Key Characteristics of the Group N Soils

Soil profiles are wet for a substantial part of the year (see Appendix 2—Soil Key for more details).

Distribution

This map presents an overview of the distribution of Group N soils. It is based on more detailed land and soil information mapped at scales of 1:50 000 or 1:100 000. Soil landscape mapping forms the foundation of this map. Each soil landscape map unit identifies a recognisable landscape area and land type with a particular geological and topographical setting, landform or landform pattern, association of soils, and range of characteristic land and soil attribute features. Highlighted map units contain more than thirty percent (>30%), or ten to thirty percent (10–30%), by area of a Group N *soil*. In instances where two or more *soils* have an extent of more than 30%, or an extent of 10 to 30%, within the same map unit, the *soil* of greatest extent is shown.

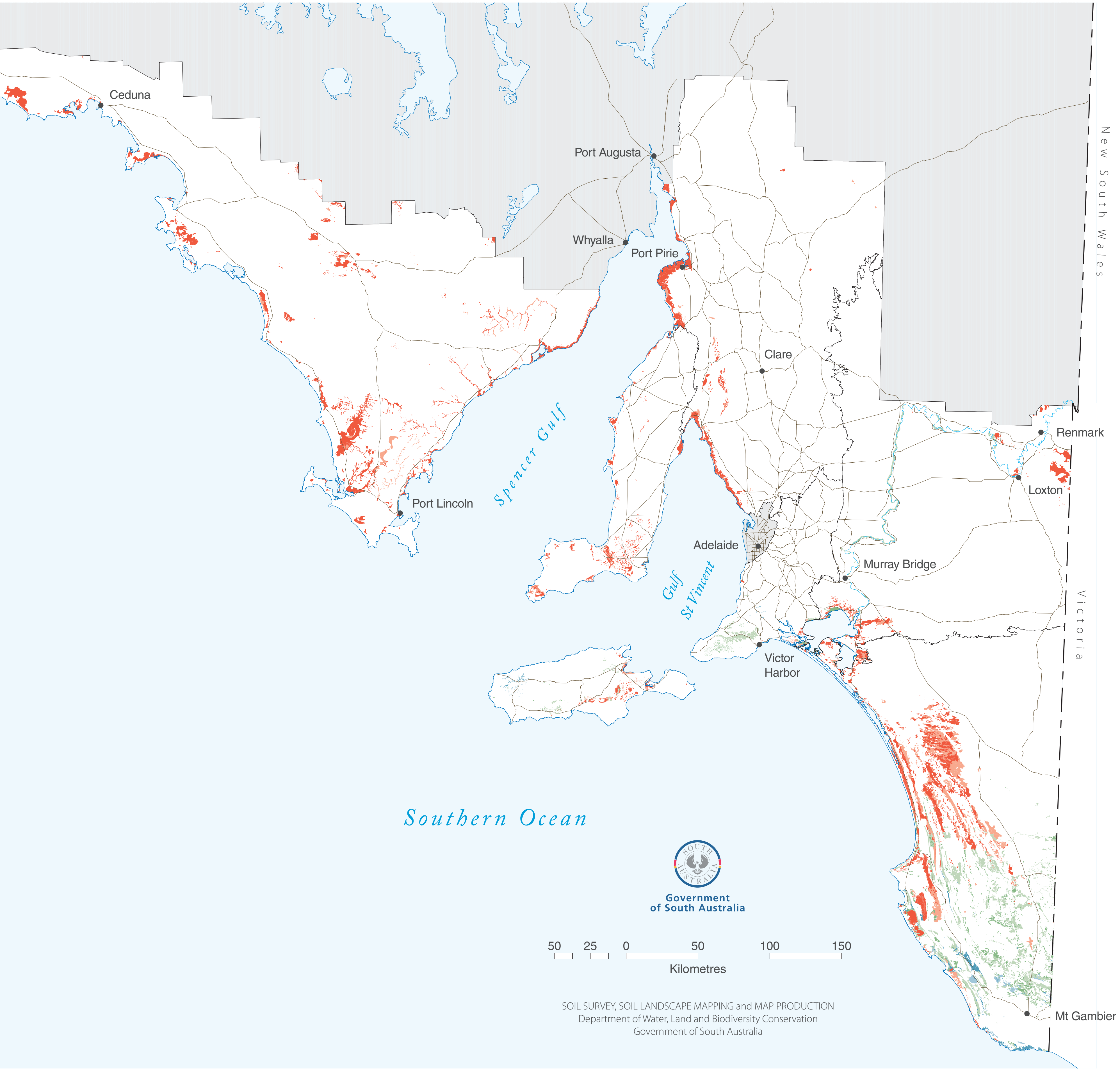
>30%	soil N1—*peat*
10–30%	soil N1
>30%	soil N2—*saline soil*
10–30%	soil N2
>30%	soil N3—*wet soil*
10–30%	soil N3

Main roads

Murray River

Biophysical regional boundaries

Coastline and shorelines



Soil Group N—Overview

The Wet Soils make up 2.7% or 431 500 ha of Southern South Australia. This is the eighth-most extensive of the fifteen Soil Groups. The soils of the group are widespread on the South East Coastal Plain, and are common on Eyre and Yorke Peninsulas and the Gulf Plains (*saline soils*), Fleurieu Peninsula, lands adjacent to Lakes Alexandrina and Albert, the Murray River valley floodplains, and in the northeastern Murray Mallee. They occur in low-lying, poorly to very poorly drained areas, including tidal flats, salt pans, old lagoon and lake floors, lake margins, closed depressions, valley floors and drainage depressions. Native vegetation is generally dominated by water-loving plants such as sedges (Family Cyperaceae), rushes (Family Juncaceae) and reeds, or salt-tolerant plants such as samphire, salt-water tea-tree and sea barley grass.

