Soils of the Angas Bremer District

South Australia

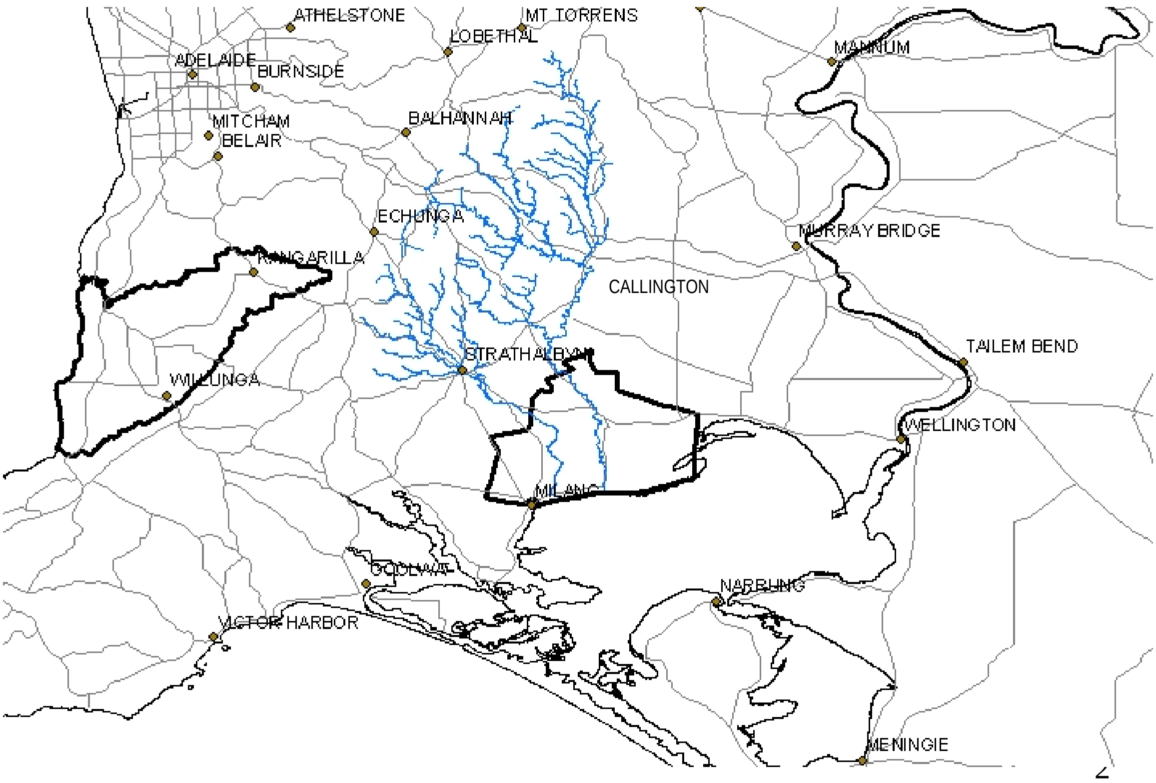
June 2007

Angas Bremer
Water Management Committee Inc

Government of South Australia
Department of Water, Land and Biodiversity Conservation

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

Bremer and Angas rivers



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Maps by Penny Baldock, Jo-Anne Cronk & Adam Caldwell
Spatial Information Services, PIRSA 08 8463 3296
Soil Management sections
edited from information provided by John Rasic,
J.R.'s Soil Management Services 08 8377 2988
Concept and editing: Tony Thomson,
Resource Management, DWLBC 08 8463 6855

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Produced By: Soil and Land Program
Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
David Maschmedt 08 8463 6682
maschmedt.david@saugov.sa.gov.au

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CONTENTS

HOW TO USE THIS BOOK

Reading the workshop-manual for a car is not sufficient to enable you to repair the car but it can improve your communication with your mechanic. This Soils Book is designed to help you to choose a knowledgeable and experienced soil specialist and then to communicate meaningfully with that professional.

This book does not include every soil. The depth of each layer showing in the photo of the soil pit may not be typical of your paddock and the results in the table of Laboratory data is accurate only for the samples that were taken from the soil pit that is shown in the photo. The actions needed to manage most soils are more complex than each summary that is provided in this book. Inappropriate management actions can cause significant soil problems.

Your soil specialist will integrate information from many soil-pits to specify a soil management strategy that is appropriate for your specific paddock, crop, vineyard or orchard.

This book is designed to help you to interpret what you are seeing in a soil profile that is exposed when you dig a soil pit. While you stand in your pit and look at the soil, open this book to page 21. Compare your soil profile with each of the 25 soil photos and record the soil-number of each photo that looks similar to your profile. Turn to the data sheet for each of the recorded soil numbers and decide which data-sheet most closely describes your soil. Use the tables of Laboratory data to guide your decisions about which chemical analyses are worth doing for your soil-profile. Note that the lower the soil-number, the smaller the investment likely to be needed into pre-planting activities. With any of the soils numbered from 18 to 25, over a long period (decades), the profit from growing irrigated winegrapes is likely to be small or negative for the reasons that are outlined in the Management sections of the data-sheets.

Because soils are extremely complex, the management recommendations that are provided by different soil specialists will vary. For Soil 12, on pages 70 and 71, note the similarities and note the differences in the two management sections.

