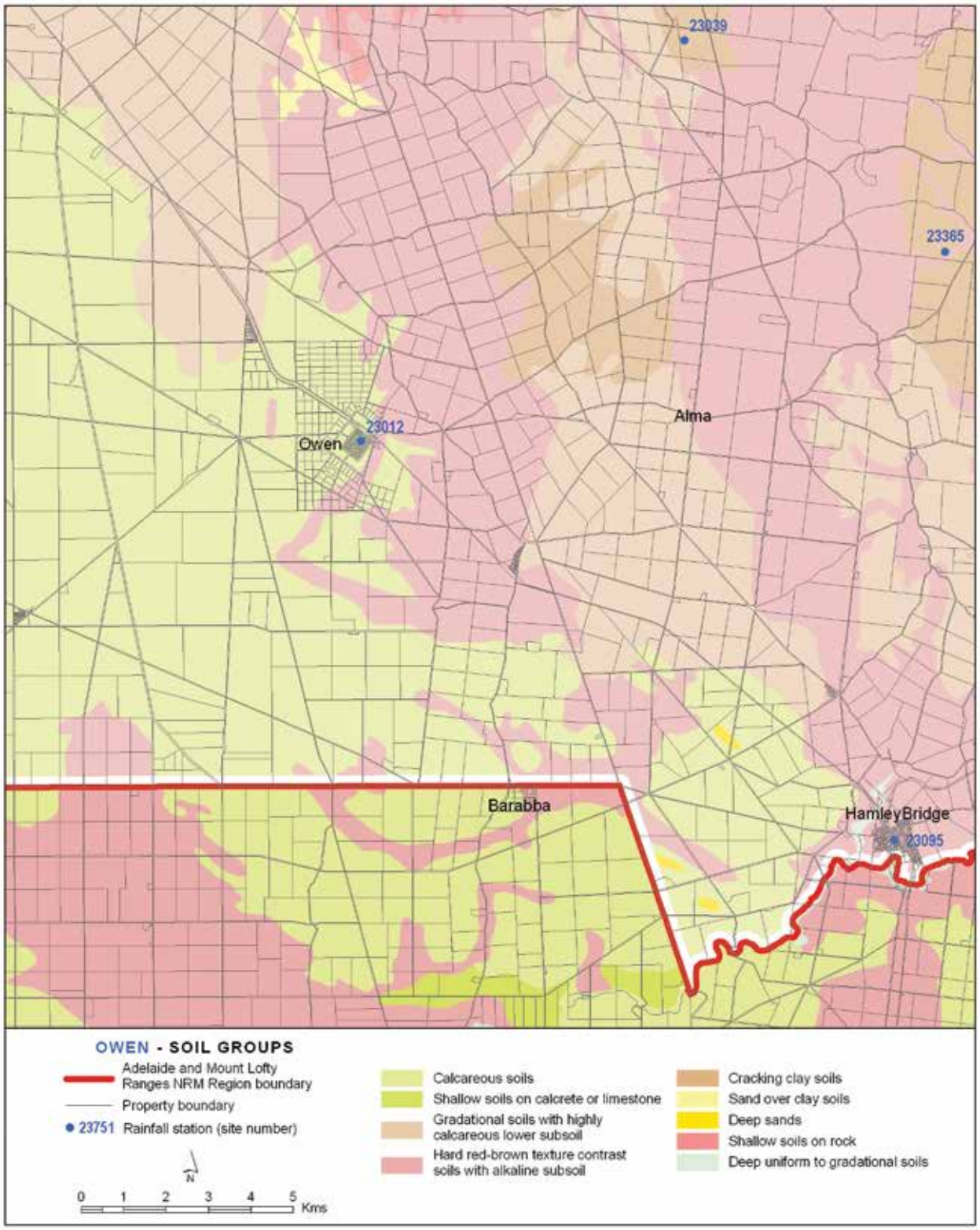

Figure 148. Owen soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

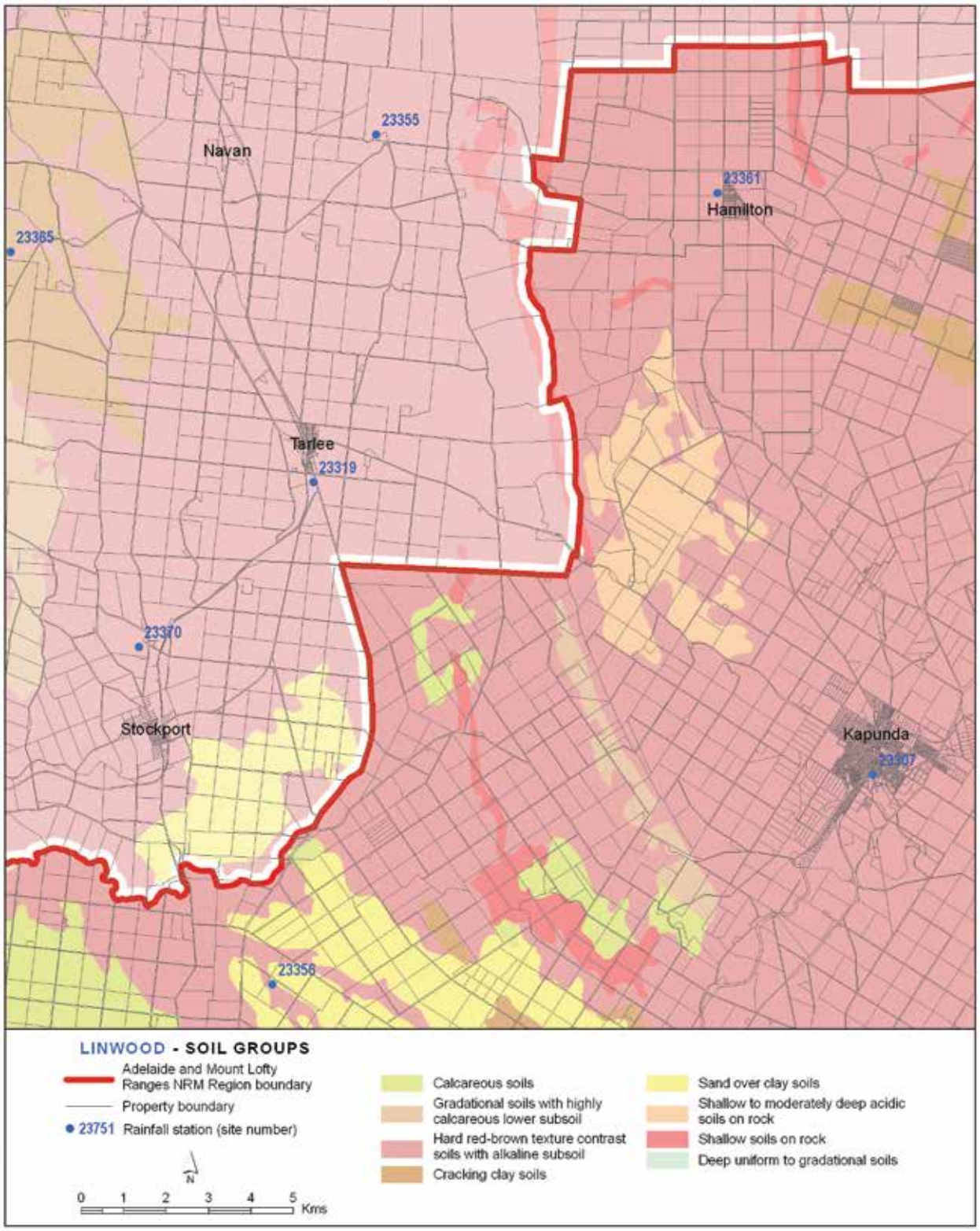

Figure 149. Linwood soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

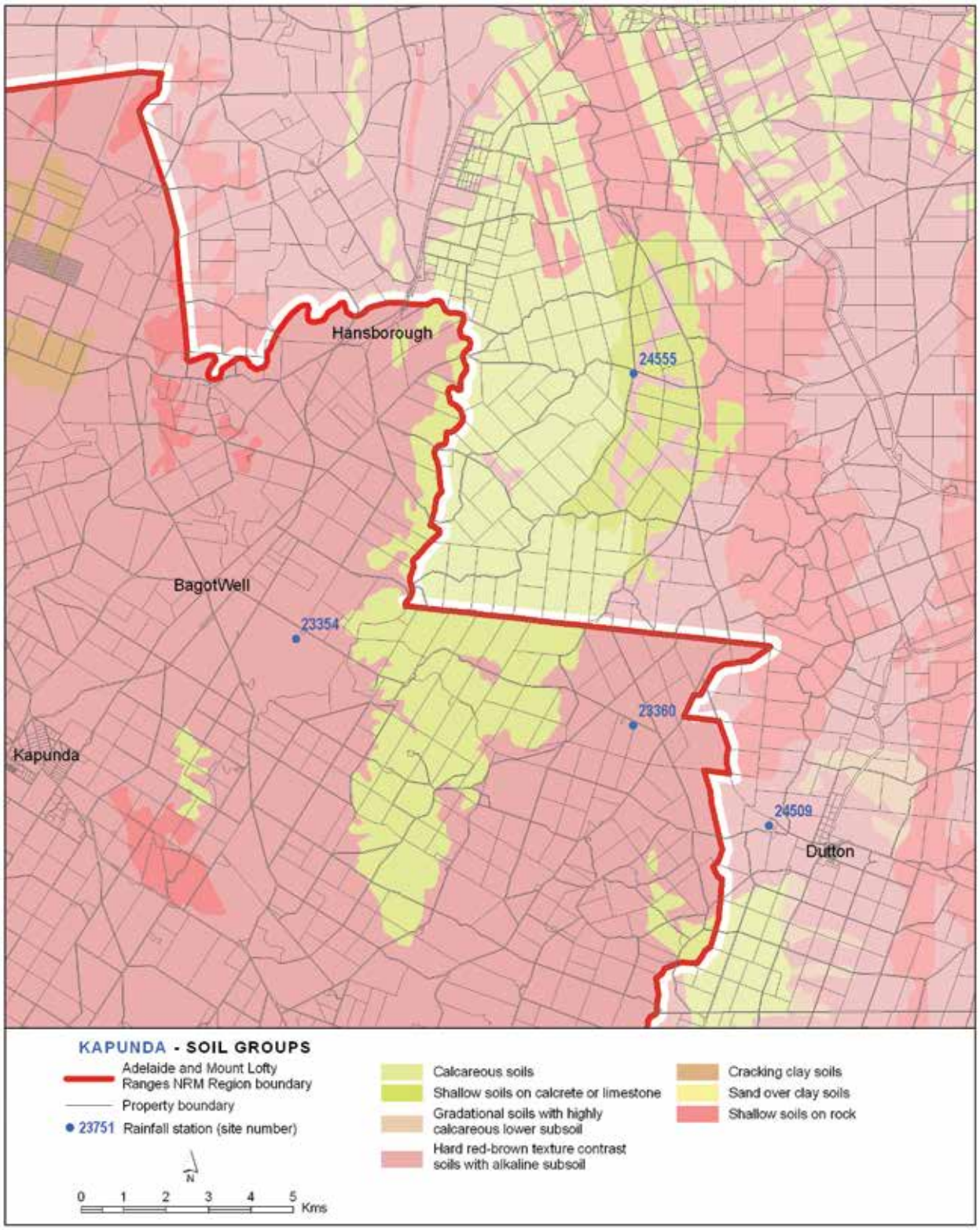

