Salinity Glove Box Guide

Tasmania

dryland

irrigation

urban

An initiative of Industry & Investment NSW, Soils and Salinity Team
Adapted for the State of Tasmania

The information contained in this publication is based on knowledge and understanding at the time of writing (November 2009). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check the currency of the information with the appropriate officer of the Department of Primary Industries, Parks, Water and Environment; regional Natural Resource Management (NRM) Organisations, or the user's independent adviser.

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The *Salinity Glove Box Guide Tasmania* has been produced by NRM North and adapted from two Industry & Investment NSW publications:
Slinger, D and Tenison, K (2005), *Salinity Glove Box Guide NSW Murray & Murrumbidgee Catchments*, NSW Department of Primary Industries.
Rowling, L and Slinger, D (2007), *Salinity Glove Box Guide NSW Namoi, Border Rivers & Gwydir Catchments*, NSW Department of Primary Industries.

Mardi Henley, (graphic design, illustration).
Barry Jensen, Industry & Investment NSW, (Tasmanian version page layout, illustration).

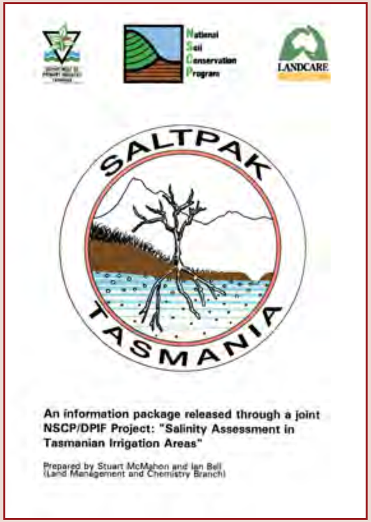

Plate 1 *Saltpak Tasmania* was prepared by Stuart McMahon and Ian Bell (Tasmanian Department of Primary Industries and Fisheries).

The *Salinity Glovebox Guide Tasmania*, is designed to move onwards from the original *Saltpak Tasmania*. Since 1992 land owners and managers have gained a great wealth of information from *Saltpak*. Over time our knowledge and understanding of salinity processes, monitoring and management has expanded significantly. This new Glovebox Guide has been adapted from the original NSW versions specifically for Tasmanians to aid our understanding and management of salinity across affected agricultural and urban regions of our beautiful island.

Introduction

The **Salinity Glove Box Guide Tasmania** has been adapted from the *Salinity Glove Box Guide NSW Namoi, Border Rivers & Gwydir Catchments* and the *Salinity Glove Box Guide NSW Murray & Murrumbidgee Catchments* to provide a handy, up-to-date salinity guide for landholders, land managers and natural resource management advisers. Technical information relevant to Tasmania has been provided by Tasmanian salinity specialists coordinated by Tasmanian regional Natural Resource Management (NRM) organisations.

The *Salinity Glove Box Guide* is supported by a NSW Salinity Training Manual which provides more detailed information on all sections of this Guide.

The close contact and relationship that advisers have with land managers makes them one of our most important tools in achieving the land management change needed to combat salinity.

Why write another salt booklet?

Land managers will find the booklet:

- brings the latest salinity information into one concise publication
- highlights the need for broad implementation of salinity management options
- facilitates the uptake of salinity management options
- provides useful information relevant to currently salt affected, or 'at risk' catchments across Tasmania.

NSW Industry & Investment

NRM North

Using the Salinity Glove Box Guide

The *Salinity Glove Box Guide* covers dryland, irrigation and urban salinity. The Guide is a practical reference tool when working in the field and is useful when discussing salinity concepts with land managers.

Please note: A working knowledge and understanding of your local landscape, climate, soils, groundwater, landuse and land management practices is critical when making salinity management decisions.

The Department of Primary Industries, Parks, Water and Environment; regional NRM organisations and independent advisers can provide more detailed and site specific management options.

Words that appear as **bold** text in the Guide are defined in the glossary.

Your comments on this booklet?

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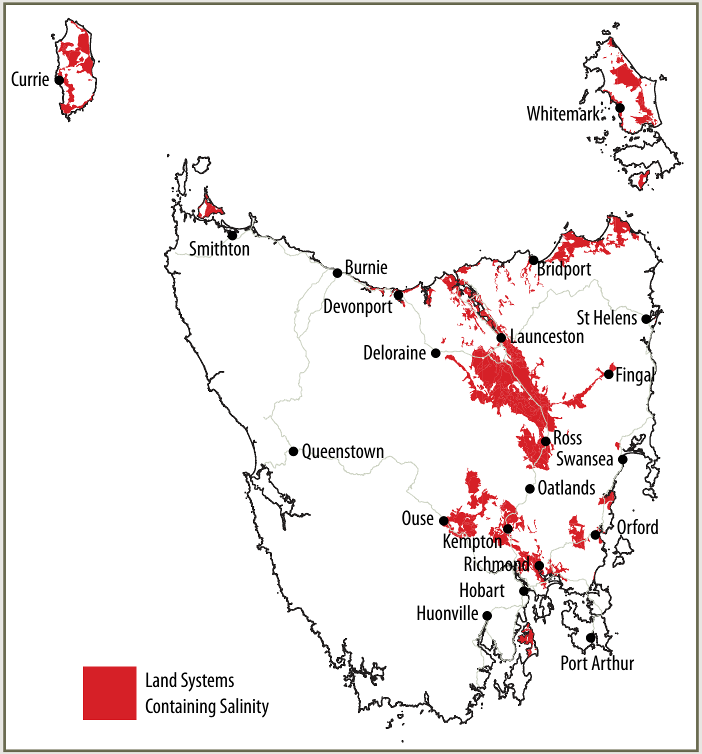


Figure 1 Land Systems of Tasmania on private freehold land that contain areas affected by salinity. Source: Bastick, C and Lynch, S. (2003)

The *Salinity Glove Box Guide* is most relevant to areas of Tasmania where annual rainfall levels are less than 800 mm and evaporation rates are very high. These climatic conditions are conducive to salinity. Some areas however, such as King Island and Flinders Island, receive more than 800 mm rainfall yet soil and water salinity still occur to varying degrees. Salinity discharge sites are typically found within land systems with similar landscape conditions such as rainfall, geology, altitude, topography, soils and vegetation. For more information refer to Grice, M.S. (1995); and maps by Bastick and Walker (2000) and Bastick and Lynch (2003).