Soil Group N—Statistics		
Area of interest	*Hectares (ha)*	*% area*
Southern SA	431 500	2.7
Biophysical Regions		
Central	4 340	0.7
Kangaroo Island	9 520	2.2
Northern	52 700	1.6
South East	188 200	6.2
Murray Mallee	31 570	1.1
Yorke Peninsula	24 560	3.1
Eyre Peninsula	120 570	2.6

Soil profiles are saturated over the majority of their thickness for at least two to three months a year, and many are subject to seasonal inundation. Indicative conditions include a seasonal watertable within one metre of the surface, poor to very poor drainage, high to extreme watertable-induced salinity, or the presence of peat (see Appendix 2—Soil Key). The degree to which soils are wet, salty, peaty or flooded influences land use and management. Profiles vary considerably (e.g. in terms of texture profile and structure); nonetheless, a number of soil characteristics indicate wetness, such as high organic matter content, mottled and gley colours, iron staining (particularly along root channels), and wet to moist soil water status in all layers most of the time.

Iron minerals are chemically reduced in low-oxygen, saturated soil, so normally insoluble iron becomes soluble and potentially mobile. Reduced iron produces dull or gley colours, unless masked by organic matter or fine carbonate, while iron depleted layers are bleached. Pockets of orange or red occur where iron remains oxidised. In the wettest clay or clay loamy subsoils: grey, blueish to greenish grey, or green colours dominate. (See Introduction Section CI 3.1 for a fuller description of soil colour in relation to soil drainage and wetness).

Soil pH is variable. Alkaline soils are associated with coastal, lower rainfall, saline environments and closed depressions, while acidic soils mostly occur in higher rainfall environments. Acid sulfate soils (see below) are an exception to this general rule, as they can occur across all rainfall zones.

Subsoils and Substrates

Many of the materials characteristic of Group N profiles have formed in shallow waters, especially via the settling out or precipitation of suspended or dissolved substances, or the deposition of shells and skeletons (see Introduction Section CI 2.6). For example, marl forms where both clay and fine carbonate are deposited; non-calcareous clayey sediments form where clay is the main deposit; while limestone forms where fine carbonate or shells accumulate. Marl can also develop where lime-rich shallow groundwater interacts with clayey sediments. Calcrete, although mostly formed in drier terrestrial environments, underlies a number of Wet Soils, particularly on the margins of swampy areas.

Saline Soils

Saline soils occur where saline watertables are relatively shallow—within approximately 1 m or so of the land surface. Salts in saline soil water, brought to the surface via capillary action, accumulate as water evaporates (see Introduction Sections CII 7 preamble, 7.1). Soluble salts are also transported by water flows to terminal, low-lying swampy areas, where they are further concentrated by evaporation. Consequently, soils in closed depressions often have very high sodium chloride, calcium sulfate (gypsum) and calcium carbonate contents.

Soil pore size determines the depth from which capillary action can act. Clayey soils have finer pores than sandy ones, and so exhibit a stronger capillary effect, with water drawn to the surface from greater depths. A vertical cycle of salt movement—corresponding to seasonal rains—occurs in all but the saltiest soils. Rains leach salt from the topsoil during the low-evaporation, high-rainfall winter period, and these are subsequently drawn to the surface again during the high-evaporation, low-rainfall summer period. Surface mulches break the connectedness of small soil pores with the surface, while vegetative cover minimises evaporation, thereby reducing capillary action and surface salt accumulation.

Extremely saline soils are devoid of vegetation and have salt-encrusted surfaces. Very highly saline soils are generally dominated by samphire species, together with salt-water tea-tree (*Melaleuca halmaturorum*) in high rainfall areas. Highly saline soils are usually dominated by sea barley grass (*Hordeum marinum*), together with salt-water tea-tree and thatching grass (*Gahnia filum*—a 'saw-sedge') in high rainfall areas, or saltbush (*Atriplex* species) in low rainfall areas, and can support salt-tolerant pasture species such as puccinellia (*Puccinellia ciliata*) and tall wheat grass (*Thinopyrum ponticum*—Liu and Wang 2000).

Many saline soils are affected by primary salinity, which is deemed to have been present before agricultural development. It includes most salinity associated with coastal areas and ancient inland salt pans. Clearance of high-water-use, deep-rooted, perennial native vegetation, and its replacement with lower water-use, shallow-rooted annual crops and pastures, have caused watertables to rise in many catchments. The extent and severity of salinity have consequently increased in many low-lying areas, and some previously arable land is now non-arable. This process is known as secondary salinisation. (See Introduction Section CII 7.1).