Figure 150. Kapunda soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

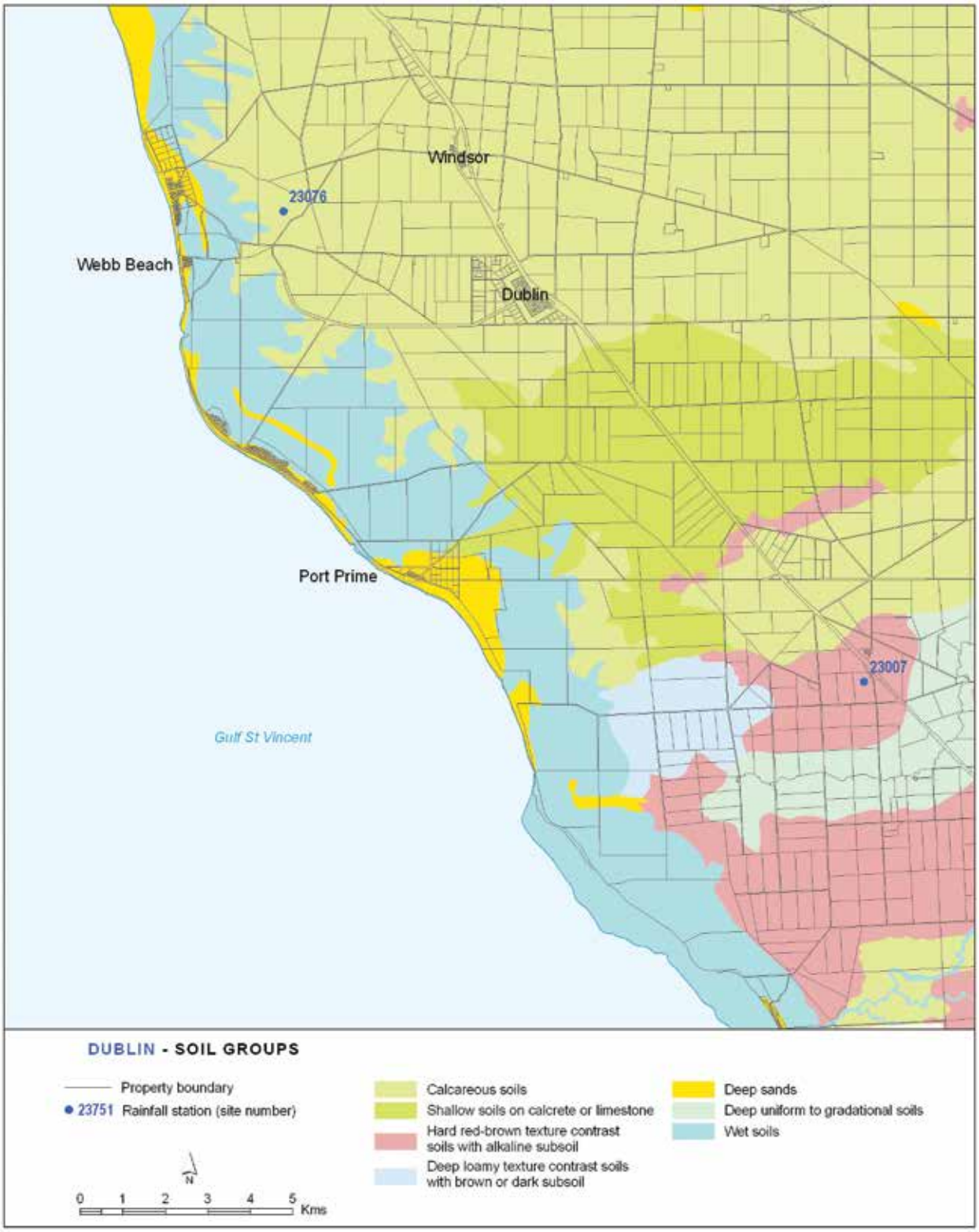

Figure 151. Dublin soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

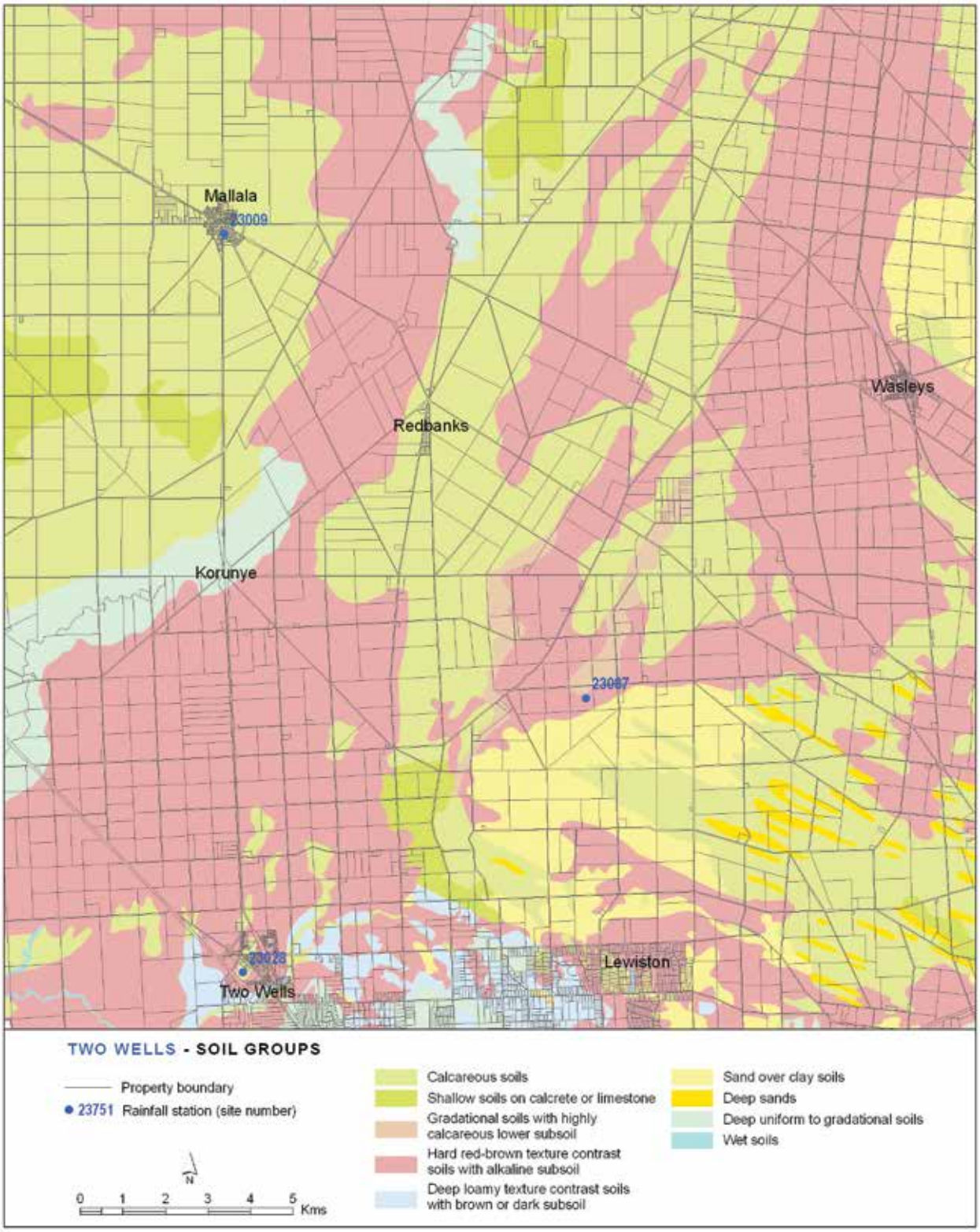

Figure 152. Two Wells soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