Tasmanian catchments – salt input estimates

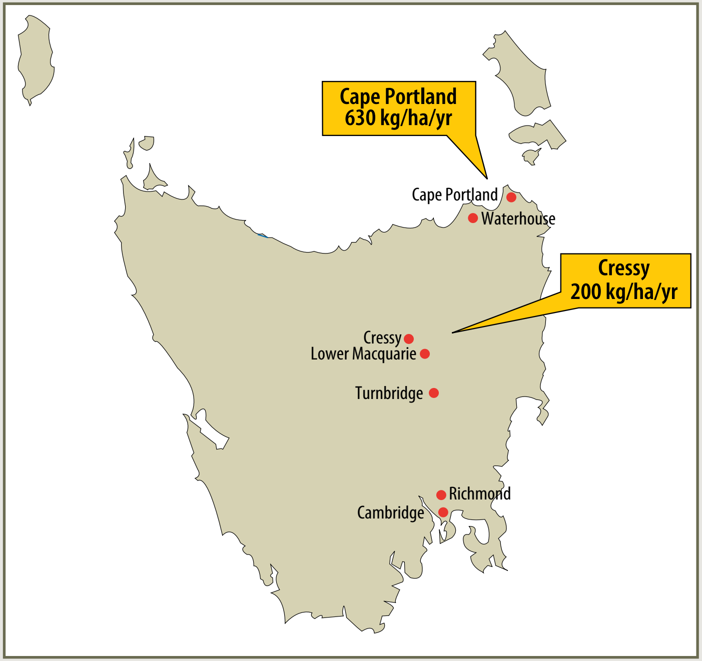


Figure 2 Location of catchments where salt input estimates have been calculated.

Since the late 1990s, various **salinity** studies have been conducted in salt affected **catchments** of Tasmania. Estimates of salt input within these catchments were calculated, providing a basic understanding of salt input on an annual basis. Table 1 lists these estimates. It is important to note that these figures are estimates only and are subject to change based on rainfall and climatic conditions.

Table 1 Annual salt input estimates for a range of Tasmanian catchments and regions.

Catchment / Region	Kg/ha/ month	Kg/ha/year
Lower Macquarie[1]	43.2	410
Cape Portland[1]	52.5	630
Chinta Road, Cressy[1]	16.6	200
Uni Farm, Cambridge[1]	17.5	210
Tunbridge[2]	7.1	85.1
Richmond[2]	6.6	79.2
Waterhouse[2]	21	252

[1] Dell (2000)
[2] DPIWE (2003)
Source: Dell (2000); DPIWE (2003)

Hydrological cycle

The **hydrological cycle** is the movement of water from the atmosphere to the earth and back again. Salts are highly soluble, so water is the key to the movement of salts in the **landscape**. How surface water and subsurface water are managed influences the occurrence and severity of salinity.

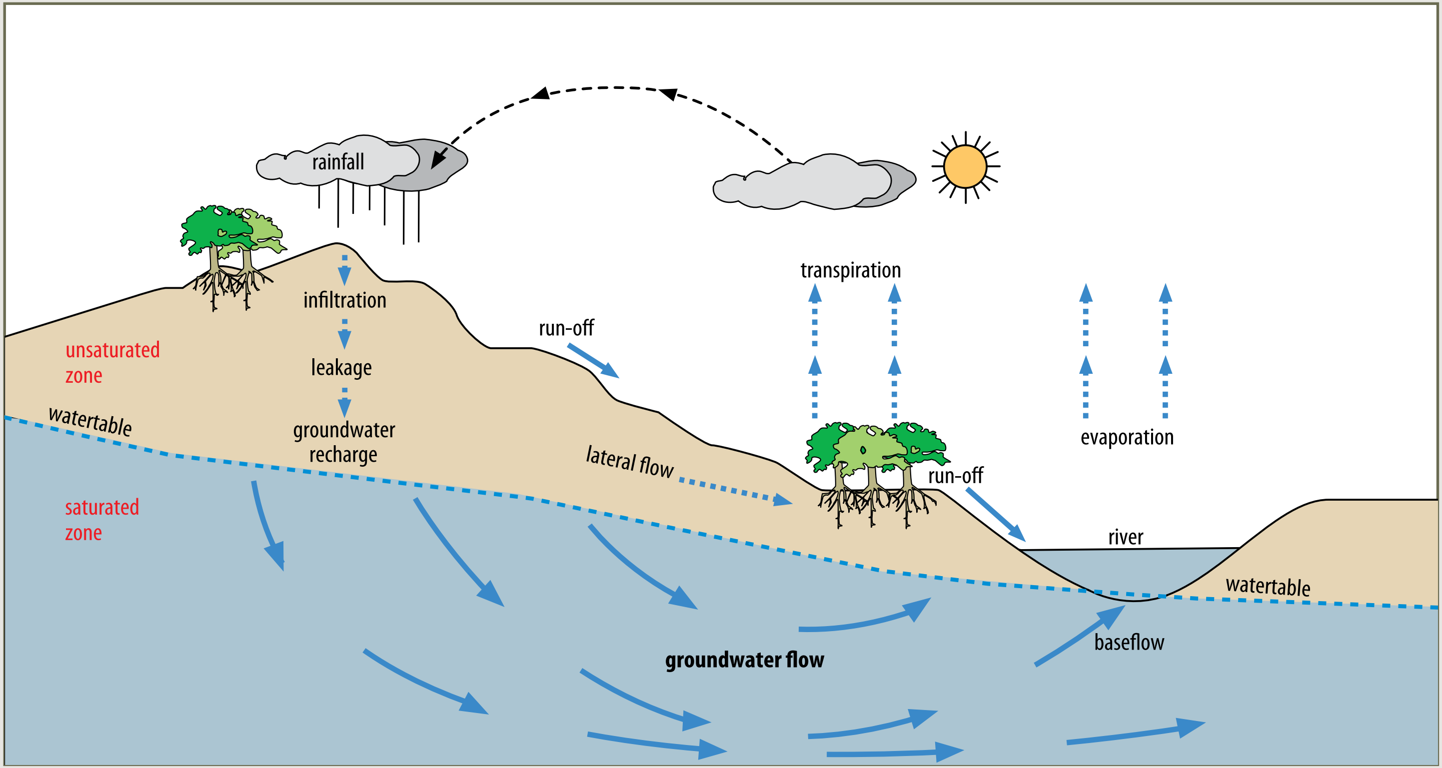


Figure 3 Water movement in the hydrological cycle (terms explained in glossary). Source: Adapted from Ward and Robinson (1990)

The groundwater system and salinity

Hydrogeology is the study of **groundwater systems.** The **unsaturated zone** is where the spaces in soil and rock are dry or only partially filled with water. The **watertable** is the surface below which all the spaces are filled with water. Water occurring in the **saturated zone** below the watertable is called **groundwater.**

Water moving downwards past the plant **root zone** is called **leakage**. Water may also leak from rivers, streams, dams and irrigation channels.