THE SOILS OF THE ANGAS BREMER DISTRICT

Additional data about Australian soils is available from the website
http://www.asris.csiro.au/index_ie.html

Information about the Angas Bremer district is available from
www.angasbremerwater.org.au

This Angas Bremer Soils book is available in electronic form on the Angas Bremer Map Layers computer compact disc and from the website www.angasbremerwater.org.au

The soils of the Angas Bremer district have been assessed as part of a state-wide mapping program that was conducted during the 1990s. This document provides an overview of the properties and of the distribution patterns of the main soils of the district. The emphasis is on the capacity of the soil to grow irrigated crops. This document is divided into three sections:

- Section 1 describes some soil properties that can cause a reduction in the growth of irrigated crops. These include:

- waterlogging (saturation) for more than 24 hours at one time
- a salt concentration that causes the Electrical Conductivity of the saturated soil water extract (ECe) to exceed 2 deci Siemens per metre (1,200 milligrams per Litre)
- a water table that is within 2 metres of the surface
- a soil layer that restricts drainage
- a low capacity to hold water and / or a low capacity to hold nutrients
- hard soil that cannot be penetrated by the roots
- soil that contains chemicals (e.g. boron) that restrict root growth
- slaking and capping

Some general suggestions for the management of soils are also provided in Section 1. These include

- establishment of cover crops
- chemical analyses of plant and soil samples
- ripping to simplify putting in the trellis posts and planting, and to break up hard layers
- continuous monitoring of soil moisture

❖ Section 2 provides a map showing the soil zones. Soil zones are distinctly different pieces of country, each with a number of characteristic soils. Thirteen soil zones are mapped for the Angas Bremer district. In each zone, each of the “main” soils occupies more than 10% of the area of the zone and each of the “minor” soils covers less than 10% of the zone.

❖ Section 3 provides a data-sheet for each of 25 soils that are typical of the Angas Bremer district. Each 4-page data-sheet includes a photograph of the soil profile, a description of each layer down to 1.5 metres or to rock and laboratory chemical analyses for each of these layers. Interpretations of the soil chemistry, suggested pre-planting activities to address the soil limitations, and suggestions for soil management after planting are provided. A thumbnail map for each soil shows the locations at which that soil occurs within the Angas Bremer district.

Soil number 1 requires the smallest investment in pre-planting activities that are needed to address the limitations for growing permanent horticulture crops like wine-grapes. Soil number 25 requires the largest investment.

In each soil profile photograph, a measuring tape shows the depth to each soil layer. The numbers on the tape are in 10 cm intervals with the red section measuring one metre.

Section 1
SOIL PROPERTIES THAT CAN CAUSE A REDUCTION IN THE GROWTH OF IRRIGATED CROPS

Large areas of the Angas Bremer district are well suited to irrigation. It is important to recognize any soil limitations so that appropriate pre-planting activities can be undertaken to address them or so that development can be avoided altogether. Soil limitations can be divided into two categories:

- water related
  Successful long-term production is unlikely where there is excess water in or below the root zone. Salinity is commonly, but not always, associated with wetness.

- chemical related
  Plant growth and / or crop quality is reduced by toxic levels of particular substances or by deficiencies of essential plant nutrients.

Soil assessments can be made visually, by inspecting the soil profile and recognising its features. Where chemical limitations are suspected, laboratory analyses are required. Observations and sampling are best done from faces excavated to a depth of at least one metre, and preferably down to two metres. This depth is needed because the soil below the root zone affects deep drainage and the leaching of salts, and this has a major impact on the long term production from an irrigation enterprise. For example, an investigation down to only 50 or 60 cm of the soil profile shown in the following photo would indicate a favourable soil. However, at 95 cm there is a heavy clay layer that will impede drainage and cause salt to accumulate within the root zone.

Tight clay from 95 cm is a hazard for irrigation, even though the soil above is favourable.

Recording the description of a soil profile involves: Inspect each layer of soil. If layering is not obvious, describe each 10 cm interval down to 30 cm, each 20 cm interval to one metre, and each 50 cm interval to two metres. For each layer describe:

- Texture (clay content) – the water-holding and the nutrient-retention capacities of soil are determined by clay content
- Strength – roots cannot penetrate hard soil
- Porosity – water and air move easily through porous soil.
- Colour – mottled or dull colours indicate waterlogging
- Carbonates – the presence of fine carbonates is often associated with undesirable chemicals that will limit the depth of the rootzone.
- pH –the availability of nutrients is changed by the acidity or the alkalinity of the soil

Details about how to assess each of these factors are available on the Angas Bremer Map Layers computer compact disc and from the website www.angasbremerwater.org.au or in

Grape Production Series Number 2
Soil, Irrigation and Nutrition – Section 1 Knowing your Soil
ed. P.R.Nicholas (2004)

1.1 Waterlogging

Most irrigated crops grow best in soils that are well drained. Where stagnant water occurs, roots are weakened. Weak roots can be attacked by root-rotting organisms and this causes a loss of plant vigour and eventual plant death. When a soil is waterlogged, the wheels of machinery and the use of soil implements can cause compaction which restricts water movement and root growth. Waterlogging also causes the loss of soil nitrogen. Waterlogging for more than two days can affect the health of sensitive plants, especially during growth flushes. Waterlogging can occur at the soil surface or below the surface.

1.1.1 Surface waterlogging

Surface waterlogging is caused either by a low infiltration rate at the surface or by the presence, at less than 20 cm deep, of a layer that restricts water movement. Sealed surfaces are often caused by poor soil management. Applications of gypsum and of organic matter can improve a sealed surface. At shallow depths, a layer that restricts water movement can be made more permeable (open) by incorporating gypsum. The effects of surface waterlogging can be reduced by mounding at establishment.