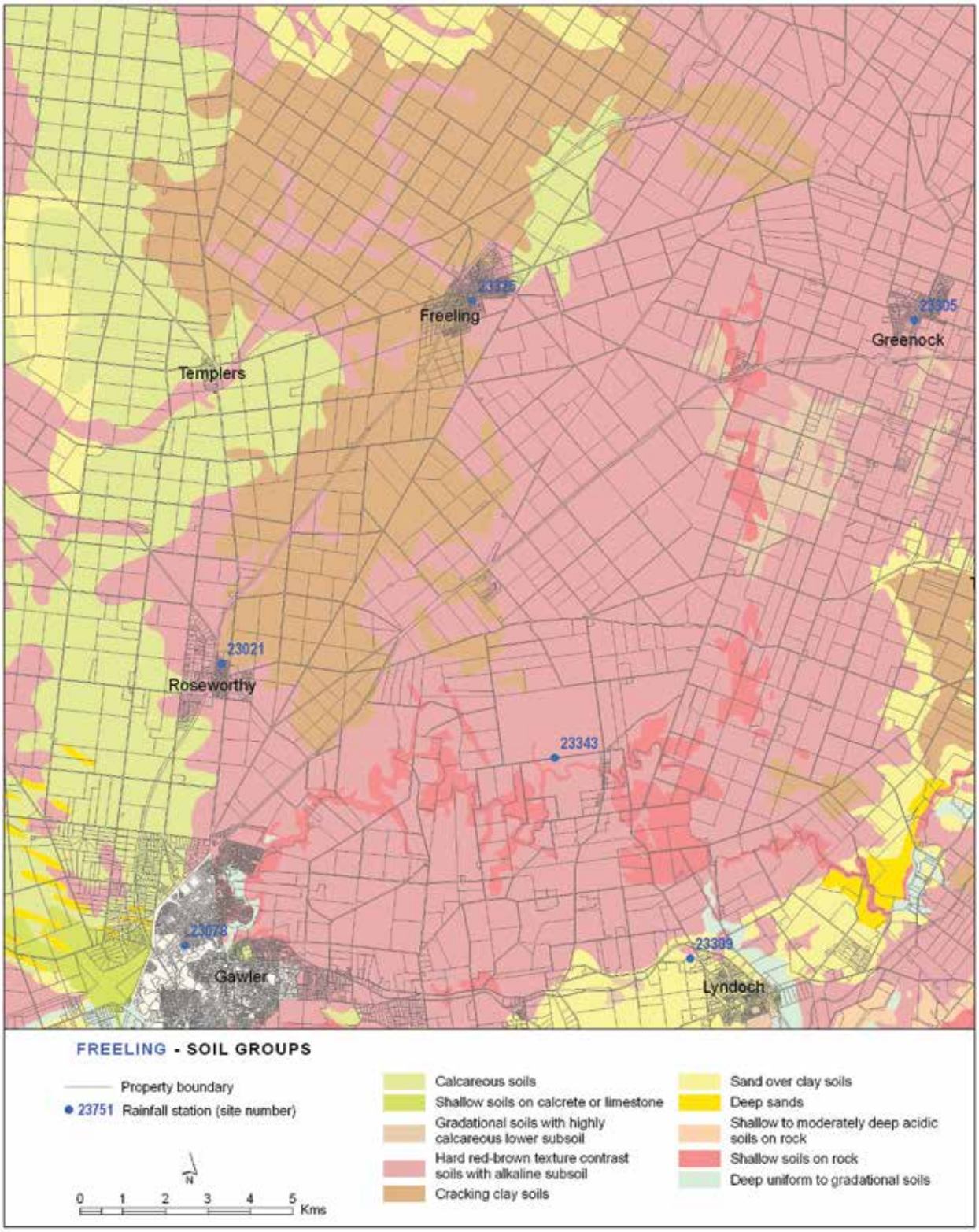

Figure 153. Freeling soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

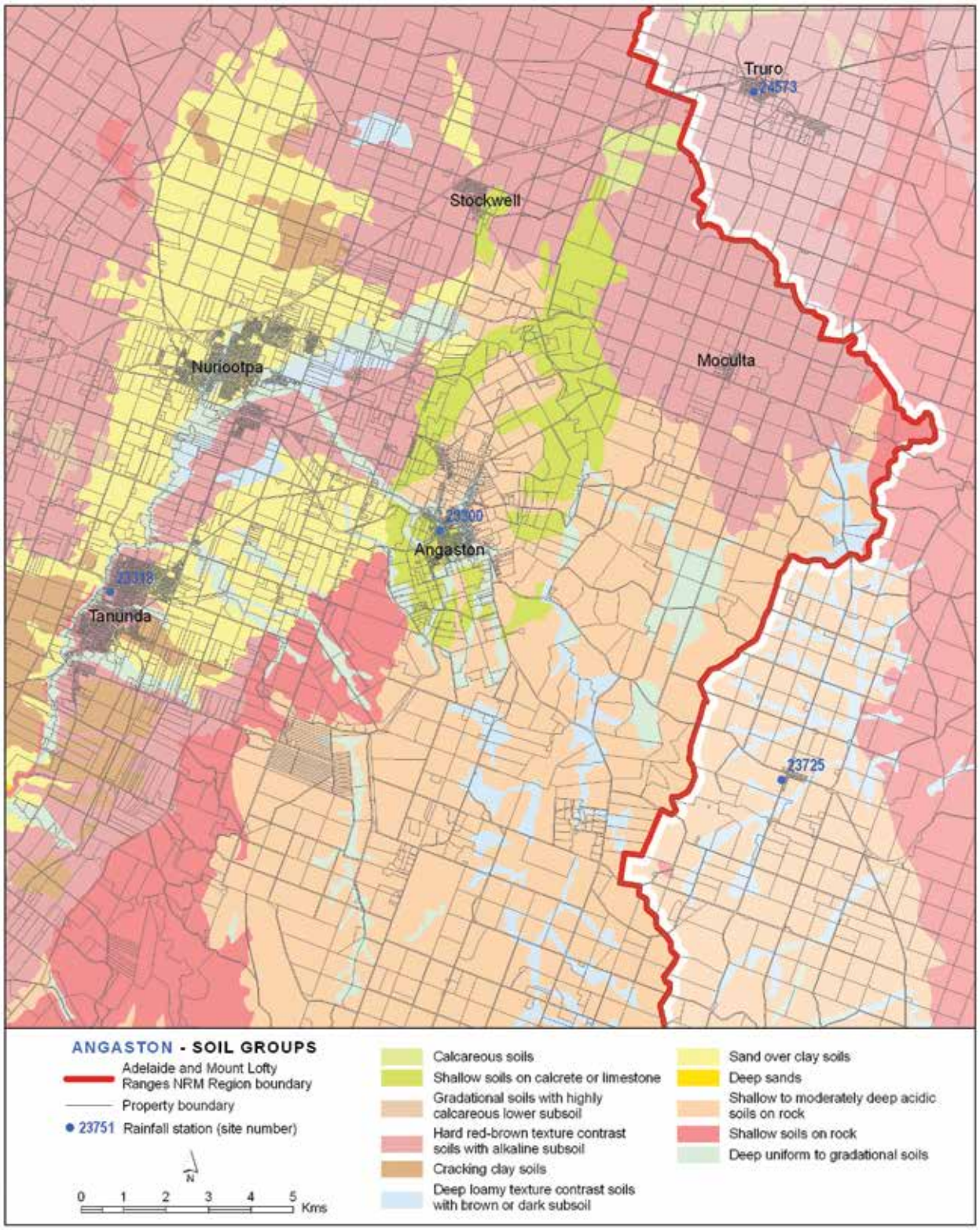

Figure 154. Angaston soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

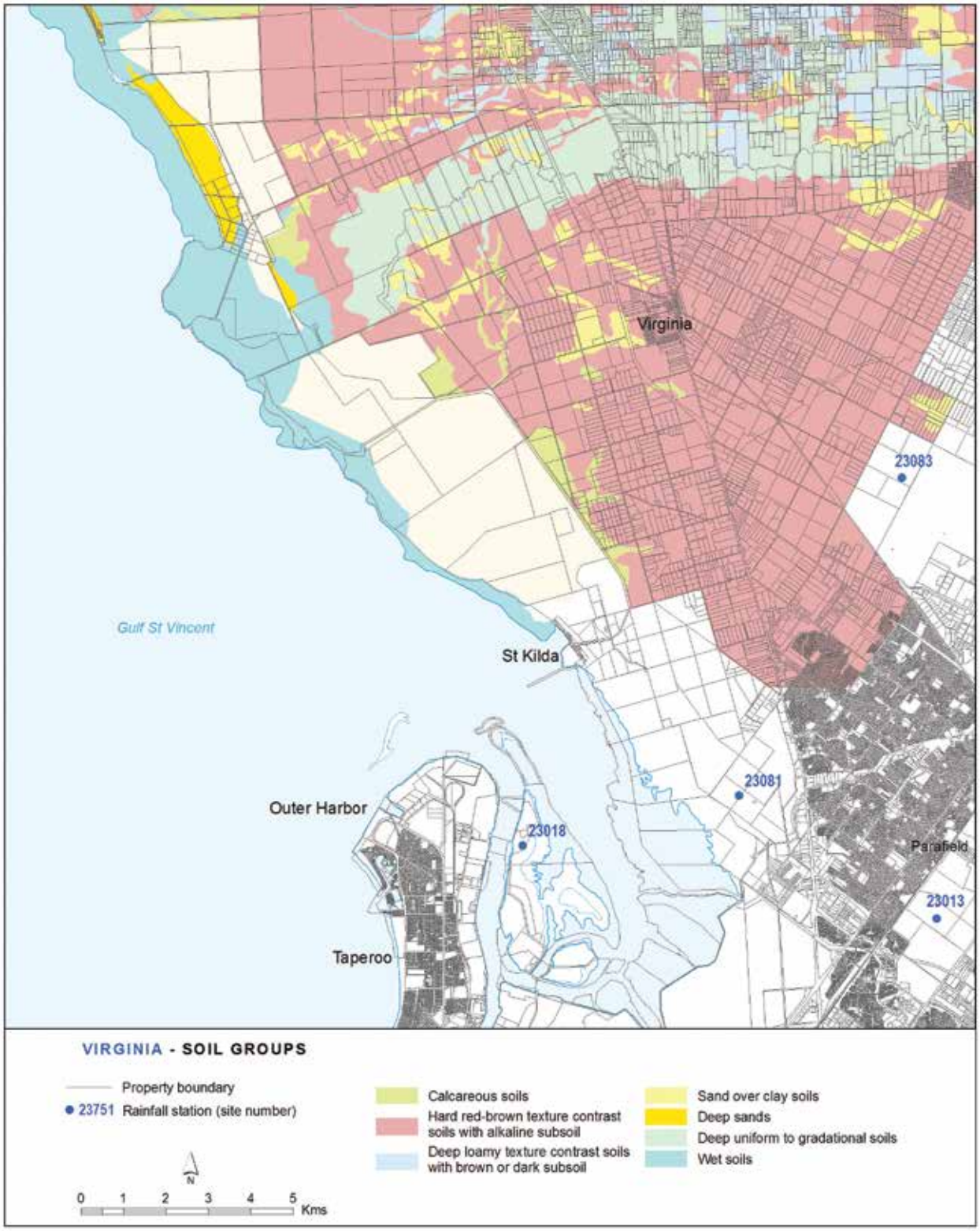