Water that enters the saturated zone is called **groundwater recharge.** Groundwater that leaves the saturated zone is called **groundwater discharge.** In all types of groundwater systems, **recharge areas** occur up slope of **discharge areas.** When groundwater is at or near the ground surface, discharge occurs as **evaporation**, **seepage**, springs, **evapotranspiration** and **baseflow** to streams.

Monitoring bores are pipes placed into a groundwater system to measure the level of the groundwater, and to allow collection of groundwater samples and geophysical data. A **piezometer** is one kind of monitoring bore that only allows measurement of groundwater level. In salinity investigations, groundwater salinity is also of interest, so monitoring bores are used.

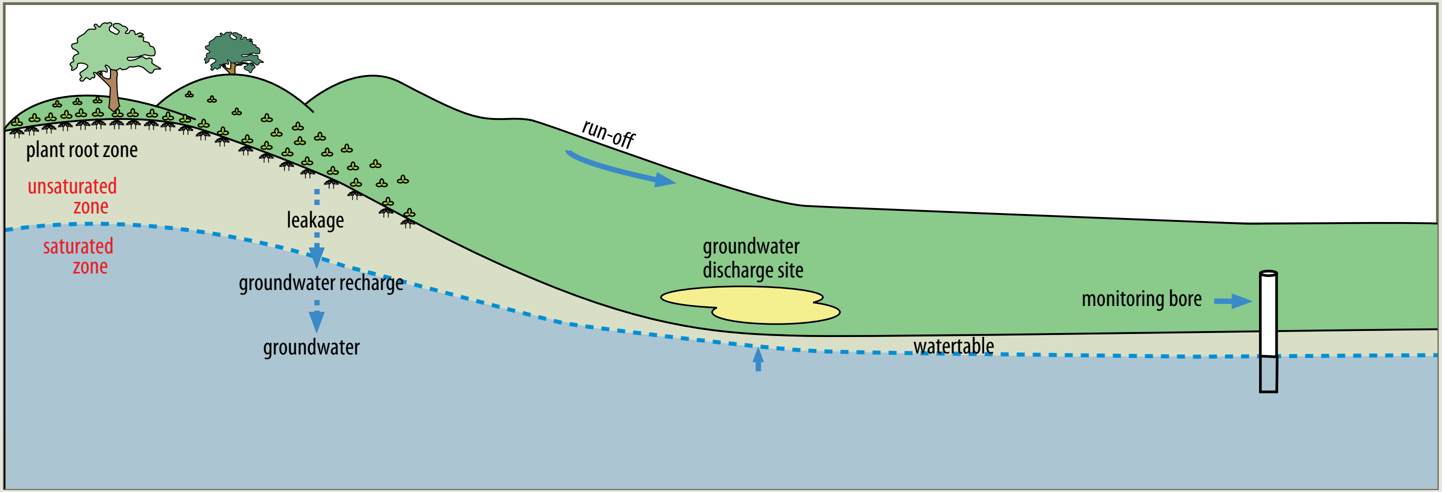


Figure 4 The groundwater system. Source: Adapted from Anderson, Britten & Francis (1993)

Groundwater flow systems

Sediments or rocks **porous** enough to store water and **permeable** enough to allow water to flow through them in economic quantities are called **aquifers**.

Some groundwater systems store and transmit water easily, but many do not. Consequently, groundwater systems range from permeable to **impermeable**. Salts cannot be flushed and water cannot drain from groundwater systems that do not transmit water easily.

Groundwater systems respond to recharge in two ways – either by actual water movement, and/or by pressure transfer.

Groundwater levels are closely linked to both short and long term climate changes. When water is added to groundwater systems with little storage space, these will show a large rise in groundwater level. These are the kind of groundwater systems most often involved in the salinity process.

There are three main Groundwater Flow Systems (GFS). These characterise similar landscapes where groundwater processes contribute to similar issues and similar management options.

Intermediate groundwater systems have characteristics transitional between local and regional groundwater systems and have 5–50 km flow paths.

Regional groundwater systems are deep and have long flow paths (>50 km) and discharge areas may be hundreds of kilometres from their recharge areas. Groundwater moves very slowly and the size of the recharge area is small compared with the total size of the system. Regional groundwater systems can take hundreds of years to respond to changes in water inputs.

Local groundwater systems are those most commonly associated with salinity, but intermediate and regional groundwater systems can also predispose an area to salinity.

On a 1:250 000 scale map, 13 GFS were identified across Tasmania (Latinovic et al., 2003). More recent, local mapping within saline areas of Tasmania has identified many more GFS (Lynch, et al., 2008). Many of these occurring within 800 mm or less rainfall zones contain some salinity.