Inherent Fertility, Plant Growth and Land Use

Inherent fertility is often reasonably high because of the nutrient retention capacity associated with organic matter, low levels of leaching and, in many profiles, high clay content. Nonetheless, nitrogen is lost to the atmosphere in wet conditions; zinc, manganese and iron deficiencies can occur in calcareous soils; iron and manganese may be depleted where chemically reduced; very high organic matter content causes certain nutrients to become less available (especially copper and manganese); bleached layers are deficient in most soil-supplied nutrients; and saturated and cold conditions limit root growth and nutrient uptake.

Plant growth is not only retarded by excessive wetness and low-oxygen conditions, but also by salinity, especially the high to extreme levels of *saline soils*. Salts increase the osmotic potential of the soil solution as well as the soil water content at which wilting point occurs. Consequently, less water is available for plant roots to extract. This produces the 'osmotic drought' associated with high levels of salinity. High salt levels are also associated with chlorine, boron and sodium toxicities. Moreover, the adverse impact on plant growth of a given level of salinity is greatly exacerbated by waterlogging.

Plants may benefit from underlying groundwater (where not too deep or saline) associated with Wet Soils. Nonetheless, drainage can improve productivity—for example, shallow drains can reduce waterlogging in topsoils and improve plant growth. Care is needed, however, when *peats* are drained, as bulk and fertility levels can reduce quickly because of oxidation and depletion by wind erosion.

Drainage of *saline soils* can be very effective, as sodium chloride is highly soluble and potentially very mobile. However, drainage must be feasible, and suitable disposal options for saline water are required. In addition, deep drains are required (e.g. ≥1 m) to significantly lower saline watertables and reduce capillary rise, while the lateral permeability of adjacent soil and substrate materials determines the spatial extent of watertable draw-down.

The agricultural use of Wet Soils is generally limited to light grazing by livestock—their value mainly lies in the provision of green feed over summer when surrounding land is dry. Drained soils are more intensively used. Other industries also make use of Wet Soils. For example: saline tidal flats have been modified for use as evaporation pans to produce salt for human consumption and industrial use; *peats* are sometimes mined for potting mix and mulch; while *wet soil* areas can be a source of naturally filtered spring water. However, low bearing strength can result in poor vehicle accessibility.

Wetlands associated with Wet Soils often have significant biodiversity value, providing refuge and habitat for a range of native plants and animals (especially birds). They also filter and clarify water (via the settling out of solid particles), and so improve water quality.

Acid Sulfate Soil

Many wet soils have the potential to become extremely acidic. Acid sulfate soils form in wet, low-lying coastal, estuarine, mangrove, lagoon, lake and swamp areas where saturated and low-oxygen conditions favour the development of sulfide minerals—mostly iron pyrite (FeS_2). Exposure to air upon drying, drainage or excavation results in the oxidation of pyrite and the formation of sulfuric acid, with soil pH falling to less than 4—see 'Sulfuric materials' in the glossary of Isbell (2002). (Fitzpatrick et al. 2007).

Such extreme acidity (or hydrogen ion activity) can cause aluminium, iron, manganese and heavy metals to come into solution—and may lead to the acidification and pollution of surface and ground waters, adversely affecting water quality and aquatic life (White et al. 1996; Fitzpatrick et al. 2007). Corrosive acids released from acid sulfate soils can also degrade infrastructure and foundations.

Group N *soils*

Constituent soils are differentiated by organic matter content and salinity levels. The potential range of profiles is very large, but because of relatively limited use and/or extent, only three *soils* have been established. These are described in the following pages and are highlighted in the table below.

Soil	Organic matter levels	Salinity levels	Predominant drainage
N1 *peat*	Profile dominated by organic matter.	low to moderately high	poor to very poor
N2 *saline soil*	Surface soil: high to low. Subsoil: low.	high to extreme	poor to very poor
N3 *wet soil*	Surface soil: usually high. Subsoil: low.	low to moderately high	poor to very poor

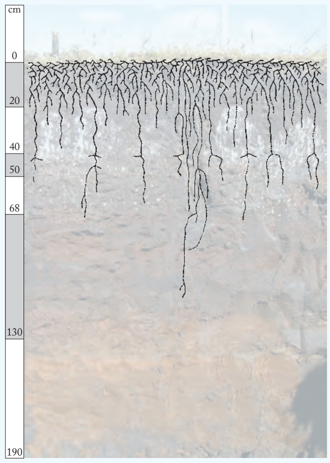
Soil Group N—soil N1

The *peats* are the fifth-least extensive of all 61 *soils*, accounting for only 0.1% or 20 200 ha of Southern South Australia. They are common in the Mid to Lower South East, and have minor occurrence on northwestern Kangaroo Island and in the southern Mount Lofty Ranges. They are situated in low-lying swampy areas in high rainfall districts—where organic matter has accumulated and is the dominant soil-forming material. Native vegetation is dominated by water-loving plants such as sedges and rushes, some grass species, and formerly included thickets of freshwater tea-tree (*Leptospermum lanigerum*—Blackburn 1952). N1 soils are associated most commonly with soil N3 (*wet soil*), to a lesser extent with soils B3, M2, I2, B5, B2, G3 and E1, as well as with waterbodies and calcrete outcrop.