Sealed surface soil restricts infiltration

1.1.2 Subsurface waterlogging

Bleached subsurface with rusty markings overlying a slowly permeable mottled clay subsoil.

This mostly occurs in soils on low-lying or flat country, where the surface soil is more than 20 cm thick and it overlies a subsoil (usually clay) that restricts water movement. Even on sloping ground, lateral movement of water along the top of the subsoil is often insufficient to prevent waterlogging. Sandy soils with mottled and / or dispersive clay subsoils are the most severely affected because their surfaces are highly permeable while their subsoils are only very slowly permeable.

Subsurface waterlogging can cause pollution of watercourses due to the lateral movement of water that is carrying chemical residues (e.g. nutrients, pesticides).

Measures to avoid subsurface waterlogging include (1) mounding at establishment, (2) deep ripping of the clay subsoil to a depth of at least 80 cm together with deep placement of gypsum and (3) artificial drainage. These measures are expensive, but they can help water to penetrate into the subsoil.

1.2 Salinity

Even when the soil is kept quite moist, osmosis causes plants in saline soils to become water-stressed or die because they cannot extract the water. Also, the toxic effects of sodium and / or chloride increase with increasing concentrations.

In their natural state, many South Australian soils contain moderate to high levels of salt because rainfall is often insufficient to leach the salt out of the profile. If deep drainage is adequate, and if sufficient irrigation water is available, these salts can be managed by using the irrigation water to leach salts out of the soil.

Any rising saline groundwater can cause soil to become saline. When the water table rises to within 2 metres of the surface, saline water 'wicks' into the root zone causing damage or killing vegetation, as shown by the dead vines in the illustration.

Dead or dying vines caused by a rising, saline water-table

In some situations local sub-surface drains may help to control this type of salinity but whole of catchment management can provide a more effective solution. Whole of catchment management involves increasing water use by existing vegetation or by planting additional perennial plants. Revegetation is a medium to long term solution. In the short term, the irrigation of land that is at risk due to salinity caused by a water table should be avoided.

Sometimes salinity may be caused by irrigation practices. This usually happens where drainage is inadequate, causing a perched water table to develop and salt to accumulate. Poor drainage may be caused by a layer that restricts water movement, like a poorly structured clay subsoil. Sub-surface drains may control this problem but, in low-lying locations, there may be nowhere low enough to accept the drainage water. High irrigation efficiency is essential to minimise the volume of drainage. Where the amount of irrigation water available is limited, there is a low risk of this type of salinity.

Standards for assessing soil salinity (from Ayres 1977)

Crop	Expected yield reduction % at the ECe value tabled in dS/m (ppm in brackets)			
	0%	10%	25%	50%
Grape vine	1.5 (900)	2.5 (1500)	4.1 (2460)	6.7 (4020)
Olive	1.8 (1080)	2.6 (1560)	3.7 (2220)	5.6 (3360)
Lucerne	2.0 (1200)	3.4 (2040)	5.4 (3240)	8.8 (5280)
Potato	1.7 (1020)	2.5 (1500)	3.8 (2280)	5.9 (3540)

1.3 Shallow water table

Water table at 120 cm. This water can 'wick' to the top of the clay subsoil (35 cm)

Water tables develop where the vertical and / or the horizontal flow of water in the soil or in the underlying materials is restricted. A low salinity water table at about two metres depth can be a benefit for crops like lucerne because it provides a source of moisture in the lower root zone. However, this may be a problem for grape-vines because the uncontrolled availability of water may cause excessive plant vigour. Shallower water tables indicate restricted deep drainage and they limit the depth of the root-zone. Water tables will rise closer to the surface if excessive volumes of irrigation water are applied.

Development of horticulture above a saline water table should be avoided. Water (with salt) can 'wick' one to two metres upwards, so any water table within two metres will affect the root zone of perennial crops. Water tables that are saline are commonly rising. All land where the depth to saline water is less than two metres is at risk.

1.4 Restricted deep drainage

Any layer which restricts the free downward movement of water away from the root zone is likely to cause problems.

Common restrictive layers include:

- poorly structured clay (as illustrated) with block-like aggregates bigger than 20 mm
- clay with exchangeable sodium percentage (ESP) of more than 6%
- unfractured rock or hardpan
- water table

Restrictive clay from 60 cm makes this soil unsuitable for irrigation

Where water accumulates, so does salt, either out of the soil itself or out of the applied water. As the salt builds up, the volume of non-saline, effective root-zone is reduced, and the salt begins to affect root health.

As a general rule, any layer that restricts the movement of water must be deeper than 75 cm and preferably deeper than 150 cm. The cost to modify these layers is high and the installation of a drainage system is often the only practical management option. However, the high cost of installing closely spaced drains and the high costs to maintain drains limit the number of situations where it is economic to install them.

1.5 Chemical barriers to root growth

Root growth is restricted in the many South Australian soils that contain excessive levels of one or more undesirable chemicals in the subsoil. This occurs where there is insufficient water passing through the soil to flush out the undesirable materials because the rainfall is less than 400 mm per year. The main chemical barriers are:

Alkalinity	a high concentration of sodium carbonate and of sodium bicarbonate can raise the soil pH into the strongly alkaline range.
Sodium	high values for Exchangeable Sodium Percentage (ESP) can indicate levels of sodium that are toxic for plant growth.
Boron	comes from the ocean and is commonly found in highly calcareous (high calcium carbonate) subsoils.
Chloride	toxic levels of chloride are likely where there are high levels of salt and of sodium.