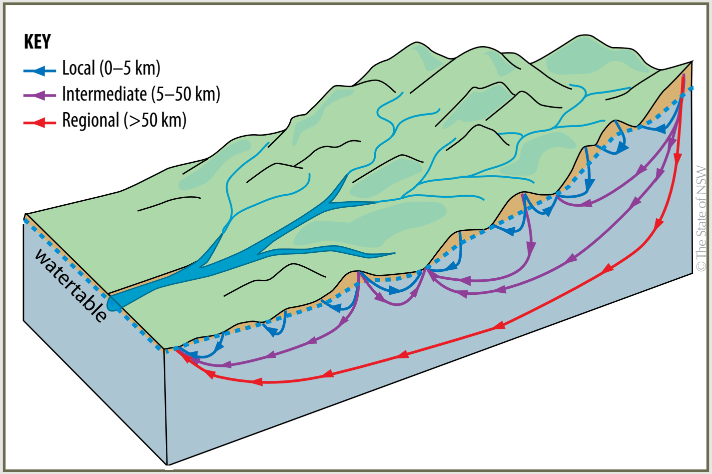


Figure 5 Extent and predicted response of local, intermediate and regional groundwater systems. Source: Adapted from Smithson, A. (2003)

Salt sources

Salt may come from several sources. These include:

- **aeolian salt** which originates from ocean spray or sedimentary deposits is transported by wind. Dry windy periods can mobilise **soil particles** with salts attached, depositing them across the land.
- **cyclic salt** is sea salt from ocean spray or pollution dissolved in rain water then deposited inland. The amount of salt deposited on the landscape in this way is estimated to range from 252 to 630 kg/ha/year on the coast and from 79 to 410 kg/ha/year inland.
- **connate salt** was incorporated in marine **sediments** at the time of deposition, during periods when Australia was partly covered by sea.
- **rock weathering** allows salt to be released as minerals break down over time. Some rock types contain different amounts and types of salt than others.

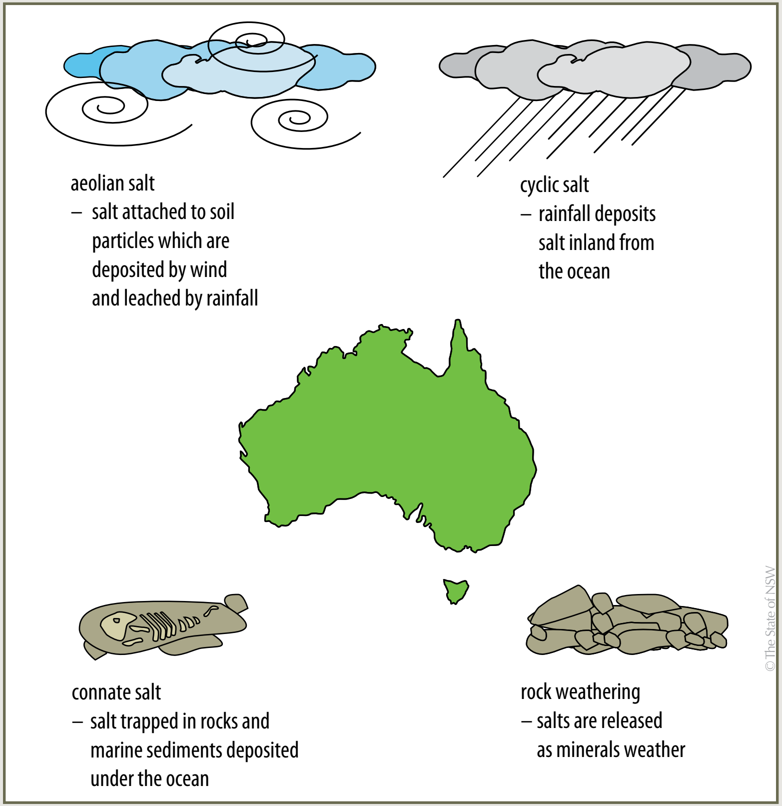


Figure 6 Salt sources include aeolian, cyclic, connate and rock weathering.
Source: Southern Salt Action Team (2003)

Primary and secondary salinity

Salinity may be described as primary or secondary salinity. Human activity has exacerbated **salinisation** of land and water resources.

Primary salinity is the natural occurrence of salts in the landscape for example salt marshes, salt lakes, tidal swamps or natural **salt scalds.**

Secondary salinity is salinisation of soil, surface water or groundwater due to human activity such as urbanisation and agriculture (irrigated and dryland).

Salinity in general refers to the presence of salts in soil or water in concentrations that become toxic for plant health and survival. Sodium and chloride are the most commonly occurring salts that cause production losses across affected agricultural regions of Tasmania. Other salts such as calcium, magnesium and potassium are also present in our soils, but are generally less common in high concentrations.

Soil and water become saline when salts are brought to the soil surface. This usually occurs when water leaking past the plant root zone enters the groundwater system and causes the watertable to rise. As watertables rise, salts found naturally in rocks and soil are dissolved and move toward the soil surface.

Salt that reaches the soil surface will concentrate as the groundwater evaporates. The concentrated salt may then be transported into waterways usually as surface run-off.

Plate 2 Natural salt pan at Woodbury. Source: Kidd, D. (2007)

Plate 3 Secondary salinity caused by rising or shallow watertables; possibly the result of human activities such as land clearing leaving few perennial plants to use water. Source: Finnigan, J. (2007)

Soil sodicity

Soil sodicity is caused by an excess of sodium **ions** (Na^+) relative to other **cations** (calcium, magnesium, potassium) on the surface of soil particles. Sodium keeps clay layers apart and they may separate (disperse) when in contact with water. This is referred to as **dispersion** and is indicated by cloudiness of water.

Soils are considered sodic when 6% or more of exchangeable cations are sodium. This measure of **sodicity** is called the **exchangeable sodium percentage (ESP).**

Soils that disperse on wetting have a very unstable structure and are characterised by:

- severe surface crusting
- formation of hard dense **subsoils**
- blocking of soil pores by dispersed soil particles
- soil swelling which restricts soil water and air movement
- slowed water **infiltration** to the root zone following rainfall or irrigation resulting in poor soil water storage
- closing of soil pores, reducing internal drainage and causing **waterlogging** and run-off
- irrigation water becoming cloudy with suspended clay
- severe gully erosion and tunnel erosion.

Salts can cause clay particles to **flocculate**. Flocculation is the aggregation of clay layers that is the opposite of dispersion and is indicated by clear water. Many clay-dominated soil types may not disperse, despite ESP values well in excess of 6% provided salt levels are also high. Soils that are saline and sodic often have the sodicity constraint masked by salinity. Once salinity is reduced, these soils may become dispersive.

Gypsum is a salt which replaces sodium cations in the clay layer with calcium, causing the clay particles to flocculate which improves soil structure.

About one third of Australia's soils are sodic. In Tasmania, sodic soils are associated with many **duplex soils** throughout the Midlands, Coal River and Flinders Island areas, and are most commonly found within subsoils . The distribution of sodic soils often coincides with areas of low rainfall and salinity.