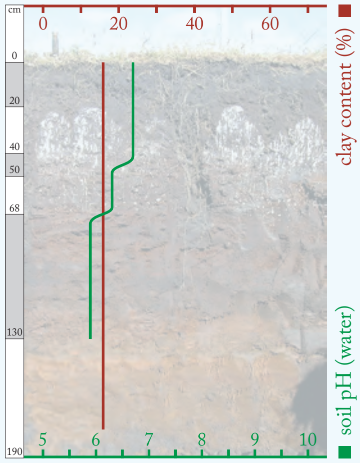
These are deep to shallow, organic-rich, dark-coloured soils formed under conditions of prolonged wetness. Wet, anaerobic conditions greatly reduce the rate of decomposition of organic matter by micro-organisms, thereby enabling it to accumulate. Profiles are dominated by fully to partly decomposed organic matter, which can vary from fibrous to granular, depending on the type and degree of decomposition. Soil materials are usually friable, although matted and weakly to moderately cemented layers occur (see representative soil profile). Soil pH varies from strongly acidic to alkaline. Coastal *peats* are usually alkaline and may contain shelly fragments. Inland *peats*, and those in the highest rainfall areas, are usually acidic. Soil pH is governed by the nature of the vegetative material from which profiles are formed, fine carbonate content, and the pH and aeration of the waters in which they are immersed.

Levels of natural fertility are moderate. High organic matter content, and a corresponding high capacity to retain and release nutrients, promote fertility. Those nutrients predominantly supplied by organic matter (e.g. nitrogen and sulfur) are in abundant supply. Calcium status is also usually very high. However, organic matter immobilises copper and manganese, and unlike mineral soils, copper applications have poor persistence. Plant availability of iron, zinc, manganese and phosphorus can be affected where *peats* are alkaline, while strongly acidic *peats* can be deficient in a range of nutrients, including boron. Nonetheless, there are usually no major physical or chemical barriers to root growth other than wetness.

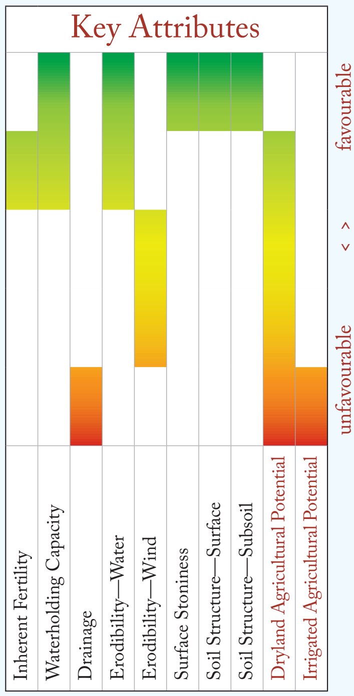
Undrained *peats* are often used for livestock grazing, especially over summer, as they remain moist and supply valuable green feed when surrounding areas are dry. Drained *peats* are highly productive, but when cultivated, become powdery and susceptible to wind erosion. They also have reasonably high fire risk, and once alight are difficult to extinguish. Irrigation potential is generally low because of the poor drainage caused by topography, wetness and shallow watertables; although soil waterholding capacity is generally high. In addition, some near-coastal *peats* are affected by saline watertables.

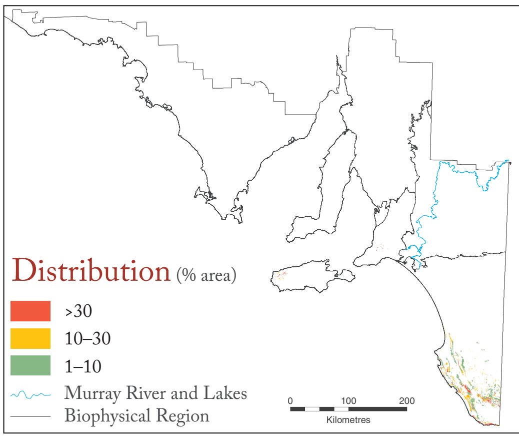


Likely growth of cereal plant roots within the representative soil profile



Clay content and pH levels within the representative soil profile





Statistics

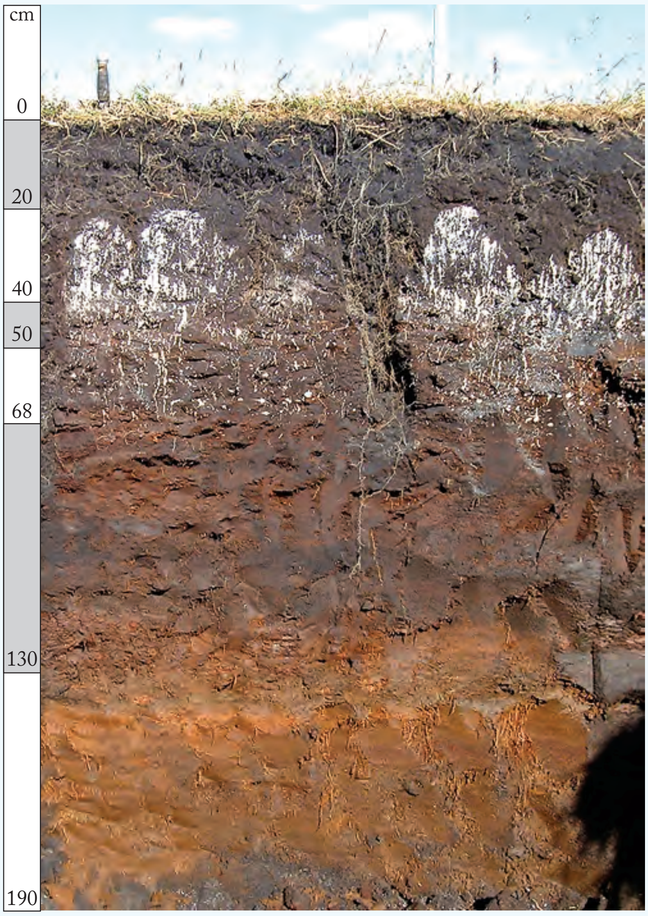
Area of interest	*Hectares*	*% area*
Southern SA	20 200	0.1
Biophysical Regions		
Central	110	0.0
Kangaroo Island	480	0.1
Northern	0	0.0
South East	19 640	0.6
Murray Mallee	0	0.0
Yorke Peninsula	0	0.0
Eyre Peninsula	0	0.0