Figure 155. Virginia soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

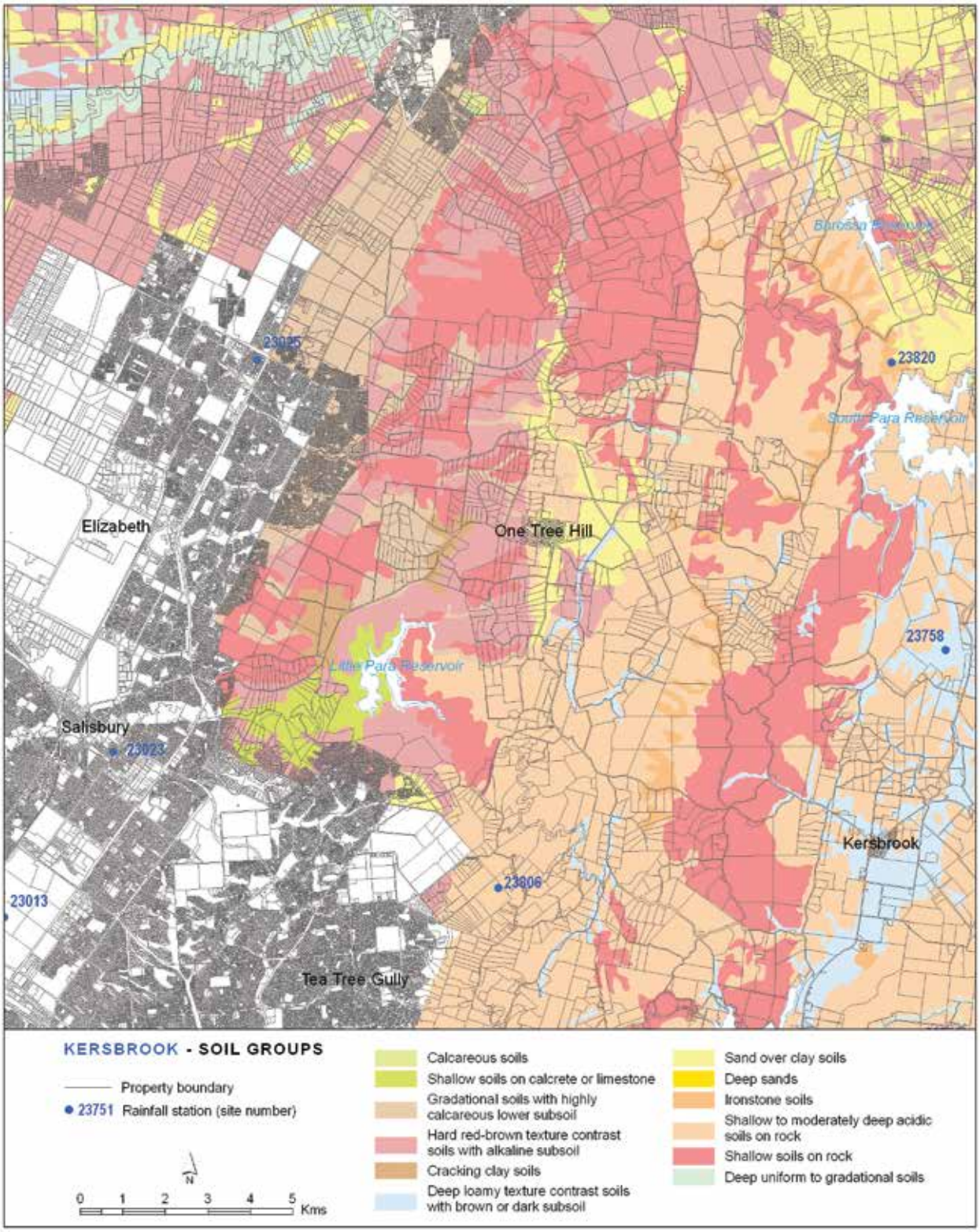

Figure 156. Kersbrook soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

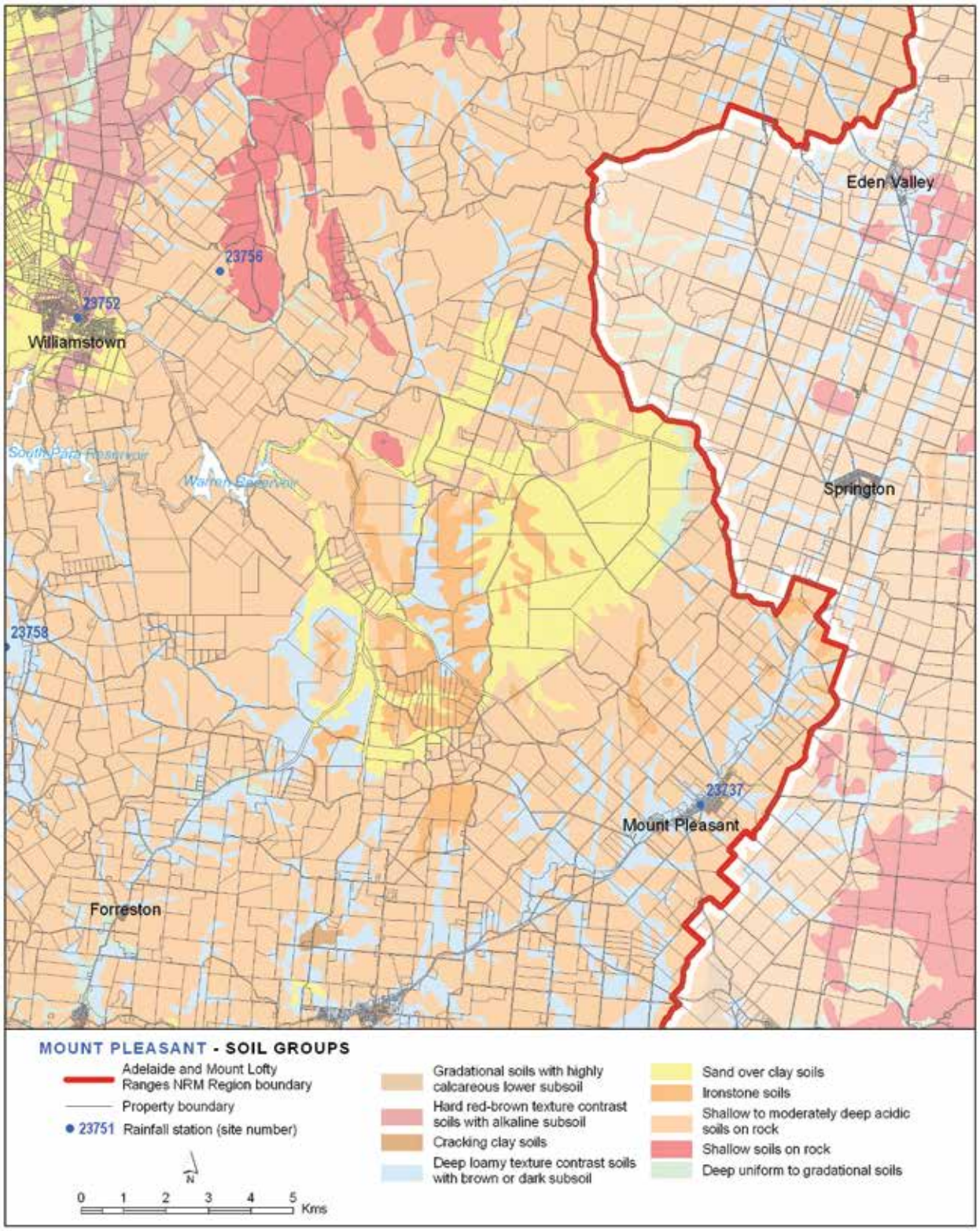

Figure 157. Mount Pleasant soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