In general, the adverse conditions caused by these chemicals are not easily altered. Apart from those situations where suitable rootstocks may help, avoiding planting in these conditions is the best option.

In higher rainfall districts, acidity and associated aluminium toxicity are the main chemical barriers to root growth. Acidity is easily managed by using applications of lime.

<u>Standards for assessing the potential for chemical restrictions</u> (using grape vines as an example). From Neja et al (1974) and Neja et al (1978).

Type of barrier	No problem	Increasing problem	Severe problem
Alkalinity (pH in water) *	Less than 8.5	8.5 – 9.2	More than 9.2
Acidity (pH in $CaCl_2$) *	More than 5.0	4.2 – 5.0	Less than 4.2
Sodium toxicity (ESP)	Less than 13	13 – 25	More than 25
Boron (mg/kg)	Less than 1	1 – 3	More than 3
Chloride (mg/kg)	Less than 350	350 – 1060	More than 1060

* Experience has shown that interpretations of pH at the acidic (low) end of the pH scale are best done using the calcium chloride ($CaCl_2$) extraction, while the water extraction is best at the alkaline (high) end. The results for both methods are provided in the soil data sheets.

1.6 Low soil fertility

Soil fertility is assessed by using laboratory analyses. The natural fertility of the soil is determined by its clay content, by its organic matter content, by rainfall and by the presence of the particular soil components which limit the availability of nutrients.

- In general, the higher the clay content, the greater is the capacity of the soil to store and supply nutrients to plant roots. The type of clay affects nutrient storage capacity. Organic matter also holds nutrients and releases them to plants.
- High rainfall leaches nutrient elements out of the soil. This leaching process is often accompanied by soil acidification.
- Soil carbonates can tie up phosphorus and some trace elements, particularly manganese, zinc and iron. The presence of ironstone in the soil also has a significant impact on phosphorus availability.

Soil pH has a major impact on nutrient availability. It is impractical to correct alkalinity (pH > 7) but acidity (pH < 7) is easily corrected by using lime or dolomite. The correction of soil acidity is essential before starting a fertilizer program. Lime dust caused by passing vehicles can cause surface pH levels to be 1 to 2 units higher near roads that are topped with lime-rubble.

Guidelines for the interpretation of chemical analyses for soil fertility are provided in the following table:

Desirable levels of nutrient elements in soils for intensive cropping
(from South Australian Soil and Plant Analysis Service 1996)

Nutrient	Measured as	Method	Desirable level
Phosphorus	Extractable (Ext) P	Colwell - bicarbonate extraction	80 mg/kg
Potassium	Extractable (Ext) K		200 mg/kg
Sulphur	Sulphate (SO_4)	KCl-40 extraction	10 mg/kg
Exchangeable calcium	Exch cations Ca	Proportion of total exchangeable cations	65 - 75%
Exchangeable magnesium	Exch cations Mg		10 - 15%
Exchangeable potassium	Exch cations K		3 - 8%
Exchangeable sodium	Exch cations Na		Less than 4%
Copper	Extractable Cu	EDTA extraction	4 mg/kg
Zinc	Extractable Zn		4 mg/kg
Manganese	Extractable Mn		? 30 mg/kg
Boron	Extractable B	Hot 0.01M $CaCl_2$ extraction	0.5 mg/kg

The desirable levels vary with crop type and with crop productivity targets. The figures in the table are at the high end of the scale because they relate to intensive cropping. The levels of some nutrients (e.g. trace elements) are best measured by using leaf analyses.

1.7 Slaking and Capping

When sand is saturated, it is unstable and it can collapse (slake), become a slurry and flow down through the profile. In layers where the soil pores become smaller, the slurry can block the smaller pores and accumulate. When the slurry dries above a change in texture, it can become a sandy, hard, impenetrable cap (capping). In the left photo a cap is visible at 90cm on top of the ledge that supports the paint-brush.

The slurry can accumulate and flow on top of the cap and down a hill-slope. In the right photo the slurry is visible at 30cm as it flows into and down the wall of the soil pit.

Before development, some soils show little evidence of the waterlogging that can develop into a serious problem if they are irrigated.

1.8 Low effective soil depth

In ideal conditions, the root systems of perennial plants like grape vines can extend downwards for several metres. Where soil properties are not limiting, the availability of water controls the depth of the root system. Most soil water comes from rainfall and irrigation is used to supplement rainfall during the dry summer months. Where it is available, shallow groundwater can provide additional water, provided that it is not saline.

Many soils have a restrictive layer that prevents roots from accessing the deeper subsoil moisture. A restrictive layer limits the depth of the root-zone, even if moisture is available at greater depths. These barriers can be (1) chemical (2) physical, caused by rock or hardpan, or (3) a water table.

In the Angas–Bremer district, all three types of barrier occur. Chemical barriers caused by high alkalinity, by sodicity, by salinity and by boron toxicity are more common on the older “mallee” landscapes than on the plains beside the rivers and the lake. Where the soil surface is lower than the 10 m contour, these barriers are increasingly likely.

Restrictive clay subsoil at 15cm

Restrictive calcrete layer at shallow depth (20cm)

Physical barriers are generally caused by poorly structured, “tight” clay subsoils. These occur at irregular intervals across the district, both on the older “mallee” country, and on the plains. Ripping and applying gypsum can reduce the problem, but root growth is always reduced. Calcrete (a type of sheet limestone) occurs mainly in the mallee country and it forms a physical barrier. Calcrete can severely restrict soil water holding capacity. Calcrete can be broken up using a ripper.