Representative Soil Profile

Depth (cm)	*Description*
0–20	Black, soft, sapric (organic and non-fibrous) loamy peat with massive structure.
20–40	Black, sapric (organic and non-fibrous) loamy peat with weak, subangular blocky structure and 10–20% ash content.
40–50	Very weak organic pan with 10–20% ash content.
50–68	Very dark brown, weakly cemented, fibric (organic and fibrous) loamy peat with massive structure and 2–10% ash content.
68–130	Very dark reddish brown, fibric (organic and fibrous) loamy peat with massive structure.
130–190	Dark brown, fibric (organic and fibrous) loamy peat with massive structure.
Note:	The ash content from 20 to 68 cm is probably a remnant of a natural peat fire. The profile has moderately low levels of watertable-induced salinity. The watertable is seasonally at the land surface.

Australian Soil Classification

Ashy, Basic, Sapric–Fibric Organosol; very thick.



Photograph: Glenn Bailey. South of Millicent, Lower South East, South East Coastal Plain, on a corridor plain adjacent to the eastern edge of an old coastal dune range. The soil is situated in a swampy depression that is seasonally inundated.

Soil characterisation site SE083.

A peat swamp dominated by soil N1, south of Mount Benson in the Mid South East, with a vegetative cover dominated by grass and sedges. Non-peaty and drier gently undulating plains with improved permanent pasture lie adjacent to the peat swamp. Beyond this is an old coastal dune range. The plains are dominated by B3 and B7 soils, with some H3 soils, while the old dune range is composed of calcreted calcarenite and is dominated by B3 soils and calcrete outcrop.

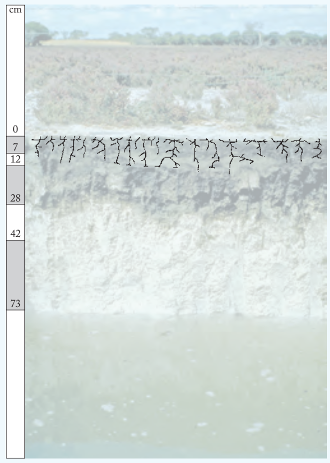
Photograph: Bruce Billing.

Soil Group N—soil N2

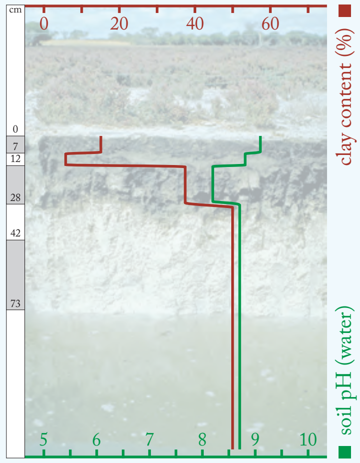
The *saline soils* make up 2.1% or 335 100 ha of Southern South Australia, and are the most common and widespread of the Wet Soils. They are particularly significant on the middle to upper South East Coastal Plain, Eyre and Yorke Peninsulas, the Gulf Plains, south-central Kangaroo Island, lands adjacent to Lakes Alexandrina and Albert, and in the northeastern Murray Mallee. N2 soils occur where saline groundwater comes close to the land surface (within approximately 1 m or so). Low-lying areas of poor to very poor drainage are predominantly affected. For example: tidal flats, backswamps, old lagoon and lake floors, closed depressions, valley floors and drainage depressions. Soils are either devoid of vegetation or support highly salt-tolerant plants. N2 soils are associated most commonly with soils H3 (*bleached siliceous sand*) and G4 (*sand over poorly structured clay*), and to a significant extent with soils G3 (*thick sand over clay*), B3 (*shallow sandy loam on calcrete*), N3 (*wet soil*), G2 (*bleached sand over sandy clay loam*), B2 (*shallow calcareous loam on calcrete*), B7 (*shallow sand over clay on calcrete*), B5 (*shallow dark clay loam on limestone*), H1 (*carbonate sand*) and H2 (*siliceous sand*) as well as waterbodies.

These are highly to extremely saline soils that are affected by shallow saline watertables. A great variety of soil profiles can be saline. They range from deep clays to sand-over-clays to deep sands. The common feature is high salt levels in the soil solution (primarily sodium chloride). Other less soluble substances are often abundant (e.g. fine carbonate and gypsum), particularly in closed depressions. Extremely saline types have salt-encrusted surfaces. The surface soils of less saline types are usually well structured due to the flocculating effect of saline soil water. Non-sandy surface soils very often have distinctive, fine granular structure, and also frequently feature a thin surface crust or flake. Subsoil structure varies with profile type. Soil pH is variable, but is typically acidic to strongly alkaline in the surface soil, and neutral to strongly alkaline in the subsoil.