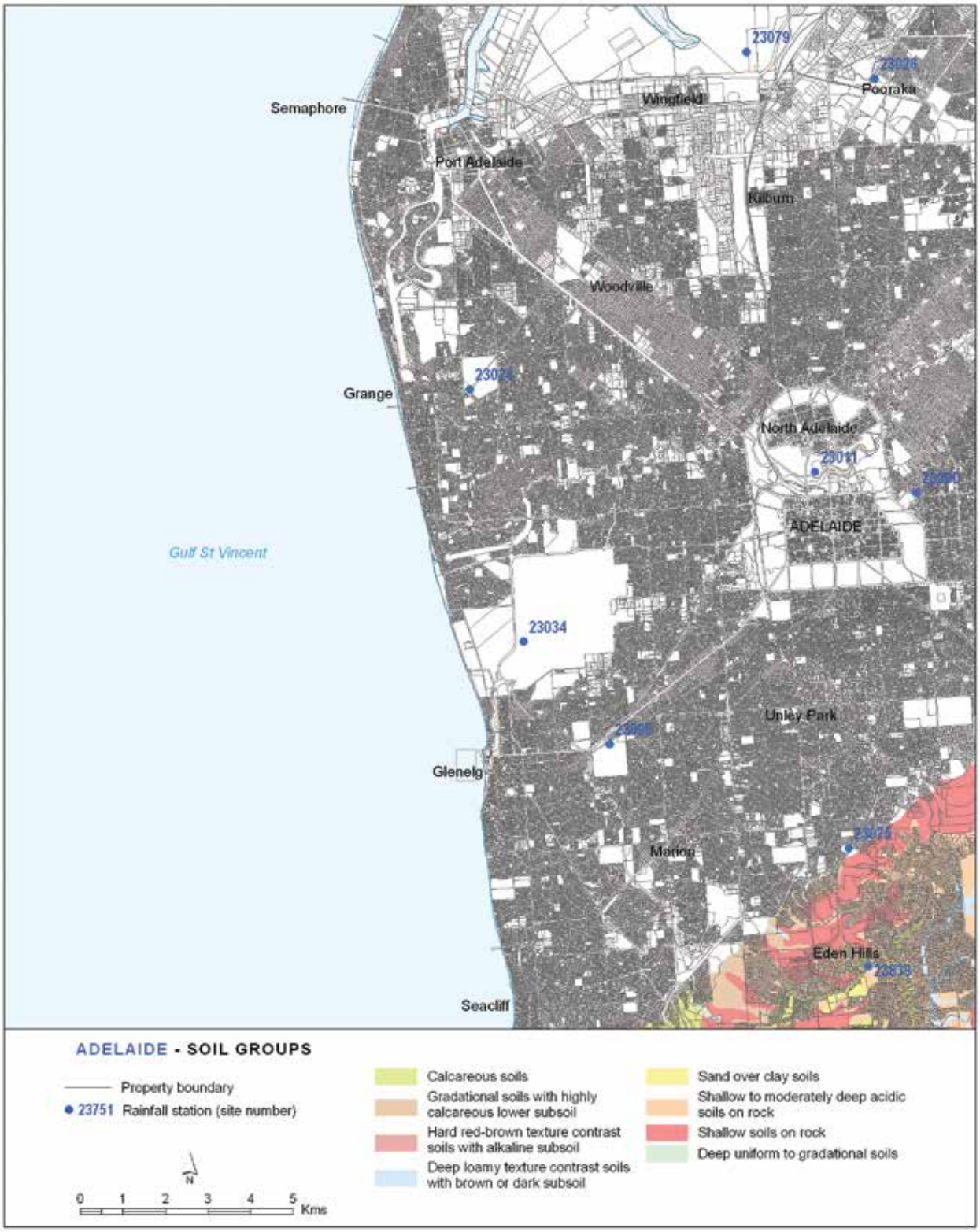

Figure 158. Adelaide soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

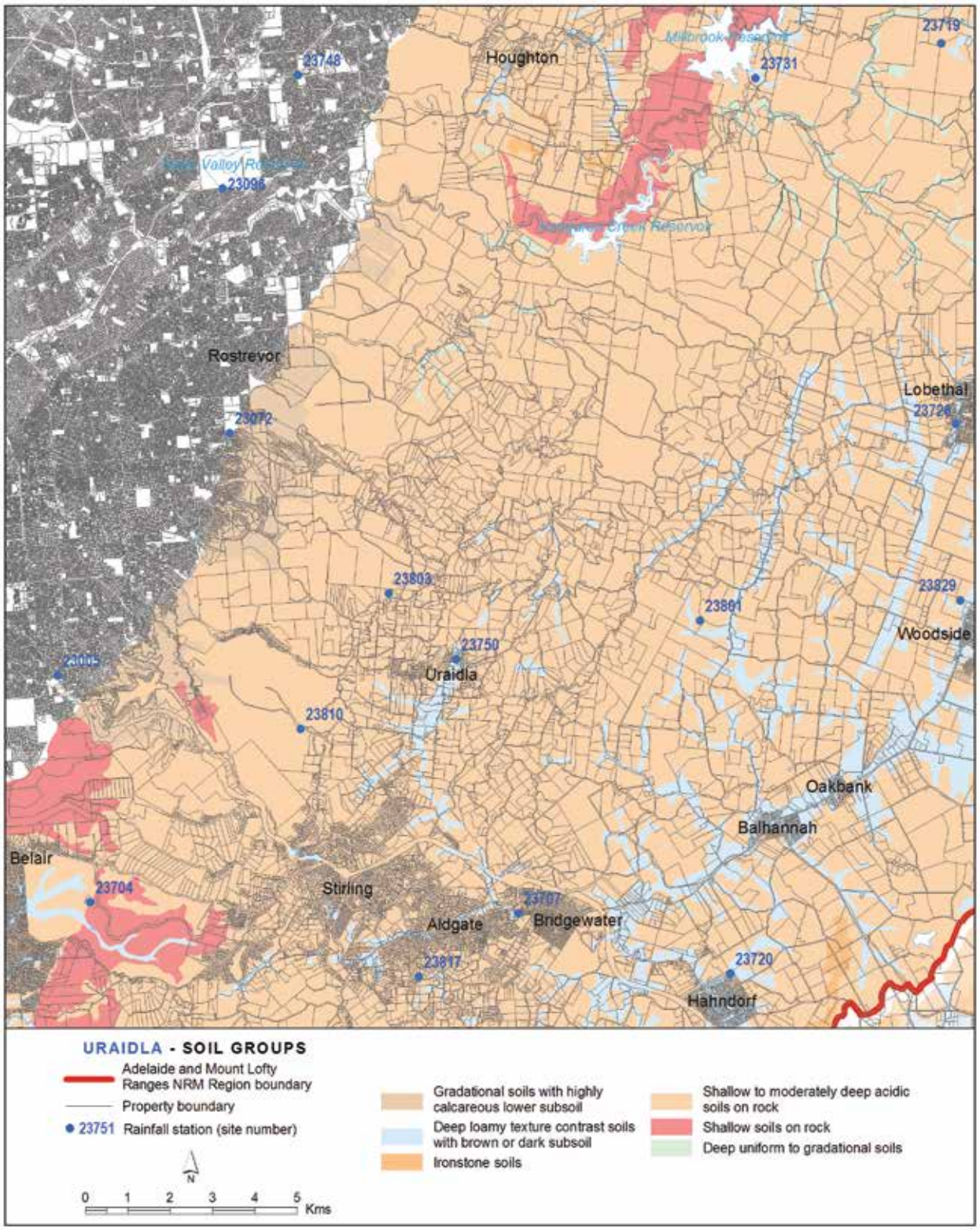

Figure 159. Uraidla soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

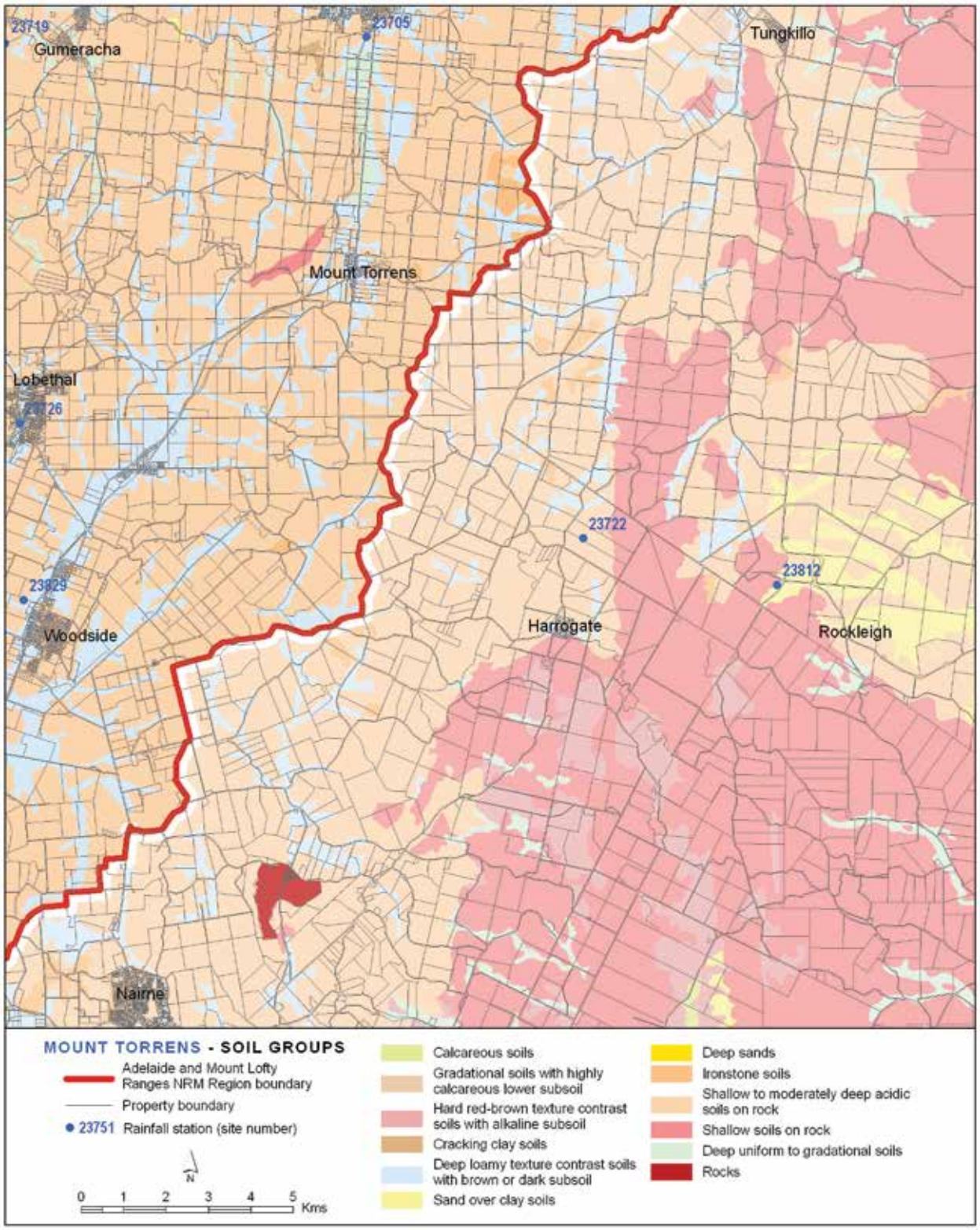

Figure 160. Mount Torrens soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