The likely depth of root penetration can be estimated from an examination of the layers of soil exposed on the sides of a soil pit.

1.9 Low soil water holding capacity

Estimates of the water holding capacity of the soil are needed to design and to operate an irrigation system. Good irrigation achieves a balance between applying sufficient water to meet the needs of the crop and minimizing the amount of water that percolates to deep drainage or accumulates as a shallow water table. The amount of water that can be held within the depth of soil that is the root-zone is determined by (1) the depth of the root zone (2) the clay content and (3) the structure of the soil.

The Total Available Water holding capacity of a soil is defined as the amount of water held between Field Capacity and Wilting Point.

A soil is at Field Capacity when it has drained for about 24 hours after having been saturated. At Field Capacity the soil water pressure is about minus 10 kilopascals. The minus indicates suction which is a negative pressure.

At Wilting Point plants die because they cannot extract any more water from the soil. At Wilting Point the soil water pressure is about minus 1,500kPa.

As the soil dries, plants need to use increasing amounts of energy in order to extract water. To achieve good crop-yield-quantity and yield-quality, irrigation water is applied well before wilting point is reached. The pressure at the Refill-Point is chosen by the irrigator. The chosen value is typically between minus 40 and minus 200kPa. The amount of water held in the soil between minus 10kPa (field capacity) and a refill point of about minus 60kPa is called the Readily Available Water (RAW).

The amount of water that can be stored in the root-zone between Field Capacity and the Refill Point determines how the irrigation system should be managed (i.e. how much irrigation water to apply and when to apply it).

If a drier refill point is chosen (e.g. minus 200kPa), more water is needed at each irrigation and this increases the time interval between irrigation applications.

As a rule of thumb for most irrigated soils, a RAW value of 60mm of water per metre of soil depth can be used as a starting value. The millimetres of irrigation water needed to wet the soil down to any desired soil depth are estimated by multiplying the root depth, in metres, by 60mm/m. After applying this calculated number of millimetres, waiting for 24 hours and then measuring the depth of soil that was wetted, the calculated number of millimetres of irrigation is increased or decreased. If the measured depth of soil that was wetted was too shallow, more water is needed at each irrigation. If the wetted soil depth was too deep, then less than the calculated number of millimetres are needed at each irrigation.

2. SOIL MANAGEMENT: PRE-PLANTING ACTIONS THAT CAN BE USED TO TACKLE PROBLEMS

2.1 Cover crops

A cover crop can be planted to hold the soil particles together and to increase the soil organic matter. If it is grown for many years, a deep-rooted cover crop can increase the depth of soil that is used by the roots of the crop

To enable a cover crop to become established, minimise vehicle traffic and exclude grazing animals and when the cover crop is growing vigorously, avoid the temptation to admit grazing animals. Apply fertiliser for quicker and better growth of the cover crop.

Organic matter helps to reduce compaction because it helps to restore soil porosity, enabling the soil to ‘spring back’ to a more favourable condition. The term ‘rebound effect’ is used to describe this “spring-back”. By holding the soil particles together, the organic matter can also reduce slaking and capping.

Information about appropriate cover crop plants is available from Rural Solutions SA.

2.2 Ripping

For easier installation of trellis posts, easier planting of grape vines, and breaking up hard pans, the soil can be ripped and the surface cultivated.

The photo on the left shows large lumps of surface soil and deep, open channels that have been created by inappropriate ripping.

The horizontal white line in the photo on the right shows that if a tube extending down into the rip-line is used to apply fertilizers, gypsum or other chemicals as dry pellets or powders, they can stay in a line exactly where they were placed and remain un-used even after many years. Consider applying the chemicals in liquid form so that they spread through a larger volume of soil.

Information about the supply of chemicals in liquid form is available from rural suppliers.

2.3 Mounding

To increase the depth and volume of soil that can be explored by the roots of the crop, some soil can be moved from the mid-row and mounded along the plant-row. Care must be taken to ensure that the soil left in the mid-row is still capable of growing cover crops and other plants. In the mid-row, exposed soils with hard compacted surfaces are susceptible to water erosion on slopes, and to water ponding on flats. Exposed sandy soils are liable to blow, causing sand blasting and the possible formation of drift banks.

2.4 Irrigation system design and management

The design of an irrigation system includes the selection of each of the dripper flow-rate, the dripper spacing, the diameter of dripper-tube and the diameters of the pipes.

Irrigation operation decisions include the selection of each date on which to irrigate and of the hours for which to run the irrigation system. Only continuous recording of soil moisture provides the accurate data that is needed to make these decisions and to learn from them.

Design the irrigation system to wet the maximum area of the soil between two emitters by choosing the emitter spacing to be 60% of the diameter of soil that is wetted by one emitter. This will help to maximise the amount of plant-available water that is stored in the soil by maximising the root-filled soil volume (area and depth) that is wetted.

Operate the irrigation system to wet the soil down to the bottom of the potential root depth by applying exactly the right amount of water at each irrigation. Applying too much irrigation water will waste water and leach nutrients to drainage. Applying too little irrigation water will reduce the volume of water that is stored, reduce the depth of roots and increase the risk of plant-water-stress.

To increase berry flavour, grape vines are often deliberately water-stressed at selected growth stages. Regulated Deficit Irrigation (RDI) waters a smaller volume of soil (perhaps 0.2 cubic metres of soil per vine) and allows the soil to become drier (a soil moisture suction of perhaps 200kPa) before the next irrigation.

Choose the emitter flow rate (litres/hour) to match the rate that the soil can absorb the water (the soil infiltration rate). At each dripper, even the lowest application rate will exceed the soil infiltration rate because all of the water output from a dripper is applied onto a point – the water is not spread over an area.