Plate 4 Sodic weathered substrate, Northern Tasmania. Source: Kidd, D. (2008)

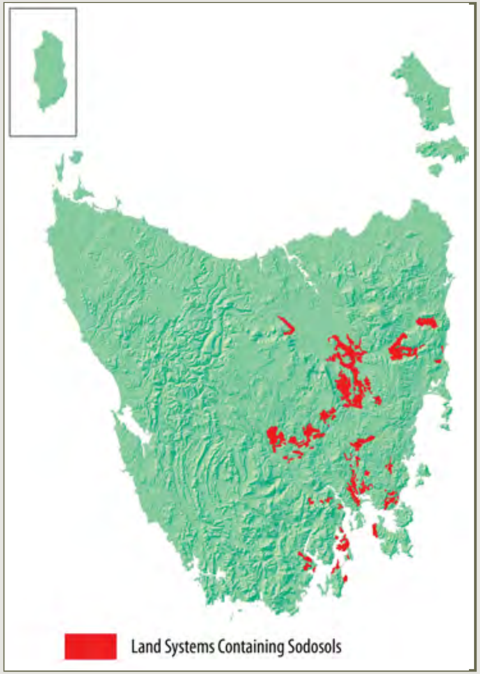


Figure 7 Land systems of Tasmania on private freehold land containing **sodosols.** Source: Kidd, D. (2008)

How salt moves to the soil surface

Surface salt

At a saline discharge site the watertable is close to or at the soil surface.
Salts that have been dissolved and moved to the soil surface by rising groundwater concentrate at this location. The water evaporates leaving the salt behind.
This process is dependent on rainfall, evaporation and vegetation cover.

Subsurface salt

When groundwater is at or near the soil surface it may evaporate. In the subsurface, plant roots take up water, leaving the salt behind. The salts that are left behind concentrate and can be moved sidewards by groundwater in a process called **lateral flow** or up and down the soil profile.

Capillary rise

The process of **capillary rise** can occur above a watertable at any depth.
Capillary rise allows groundwater to be drawn into the dry soil above the watertable like water into a sponge. This gives the **soil profile** a damp appearance.

Watertable

The watertable rises as water leaking past the plant root zone fills the groundwater system.
As the watertable rises it dissolves and moves salt found in the soil, towards the soil surface.

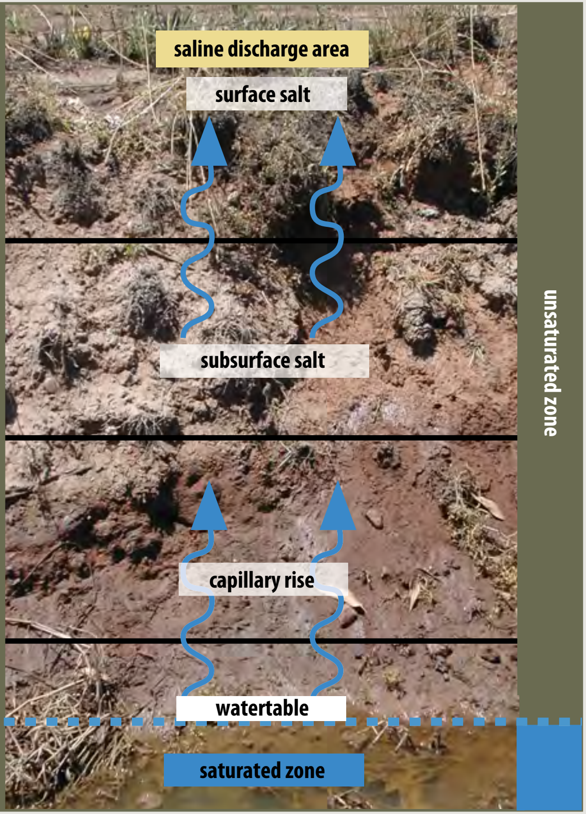


Figure 8 How salt moves to the soil surface. Source: Southern Salt Action Team (2003)