Many saline soils are naturally occurring, while others are the result of higher watertables caused by native vegetation clearance. The productive capacity of N2 soils is severely limited. They are non-arable (crops cannot be successfully grown); although salt-tolerant pasture species (e.g. puccinellia and tall wheat grass) can be established on less saline types. Bare surfaces, as well as poor germination and plant establishment, along with moisture-stressed plants, are typical. Amelioration involves lowering watertables—either via local drainage or by decreasing recharge into groundwater by increasing catchment-wide plant water use—and leaching of excess salts. Flooding and waterlogging are common. The latter greatly exacerbates the adverse effect salinity has on plant growth. Evidence of erosion, much of it natural, occurs in many areas: built-up or remnant soil around the base of shrubs; broad and shallow channels where topsoil has been removed by water flow; and lunettes on the leeward side of salt pans.

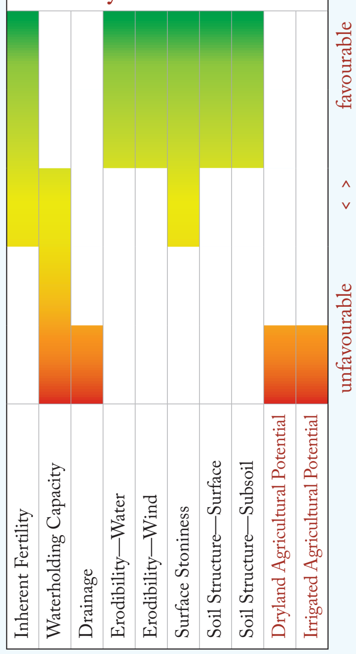


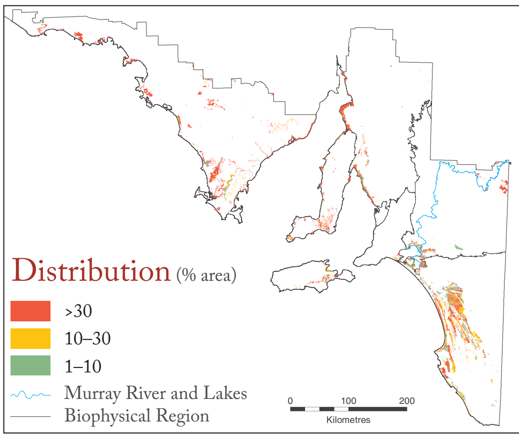
Likely growth of cereal plant roots within the representative soil profile



Clay content and pH levels within the representative soil profile

Key Attributes





Statistics

Area of interest	*Hectares*	*% area*
Southern SA	335 100	2.1
Biophysical Regions		
Central	1 240	0.2
Kangaroo Island	7 270	1.6
Northern	52 700	1.6
South East	103 860	3.4
Murray Mallee	24 870	0.9
Yorke Peninsula	24 560	3.1
Eyre Peninsula	120 570	2.6

Representative Soil Profile

Depth (cm) Description

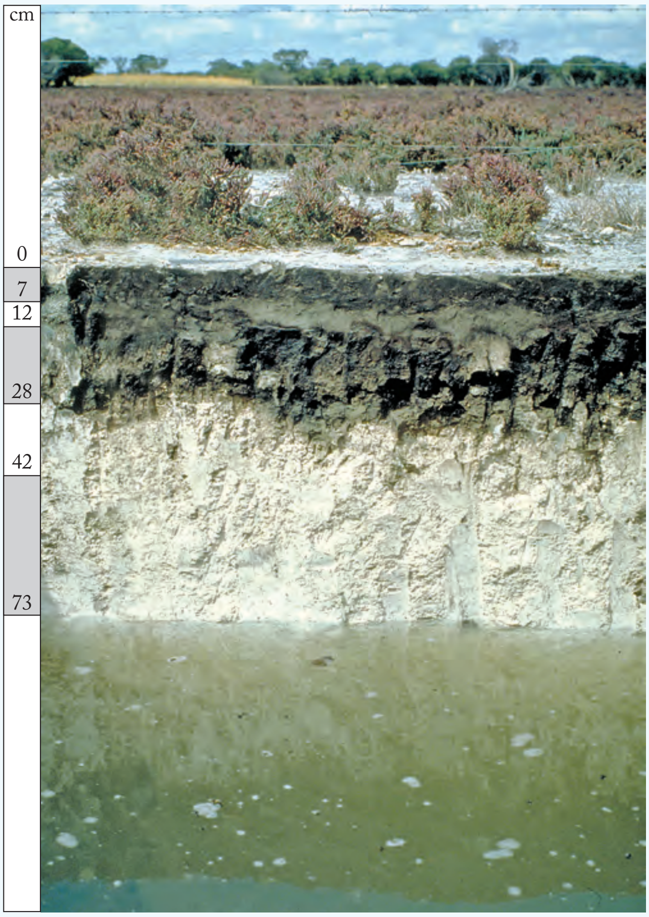
0–7	Grey and black, firm, moderately calcareous, sandy loam with single grain structure.
7–12	Light grey and dark grey, slightly calcareous, loamy sand with single grain structure.
12–28	Very dark grey, slightly calcareous, sandy light clay with coarse, strong columnar–prismatic structure.
28–73	Highly calcareous, medium clay with abundant fine carbonate. 28–42 cm: light grey with moderate, angular blocky structure. 42–73 cm: white with massive structure.