For any chosen pump flow-rate, the smaller the flow-rate from each emitter the more emitters, and hence more hectares, can be watered at the same time. A smaller emitter flow-rate reduces the required diameters (and hence the capital costs) of dripper-tubes and pipes. However, a smaller emitter flow-rate makes blockages more likely because the cross-section of the flow-path inside each emitter is smaller.

2.5 Fertiliser application through the irrigation system (fertigation)

When designing and installing the irrigation system, include equipment that can be used to mix and distribute fertiliser with the irrigation water so that the chemical fertility of the soil can be managed by using frequent, precise applications of liquid fertilisers.

3. SOIL MANAGEMENT AFTER PLANTING

3.1 Chemical analyses of leaf samples and of soil samples

To manage yield-quality and yield-quantity, at the start and at the end of the growing season collect and send samples of leaves or petioles to a laboratory for chemical analyses.

Use the laboratory data to decide:

- dates and amounts for applications of fertilizers and agricultural chemicals like gypsum and dolomite
- whether and when additional irrigation water is needed for leaching to remove any accumulating salts, boron or other toxins.

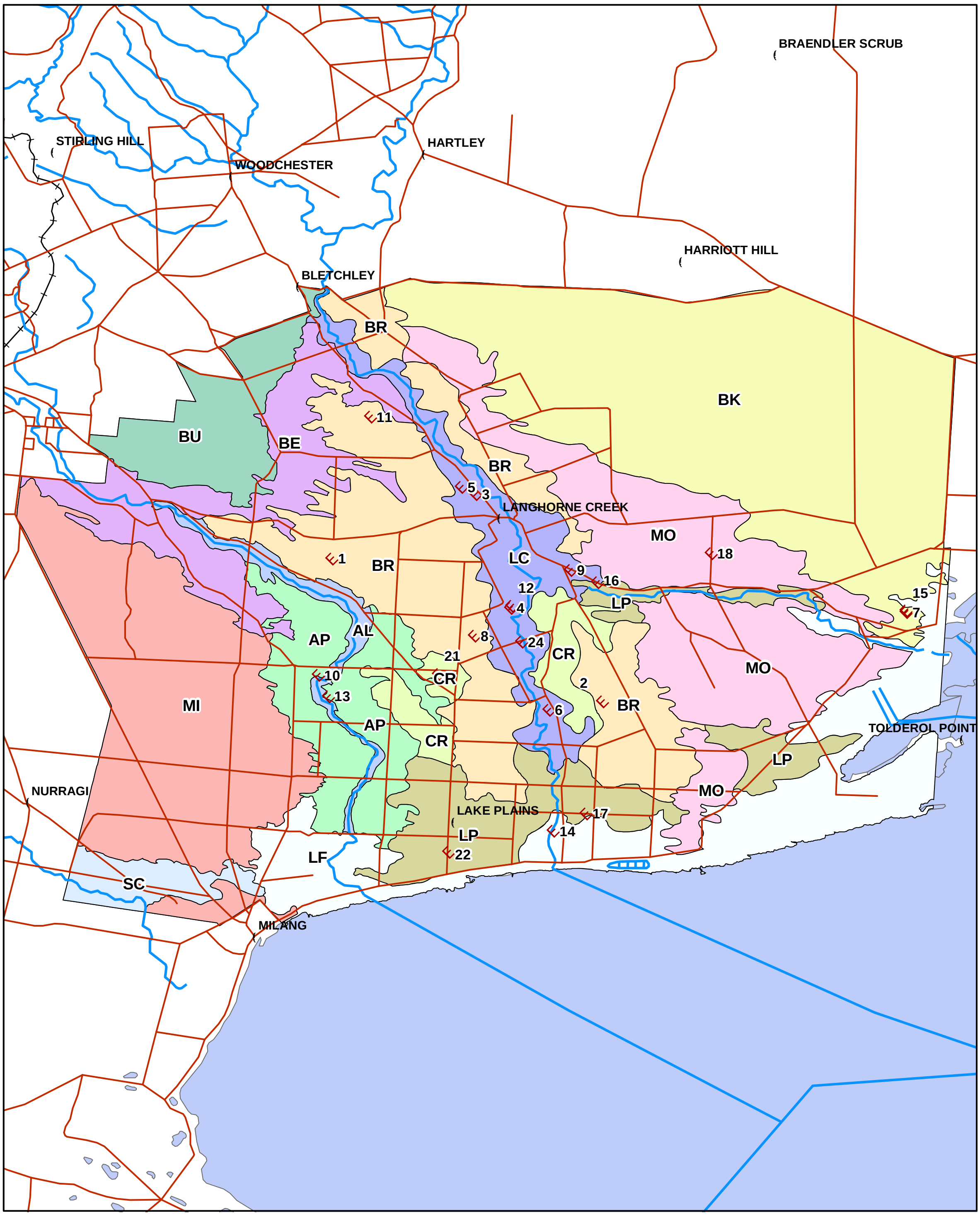
Section 2
SOIL ZONE MAP

Geology (the rocks and sediments), topography (the variations in height of the land surface) and climate together all influence soil formation. A soil zone is an area of land which all formed on similar geological material, and which has common topographic features. The same set of soils occurs throughout a soil zone.

It is rare to find a large area of land with only one soil type – most blocks contain two or more soil types. Several soils are present within any soil zone. Some soil types are common in some zones, and less common or absent in other zones. The map on the following page shows areas where particular soil types are widespread. "Main soils" are those that occupy more than 10% of the area of the zone while "minor soils" are locally-significant but they cover less than 10% of the zone.