How salt moves into waterways

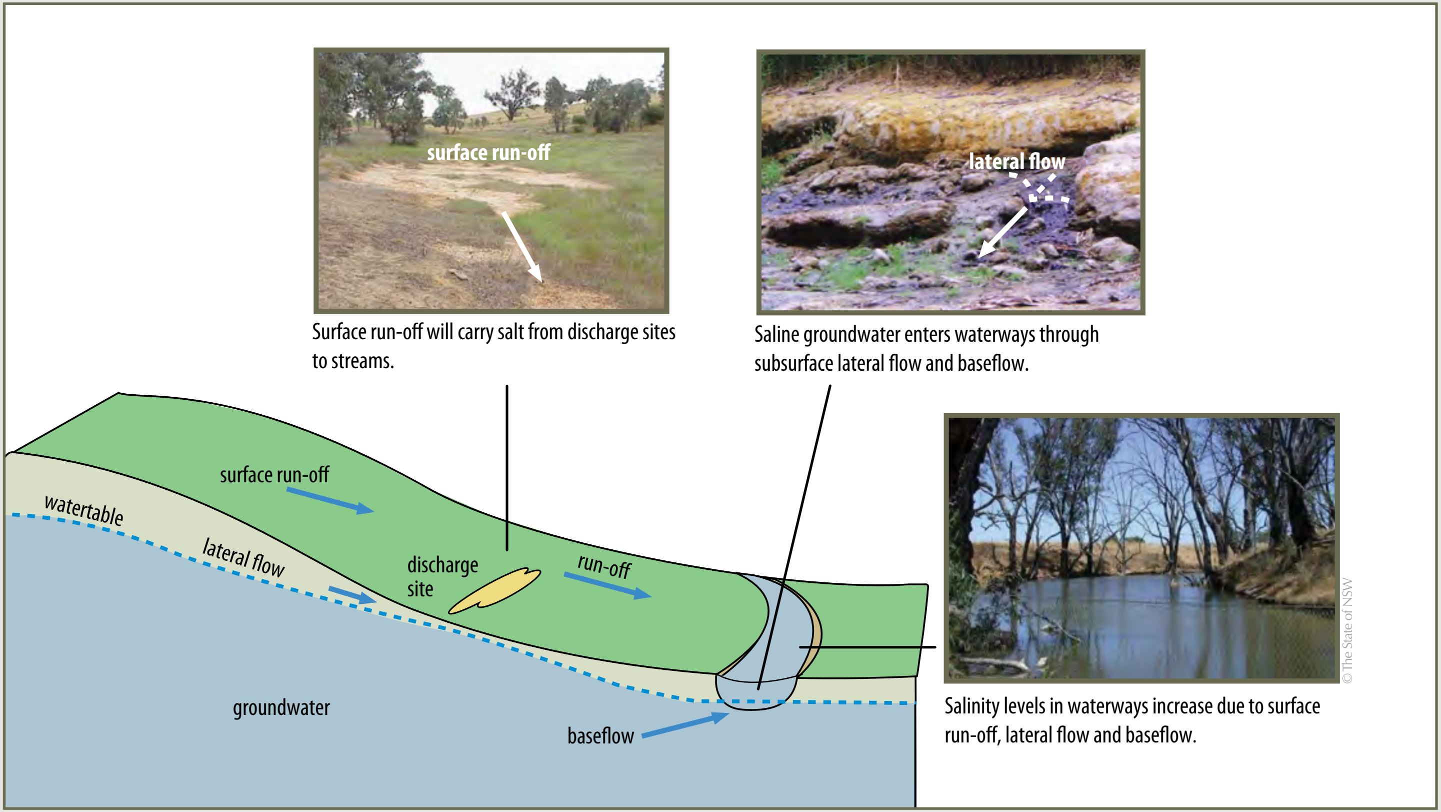
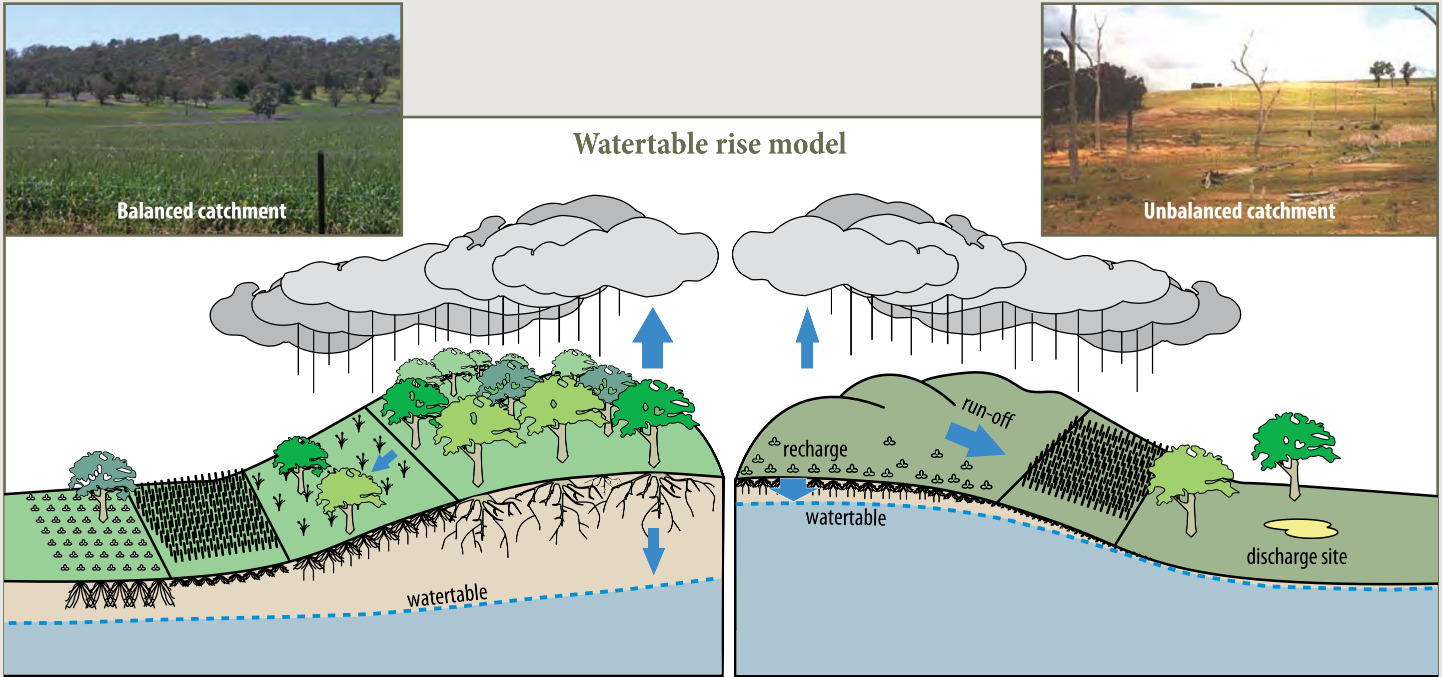


Figure 9 Salt enters waterways through subsurface lateral groundwater movement and surface run-off from discharge sites. Baseflow that contains salt also contributes to the **salt load** of waterways. Source: Southern Salt Action Team (2003)

Causes of dryland salinity



Trees, deep rooted **perennials** and **native vegetation** use most of the water that enters the soil resulting in reduced **leakage** past the plant **root zone**.

Removing native vegetation, growing shallow rooted **annuals** and long **fallowing** of paddocks increases leakage to the groundwater system. Watertable rise brings salt to the root zone and the soil surface. Other soil constraints including sodicity may also develop as a result of altered land use.

Figure 10 A hydrologically balanced and unbalanced catchment, demonstrating how vegetation type can impact on the watertable. Source: Adapted from Walker, G. et al. (1999). Photo source: Southern Salt Action Team (2003) and Truman, G. (2005).

Causes of irrigation salinity

Irrigation salinity occurs due to the same process as dryland salinity. Both occur when leakage past the plant root zone causes the watertable to rise. Recharge rates in irrigation areas can be much higher than dryland areas due to leakage from both rainfall and irrigation. Factors such as irrigation layout and management practices, soil type, quality of water applied, and the climate all influence irrigation salinity.