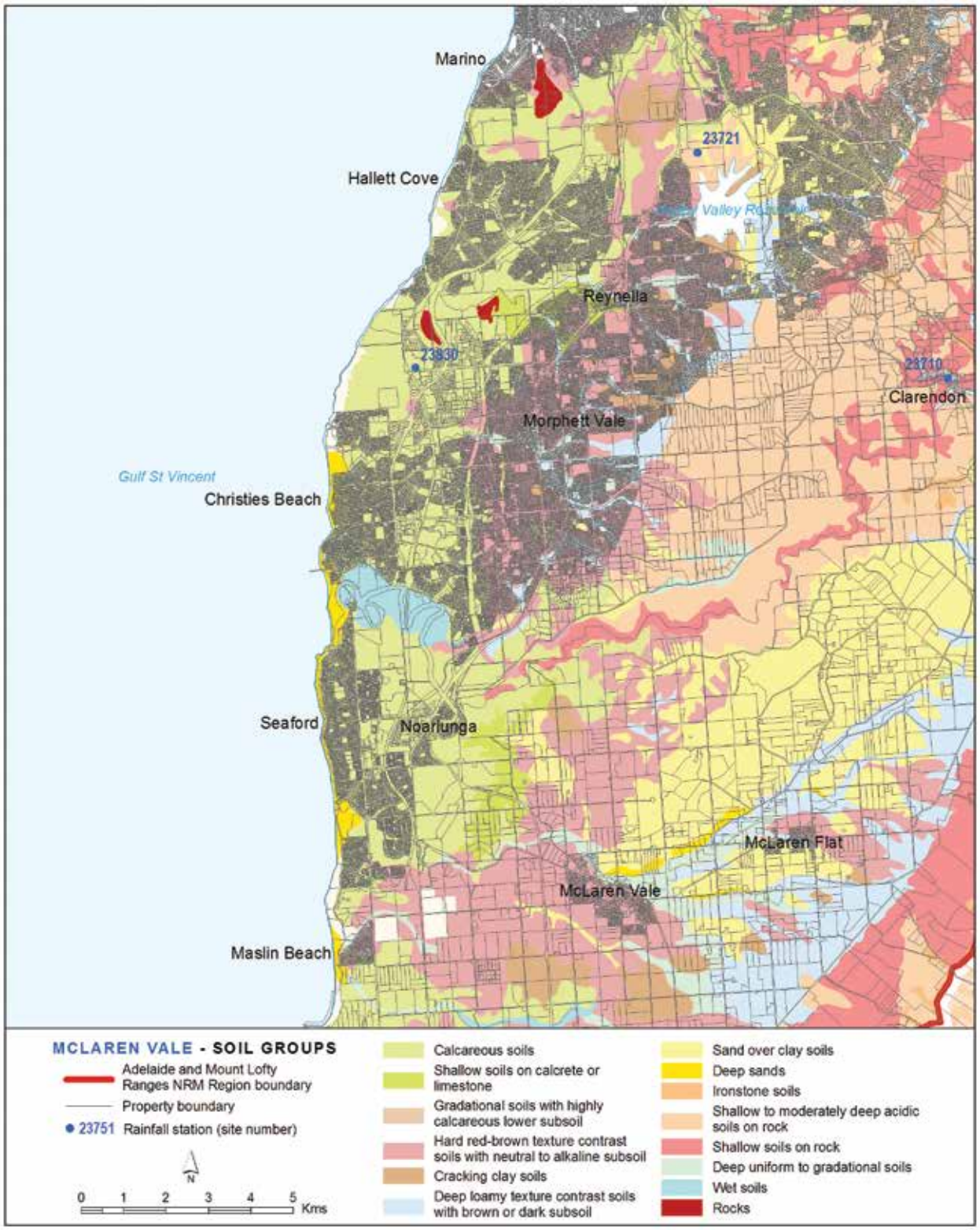

Figure 161. McLaren Vale soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

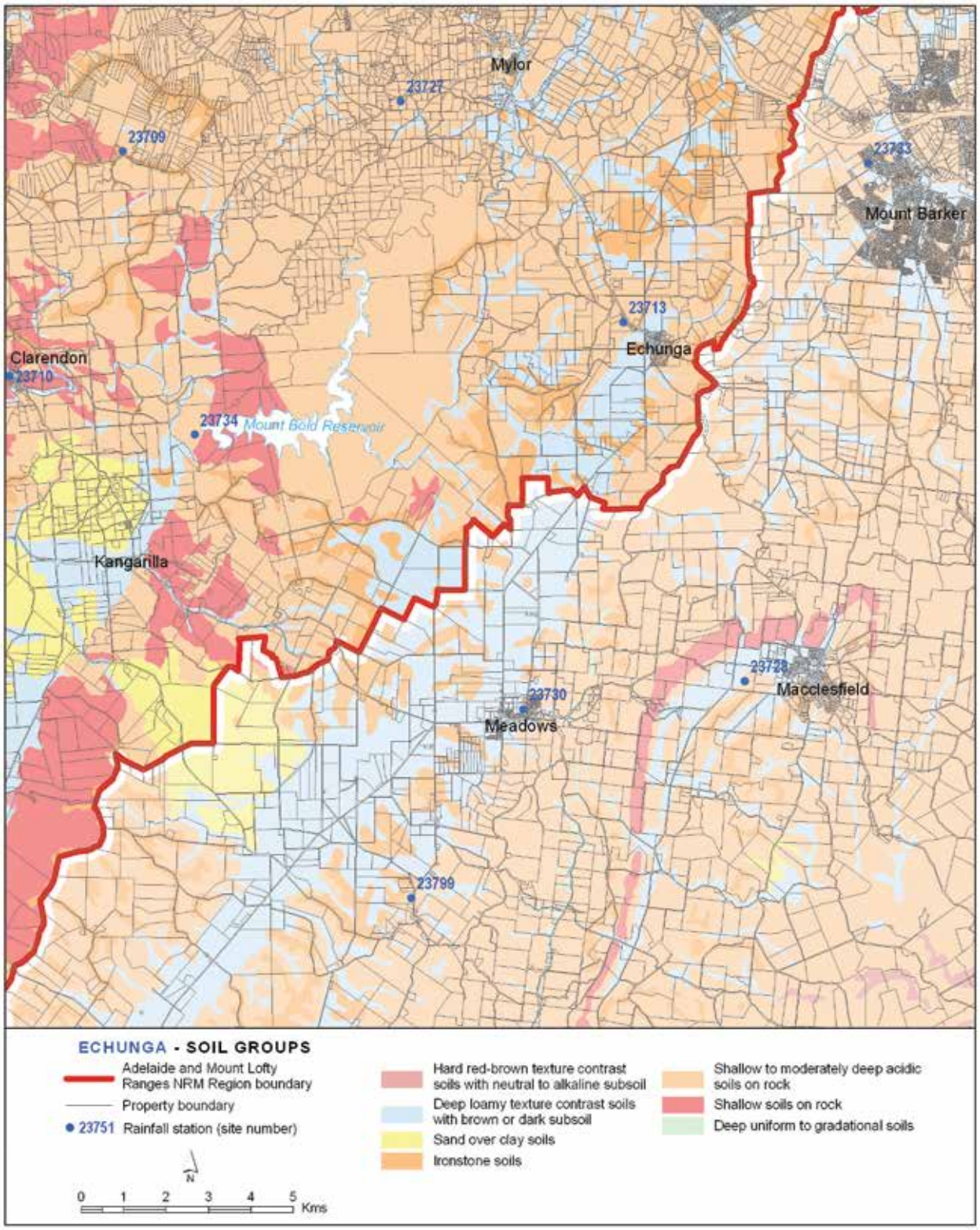

Figure 162. Echunga soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

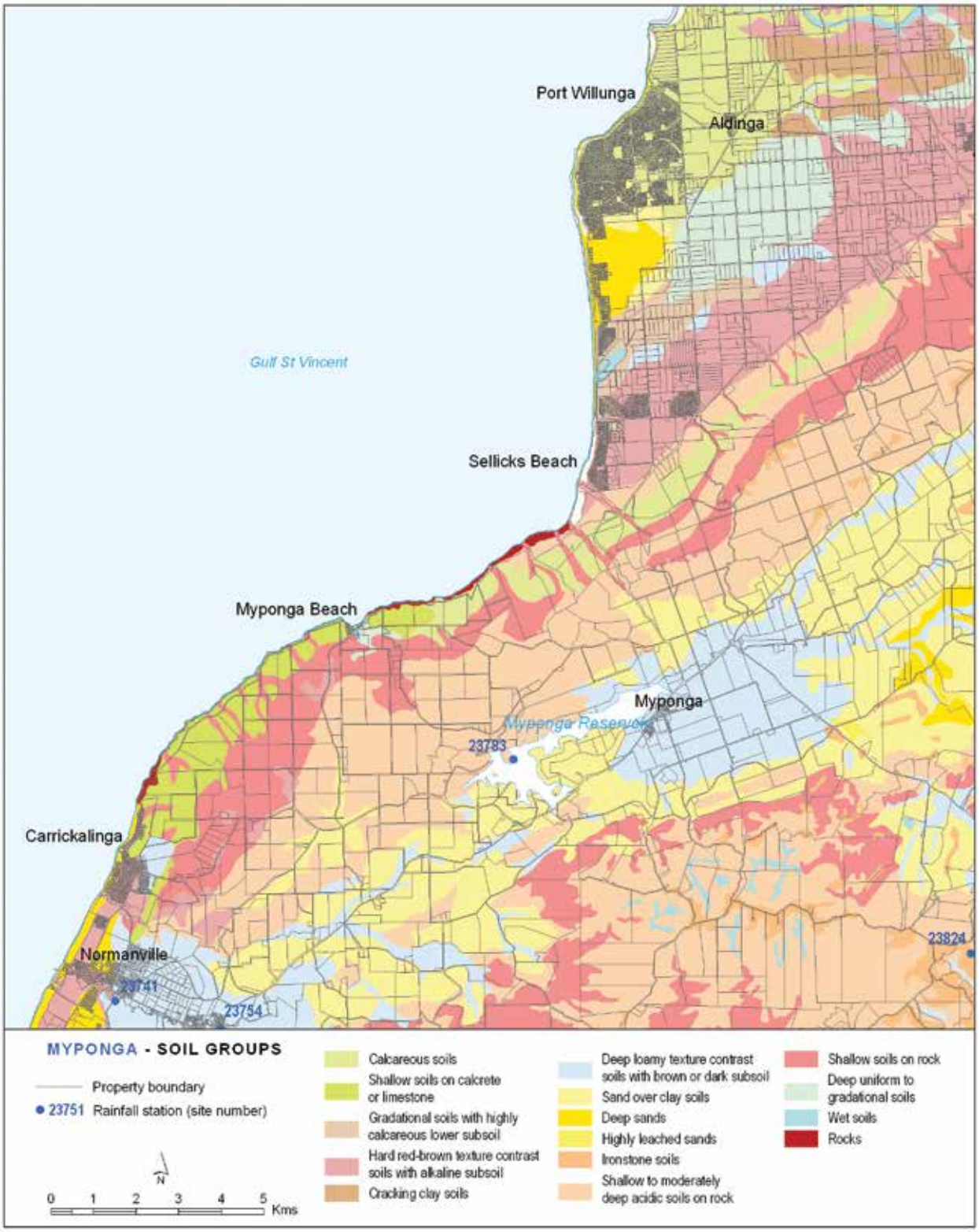