Soil layer not shown in profile image:

73–120	White and olive-grey, moderately calcareous, medium clay with massive structure.
Note:	There is a saline watertable at 73 cm. Surface soil fine carbonate content is 3%. This soil has formed in highly calcareous, fine-textured, saline swamp sediments (see Appendix 4 Section II 1d).

Australian Soil Classification

Regolithic, Calcarosolic, Salic Hydrosol;
thin, non-gravelly, loamy / clayey, very shallow.



Photograph: Andy McCord. On a corridor plain, south of Tintinara, Upper South East, South East Coastal Plain. The soil is situated in a very highly saline, seasonally inundated, swampy depression. Samphire plants occur on the swamp surface, while salt-water tea-tree (visible in the background) occupies the swamp margins.

Soil characterisation site MM068.

Spectacularly pink samphire covers this very highly saline backswamp on Northern Yorke Peninsula, which is dominated by soil N2. This area is situated behind a coastal dune range (visible in the background), beyond which is Spencer Gulf. Samphire species are some of the very few plants that can survive in such a harsh environment. Soils here are generally dark-coloured, calcareous clay loams with shelly fragments.

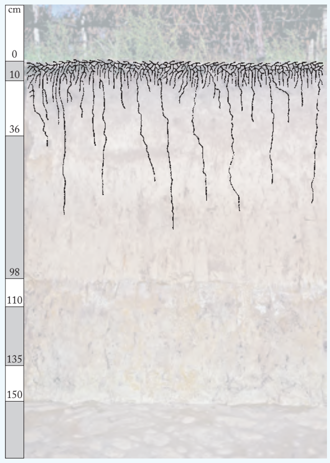
Photograph: James Hall.

Soil Group N—soil N3

The *wet soils* make up 0.5% or 76 100 ha of Southern South Australia. The vast majority are located in the Mid to Lower South East; however, they also occur on Fleurieu Peninsula, the Murray River valley floodplains, the margins of Lakes Alexandrina and Albert, as well as Kangaroo Island. They are situated in low-lying and poorly to very poorly drained areas, mostly in high rainfall parts of the state. The distinctive native vegetation associated with *wet soils* includes sedges (especially *Carex* species), rushes (especially *Juncus* species), common reed (*Phragmites australis*), bulrushes (*Typha* species) and 'tea-trees' (*Leptospermum* species). N3 soils are associated most commonly with soils G3 (*thick sand over clay*), N1 (*peat*) and B5 (*shallow dark clay loam on limestone*), to a significant extent with soil M2 (*deep friable gradational clay loam*), and to a lesser extent with soils B3–2, I2, G4, B7, H3, N2 and F2 as well as waterbodies.

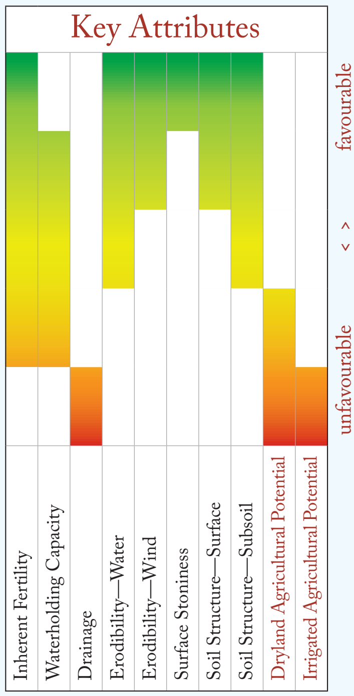
These soils are affected by prolonged wetness, but are not peaty or highly to extremely saline. The variation within soil profiles is great. They range from deep clays to sand-over-clays to deep sands. However, many are deep clays that have formed in low-energy depositional environments. The degree of wetness is variable, but profiles are saturated for at least several months in most years. Organic matter content is typically high, at least in the surface soil. Bleached subsurface layers are common in texture-contrast and deep sandy types. Soil profiles usually exhibit signs of prolonged wetness in the form of mottled colour patterns, gley colours (grey, greenish or blueish grey, or green), iron-stained root channels, manganese segregations, and soft iron-rich pans. Organic coatings or stains on the faces of structural units are also indicative of extended wet conditions. In the South East, many clayey types are calcareous throughout (owing to the influence of carbonate-rich groundwater). In swampy areas, and on flats and slopes, the formation of swamp hummocks or small mounds, usually around 10 cm high, is indicative of significant and prolonged wetness.