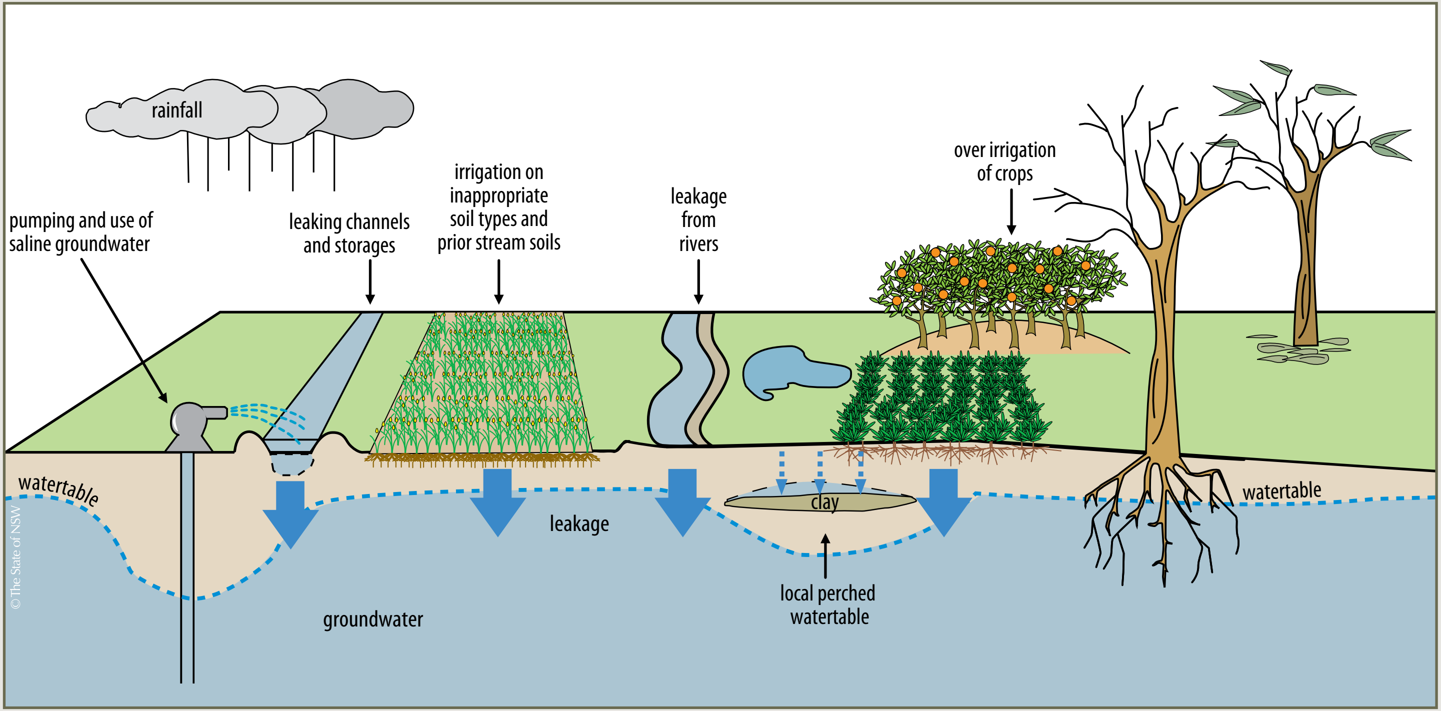


Figure 11 Causes of irrigation salinity. Source: Southern Salt Action Team (2003)

Causes of urban salinity

Factors that contribute to urban salinity include:

- replacing native perennial vegetation with shallow rooted species
- development on high **recharge** or discharge sites
- disruption of natural **drainage lines**
- over irrigation of gardens, parks and recreation areas
- water, sewer and stormwater pipe leakage
- stormwater disposal by back yard **rubble pits**
- leaking septic tanks.

The salts and waterlogging associated with urban salinity can damage roads, pavements, railway lines, underground services, buildings and playing fields.

Urban salinity also reduces water quality as salts are washed into waterways. Salinity may increase costs of urban construction and maintenance; for example, roads may require more frequent repair and reconstruction.

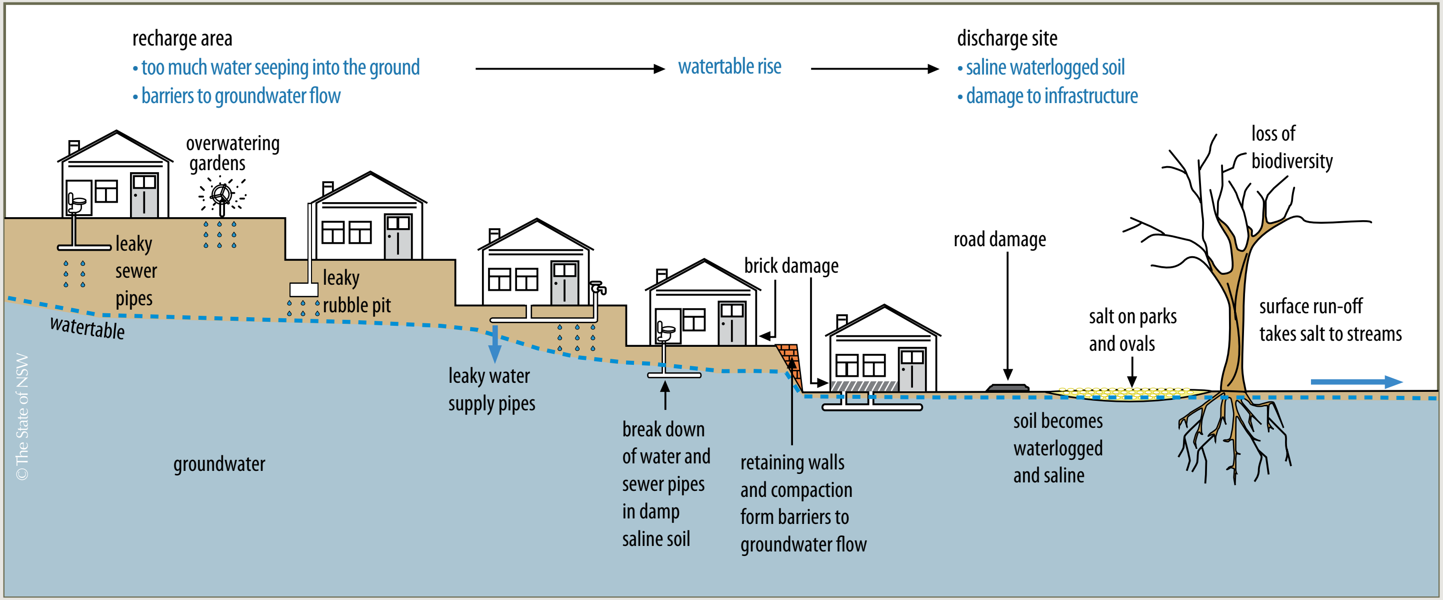


Figure 12 Causes of urban salinity. Source: Adapted from Slinger, D. (1996)

Leakage factors – soils

Leakage is the movement of water past the root zone to the groundwater system. Extensive leakage adds water to the groundwater system and may cause the watertable to rise. Salinity is largely attributed to this process. The amount of leakage occurring in a landscape depends on the following factors:

- soils
- vegetation
- climate
- land management.