Figure 163. Myponga soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

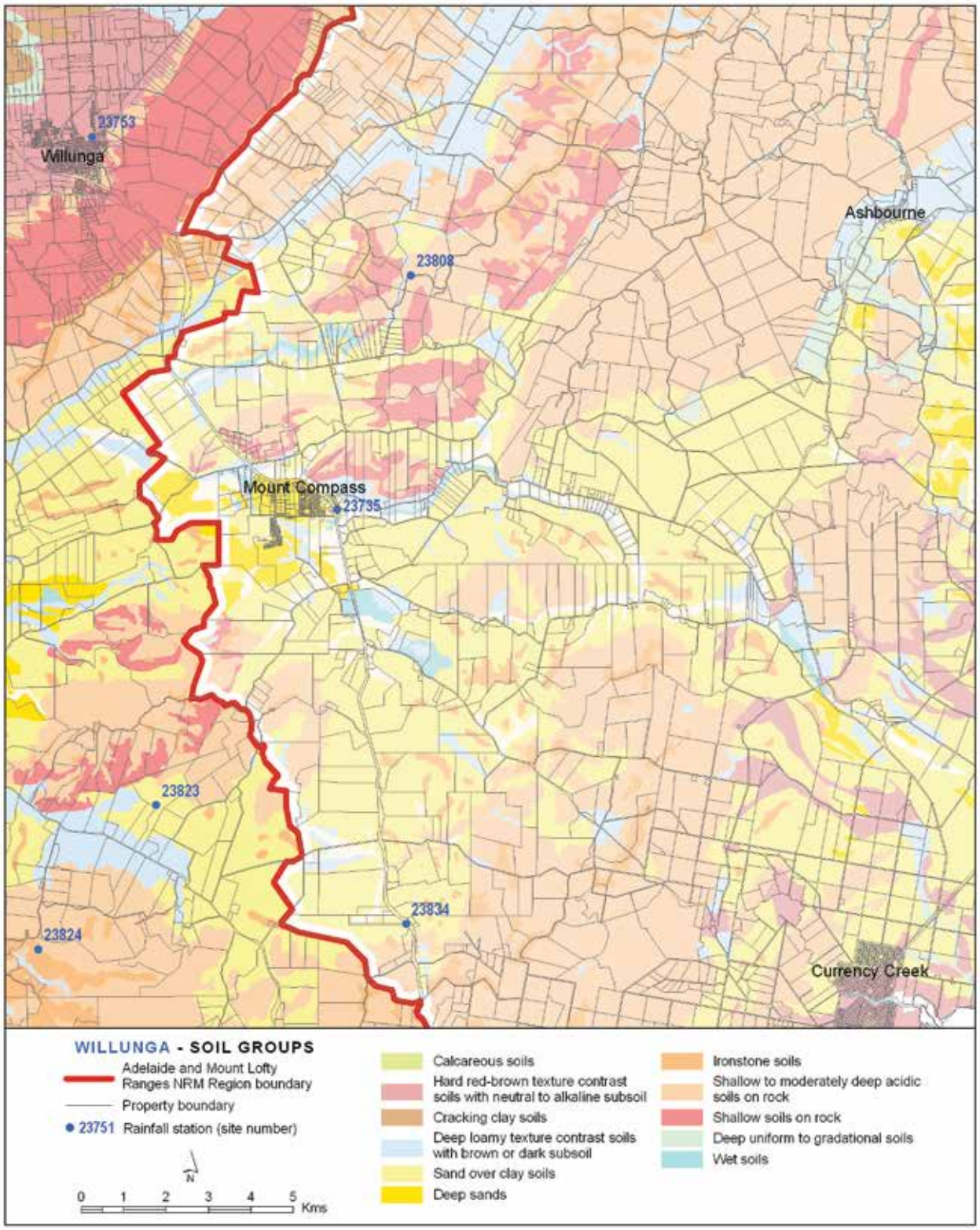

Figure 164. Willunga soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

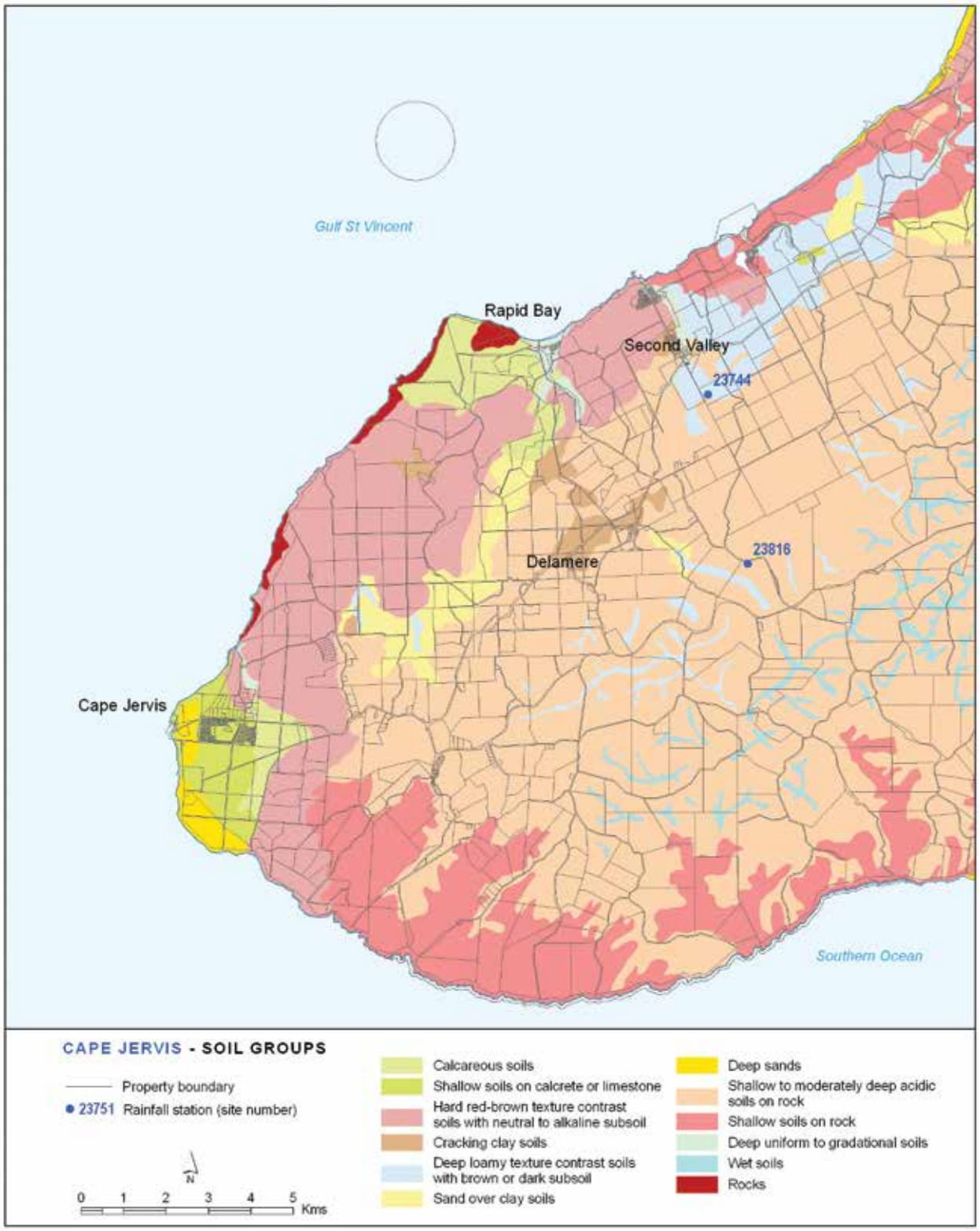

Figure 165. Cape Jervis soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

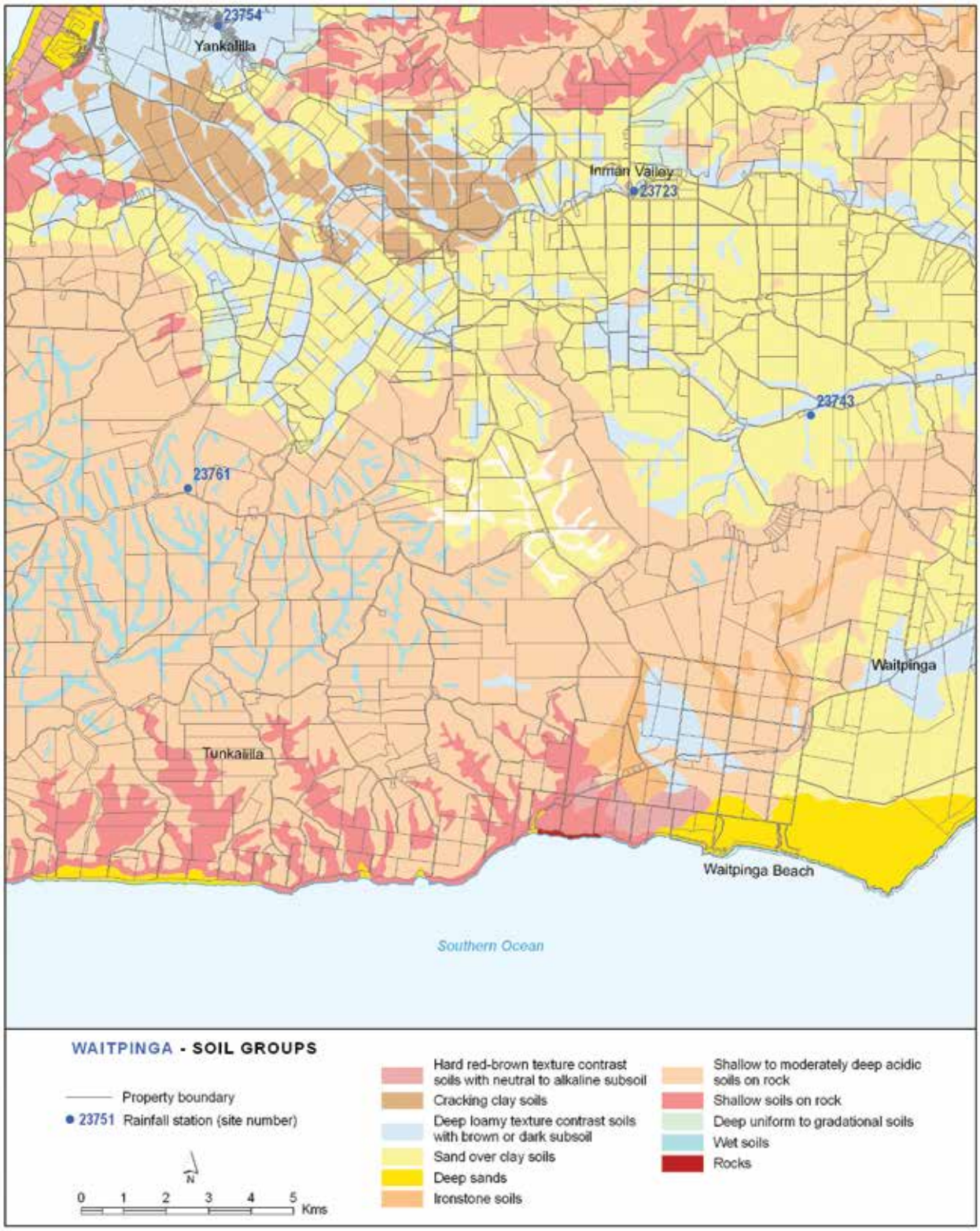