SOIL ZONES of the ANGAS BREMER DISTRICT

based on Soil and Land Information (2004) Land Systems



Soil Zones

5 0 5

Kilometres

Soil Pit Locations*

Soil Zone Boundary

Government of South Australia
Department of Water, Land and Biodiversity Conservation

Government of South Australia
Primary Industries and Resources SA

Soil data from Soil and
Land Information, DWLBC.
Processing and map production
by Spatial Information Services, PIRSA.

* Four additional soils, typical of those not commonly used for irrigation, are described in the following Soil Data Sheets. Pit sites for these soils are outside the mapped area.

Soil Zone Legend

Soil Zone		Description	Main soils *	Minor soils
Angas Levees	AL	Angas River channel and adjacent levees with deep coarse to medium textured soils	3, 5	-
Angas Plains	AP	Old alluvial plains flanking Angas River with sandy loam over clay and deep sandy loam soils	10, 8, 5, 6	24, 21, 14, 13, 11, 2, 1
Belvidere	BE	Old alluvial plains with deep loamy sand and sandy loam over clay soils	5, 8, 3	10, 4
Bremer	BR	Old alluvial plains with soils as for Belvidere Zone and extensive low sandy rises	1, 5, 3	13, 11, 8, 4, 2
Brinkley	BK	Undulating dune-swale land with sandy and calcareous (mallee) soils	15, 20, 19	23, 18, 7, deep sand, 23 (sandy loam)
Burnlea	BU	Undulating rises with sandy and sandy loam over clay soils	7, 19, 23	18, 15, 20
Chapel Road	CR	Old alluvial plains similar to Bremer Zone, but with slightly impeded drainage	1, 12, 13, 17, 21, 7	9, 3, 2
Lake Fringe	LF	Low lying often swampy flats with variable soils prone to waterlogging and salinity	22, 25, 14	-
Lake Plains	LP	Plains mostly below the 10 m contour with loamy sand to clay loam over clay soils	22, 1, 12, 14	25, 21, 16, 13, 10, 9, 8, 5, 3, 2
Langhorne Creek	LC	Current flood plain of Bremer River above the 10 m contour with variable deep alluvial soils	3, 6, 5, 8	24, 16, 12, 9, 4
Milang	MI	Gently undulating dune-swale land with sandy and calcareous (mallee) soils and clay flats	23, 7, 20	15, 12, 19, deep sand, 23 (sandy loam)
Mosquito	MO	Gently undulating plains and low sandhills with sandy and loamy mallee soils	18, 20, 7	23, deep sand
Sandergrove Creek	SC	Ancient Angas River plain with sand to sandy loam over clay soils	12, 17, 23, 19	20, 7

* Approximate order of dominance

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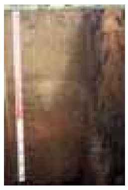
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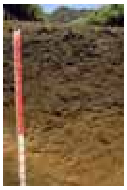
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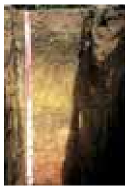
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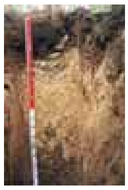
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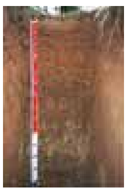
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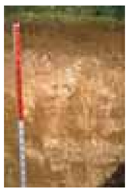
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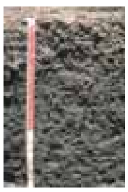
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Section 3

SOIL DATA SHEETS

This section contains a four-page data sheet for each of the 25 soils displayed in the 'Index of Soils' on the previous page.

Each data sheet includes the following:

- a thumbnail map showing where the soil is "common" (more than 10% of the area), or "minor" (1-10% of the area).
- a brief description of the landscape and the soil profile.
- a photograph of the soil profile and a detailed description of the profile.
- a summary of actions for the management of the soil.
- a description of the physical and chemical properties of the soil.
- a table of selected laboratory data for each layer down the profile to at least 150 cm. The analytical results that are reported in the table include:
  - pH measured in water (H_2O) and in calcium chloride ($CaCl_2$)
  - Carbonate (CO_3) percentage
  - Electrical conductivity of the saturation extract (ECe) - a measure of soil salinity
  - Chloride (Cl)
  - Sulphur (S)
  - Boron (B)
  - Phosphorus (P) and potassium (K)
  - Organic carbon (org C)
  - Exchangeable cations

    Cations are positively charged particlesthat attach to negatively charged sites on the surfaces of clay particles. These cations can exchange places with one another. The dominant cations in neutral to alkaline soils are calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). The total number of negatively charged sites is measured as the cation exchange capacity (CEC). Unless the soil is acidic, the CEC can be estimated from the sum of the exchangeable cations (in acidic soils, aluminium and hydrogen cations also occur). Where the CEC has been measured in the laboratory, the values are included in the tables. Where CEC has not been measured, the sum of the cations is used as an approximation.

    The data provide an indication of the availability of Ca, Mg and K as essential plant nutrients, but the main purpose of measurement is to assess soil physical condition. The higher the proportion of calcium relative to the other cations, the more stable is the soil structure. Increasing proportions of sodium, and to a lesser extent, of magnesium, lead to deterioration in soil condition, mainly due to increased clay dispersion.