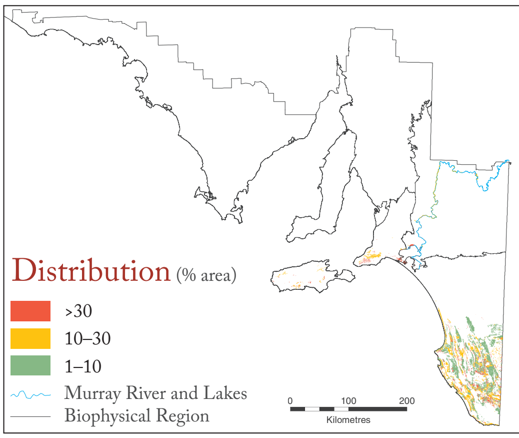
In the South East, *wet soils* usually have clayey subsoils or substrates (white lime-rich marls or 'pipe clays' and gley-colour clays are common). In the Mount Lofty Ranges and on Kangaroo Island, *wet soils* are mostly situated on lower slopes, valley floors and in drainage depressions, and have formed on a range of sediments (from sands to clays) and, therefore, have highly variable profiles. However, in low-lying areas on Kangaroo Island plateau surfaces, *wet soils* have formed in clayey sediments and have clayey subsoils. Unless drained, the productive use of N3 soils is very limited owing to wetness, shallow watertables, moderate levels of salinity (in some areas), and flooding. Agricultural use is generally limited to providing summer grazing for livestock, which provides valuable green feed during the dry season. Areas dominated by *wet soils* often provide habitat areas, and are important sanctuaries, for native plants and animals.



Likely growth of cereal plant roots within the representative soil profile

Clay content and pH levels within the representative soil profile





Statistics

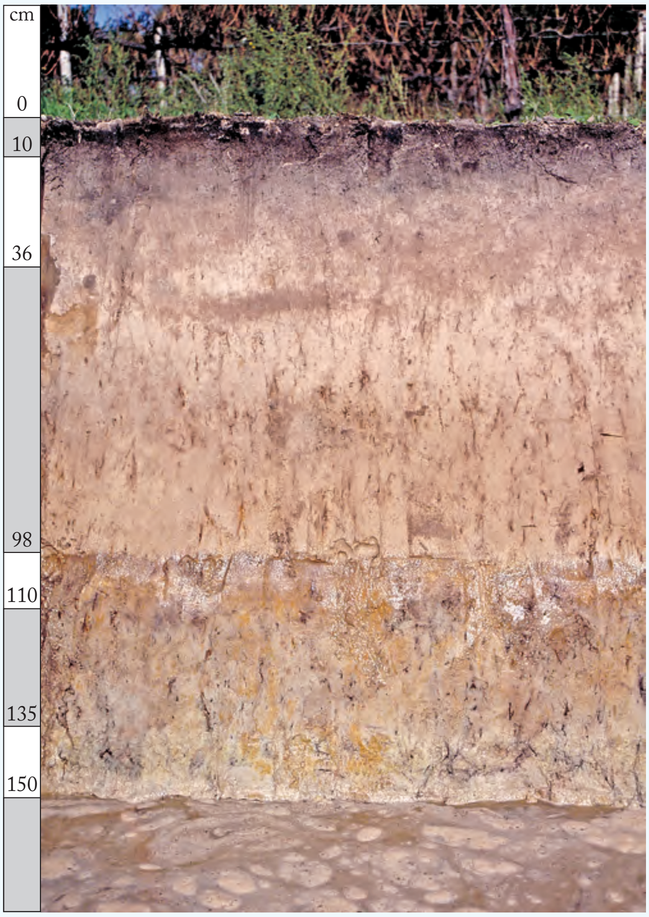
Area of interest	*Hectares*	*% area*
Southern SA	76 100	0.5
Biophysical Regions		
Central	2 990	0.5
Kangaroo Island	1 760	0.4
Northern	0	0.0
South East	64 690	2.1
Murray Mallee	6 700	0.2
Yorke Peninsula	0	0.0
Eyre Peninsula	0	0.0

Representative Soil Profile

Depth (cm)	*Description*
0–10	Black, soft, loamy sand with single grain structure.
10–36	Greyish brown sand with single grain structure.
36–98	Light grey, bleached sand with strong brown iron staining and single grain structure. (Seasonal perched water is visible seeping from the base of this layer).
98–135	Clayey sand with weak prismatic structure. 98–110 cm: light brownish grey with reddish yellow and brownish yellow iron staining. 110–135 cm: light brownish grey with reddish yellow iron staining.
135–150	Light olive-grey and greenish grey, sandy clay loam with angular blocky structure.
150+	Watertable.
Note:	From 98 to 150 cm was saturated at the time of sampling (May 1995). Grey soil colours and sporadic dark organic staining indicate wetness. This soil has formed in Tertiary-age, sand-rich sediments (see Appendix 4 Section II 7d).

Australian Soil Classification

Bleached, Sodosolic, Redoxic Hydrosol;
thick, non-gravelly, sandy / clay loamy, very deep.



Photograph: David Maschmedt. Northeast of McLaren Vale, Southern Vales wine district, Willunga Basin (part of the Central Biophysical Region). The soil is situated on a lower slope (1%), on the margins of a drainage depression, among undulating rises.

Soil characterisation site CH079.

A high-elevation, swampy drainage depression with N3 soils and distinctive water-loving vegetation (sedges and rushes), near Parawa on southern Fleurieu Peninsula. The adjacent slopes are dominated by K4 soils. The small dam at the top of the swamp is within 50 m of a narrow remnant plateau surface dominated by J2 soils. High rainfall, seepage and runoff from surrounding soils, together with shallow groundwater, cause these depression soils to be wet throughout the year.

Photograph: David Maschmedt.