Figure 166. Waitpinga soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

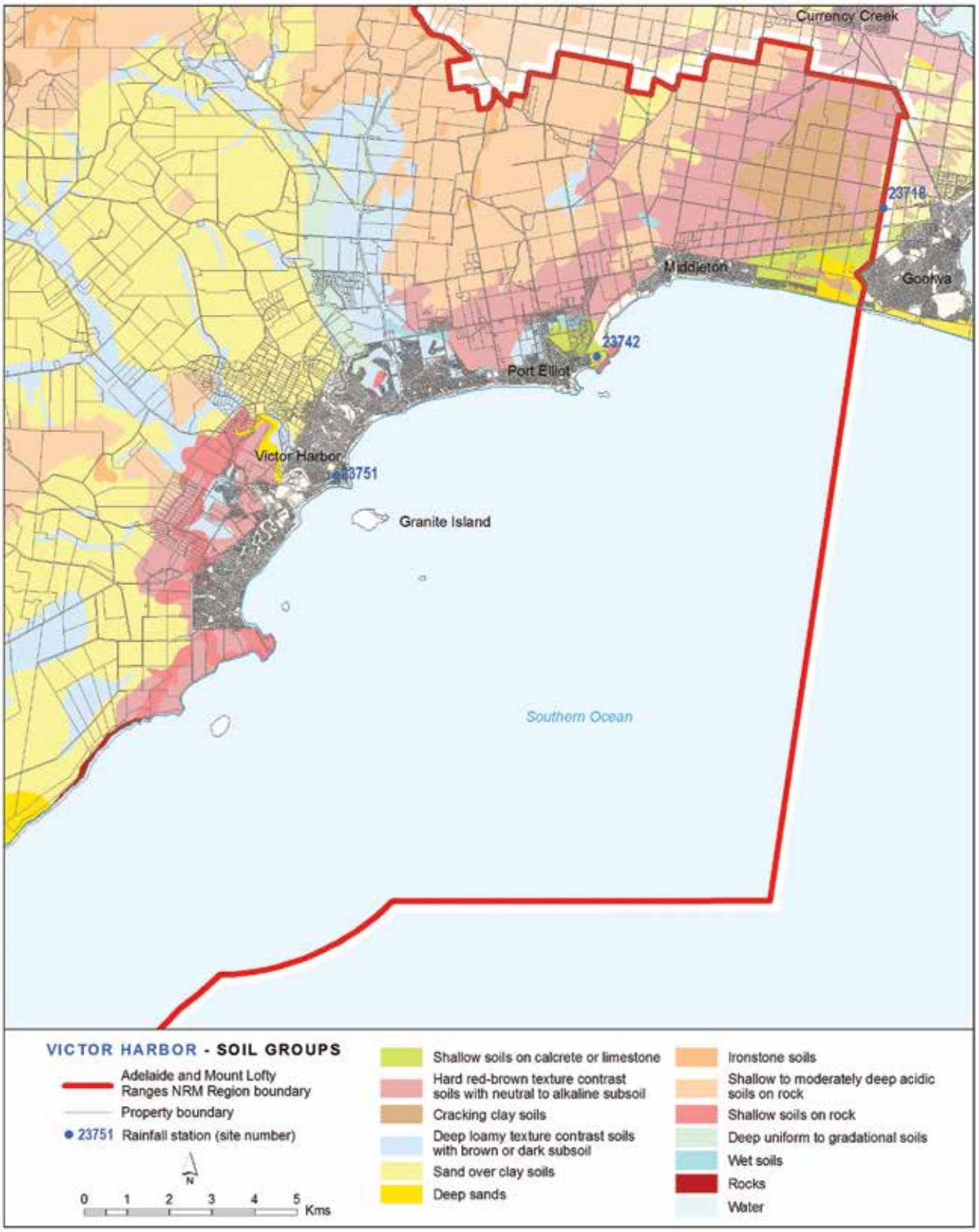

Figure 167. Victor Harbor soil groups
Map: Science Resource Centre, Department of Environment and Natural Resources, June 2011

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