    An indication of structural stability is provided by the exchangeable sodium percentage (ESP). ESP is calculated by dividing the exchangeable sodium value by the CEC (or CEC as estimated by the sum of the cations). At low

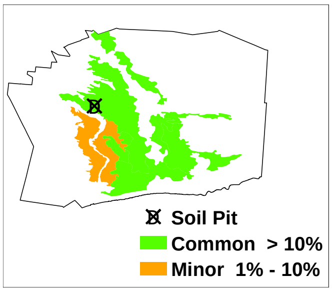
CEC levels, ESP is meaningless, and is reported as not applicable (‘na’) in the table.

The top row in the table of laboratory data includes indicative ‘Target’ values.

- An electrical conductivity of more than 2.0 dS/m (ECe) indicates the level of soil salinity at which yield decline can be expected, but more importantly, it can indicate that the soil is susceptible to salt accumulation.
- Chloride levels of more than 350 mg/kg also indicate a higher than desirable salt concentration.
- Boron concentrations of more than 1 mg/kg may affect vine performance and values exceeding 3 mg/kg are considered to be excessive for grape vines.
- Exchangeable sodium values exceeding 6% are widely used to describe a soil as ‘sodic’, and to indicate where sodicity is a potential problem. Values above 13% (in clayey materials) are indicative of situations where irrigation with saline water should be avoided.

The cells in the table are coloured to highlight those values that lie outside target levels. Each colour code is explained in the box below the table.

Soil 1 Deep red sand



Landscape: Low irregular sand rises superimposed on alluvial plains of the Angas-Bremer system. Surface soil is loose and stone free.

Profile: Variable thickness, but always more than 80 cm of loose red sand over buried sandy duplex soils or alluvium.

Depth (cm)	*Description*
0-15	Reddish brown soft single grain sand. Gradual to:
15-50	Reddish yellow soft single grain sand. Diffuse to:
50-100	Reddish yellow soft single grain sand. Abrupt to:
---------------- buried soil -----------------------	
100-120	Yellowish red soft single grain sand. Clear to:
120-145	Yellowish red soft single grain sand. Abrupt to:
145-155	Reddish brown friable sandy clay loam with weak coarse subangular blocky structure.

Key properties

Drainage: Rapidly drained. The soil never remains wet for more than an hour or so following heavy or prolonged rainfall. Deep drainage is good.

Potential root zone: Roots to at least 155 cm in sampling pit, but few below 145 cm.

Barriers to root growth

Physical: There are no physical barriers.

Chemical: Low nutrient availability is the only likely chemical barrier.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 110 mm
Readily available: 70 mm

Fertility: Nutrient retention capacity is low throughout the root zone. Natural reserves of phosphorus, nitrogen and trace elements are very low, and the soil has little capacity to store substantial concentrations of added fertilizer nutrient.

Erosion potential: Potential for water erosion is low; moderate for wind erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg Ca	Mg	Na	K	#CEC	#ESP
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K) 65-75	10-15	< 6	3-8	> 5	< 6
0-15	8.7	7.6	0	0.79	31	3.1	0.4	7	182	0.09	2.24	0.48	0.24	0.44	3.4	na
15-50	7.5	6.8	0	0.29	10	1.6	0.3	8	109	<0.05	0.98	0.42	0.08	0.24	1.7	na
50-100	7.6	6.7	0	0.40	13	2.2	0.4	7	114	<0.05	0.85	0.61	0.10	0.26	1.8	na
100-120	6.9	5.8	0	0.58	44	6.2	0.3	3	135	0.13	0.97	0.78	0.28	0.26	2.3	na
120-145	7.8	6.8	0	1.12	56	8.1	0.3	3	114	0.25	1.32	1.24	0.43	0.21	3.2	na
145-155	7.5	6.6	0	1.20	70	12.9	0.9	3	205	0.11	3.34	2.94	1.62	0.50	8.4	19.3

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Sum of exchangeable cations in surface of less than 5 cmol(+)/kg is an indicator of low fertility. Low phosphorus concentration is also typical of a low fertility sandy soil.
High surface pH due to residues of former lime application or road dust.
Exchangeable sodium less than 6% of total of all four cations is desirable, but not an issue at this depth for this soil.

Notes:

Management of Soil 1

Deep red sand

by John Rasic

Problems

Plants growing in this soil become water stressed during hot, dry weather (drought stress) because the capacity of sand to hold water and nutrients is low.

This soil is low in organic matter and it is highly susceptible to wind erosion because the soil particles are not bonded together. Any nutrients can be quickly removed (leached) because this soil drains rapidly.

When saturated, sand is unstable and it can collapse (slake), become a slurry and flow down through the profile. This slurry can block pores and then, when it dries, the slurry can become a sandy impenetrable cap (capping).

Machinery or animal feet can compact this soil. If sand becomes compacted, it does not self-repair because it does not shrink and swell.

Sand particles do not carry electric charges so the addition of lime or gypsum will not hold the particles together to prevent slaking and wind erosion.

Pre-planting action that can be used to tackle the problems

The chosen irrigation system should include equipment to mix fertiliser with the irrigation water so that the low chemical fertility of the soil can be managed by frequent, precise applications of liquid fertilisers.

If this soil is not compacted, mechanical mixing of the soil layers is not needed because there is no physical limitation to the penetration of roots and of water.

Soil management after planting

Because the threat of wind erosion is always present, establish a drought resistant mid-row cover crop that will hold the soil particles together and provide the much needed increase in soil organic matter.

Compensate for low water holding capacity and for rapid drainage by maximising the volume of soil that is wetted. Encourage deep growth of roots by applying enough water to wet the soil down to a depth just below the roots.