Soil water holding capacity (SWHC) is the amount of water retained by the soil after leakage occurs (Charman & Murphy, 1991). Leakage is potentially less in soils with a higher soil water holding capacity, as larger volumes of water can be stored and used by plants.

Soil water holding capacity is influenced by **soil texture** and depth, as well as **soil structure**. The ideal soil structure is achieved by ensuring high **organic matter** content and minimal compaction.

Leakage may be influenced by soil texture and its associated **permeability**. Coarser textured soils tend to be more permeable and potentially more 'leaky' than fine textured soils.

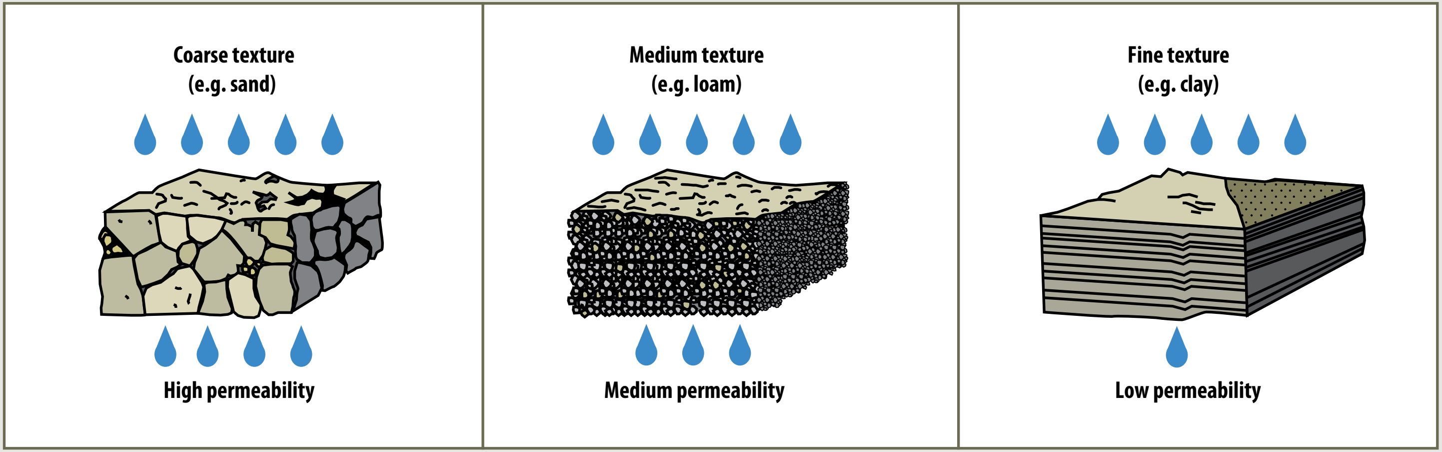


Figure 13 The permeability of different soil textures influences leakage rate to the groundwater system. Source: Raymond, L. (1992)

Leakage factors – geology

Geology affects salinity through its influence on the groundwater system. The features of different rock types determine groundwater infiltration and movement rates, available and stored salts, weathering rate, storage capacity and fracture characteristics.

A solid (or massive) rock unit with poor fracturing, or a heavy clay unit, will act as an impervious layer restricting groundwater movement. By comparison, sands and gravels will quickly move water past the plant root zone.

The plates below show how differing geology can affect groundwater recharge and discharge in some typical landscapes of Tasmania.

The three major geological landscapes found in salt-affected catchments of Tasmania include:

- dolerite
- unconsolidated sediments
- fractured sediments.

While there are many other geological landscapes in Tasmania containing areas affected by salinity, such as basalt and granite landscapes, they are not discussed in detail in this guide. Contact DPIPWE for further information.

Plate 5 Thin veneer of shallow soil overlying massive dolerite geology, near Tunbridge. Source: Hocking, M. (2008)

Plate 6 Fractured sediments (Triassic sandstone) displaying vertical and horizontal fractures, near Jericho. Source: Hocking, M. (2008)

Plate 7 Deeply-weathered, unconsolidated sediments displaying kaolin-rich clay (high salt store), near Campbell Town. Source: Hocking, M. (2008)

Leakage factors – vegetation

Vegetation can be managed with the objective of reducing leakage, either where the rain falls or where water accumulates in depressions or discharges at **break-of-slope**.

Perennial vegetation has the potential to use water over a greater part of the year, which reduces leakage and leaves the soil profile relatively drier than annual vegetation. Deep-rooted vegetation including trees and perennial pasture can dry the soil to a greater depth than shallow-rooted vegetation.

Plate 8 Summer active perennial trials by Tasmanian Institute of Agricultural Research (TIAR) in the Southern Midlands showing growth and early persistence of Birdsfoot trefoil during drought conditions. Source: Finnigan, J. (2007)

Summer active perennial species dry the soil profile in the period leading up to winter. A dry soil profile prior to winter can store more winter rainfall and act as a buffer to leakage past the plant root zone.

Groundcover is vitally important to reduce surface run-off. When groundcover is low, storms with high rainfall intensity can lead to large amounts of run-off and soil erosion. Vegetation systems with summer and winter growing components (including legumes) are likely to maintain a dry soil **buffer** year round, while providing ideal groundcover.

Plate 9 Newly established salt tolerant pasture including summer active fescue on the east coast of Tasmania. Source: Finnigan, J. (2006)

Plant water use is highest when plants are actively growing and as a result the soil profile is kept relatively dry. Managing plants through rotational grazing can prolong the growing season and reduce leakage.

When cropping, it is important to maintain flexible cropping systems incorporating **opportunity cropping** and summer crop rotations when appropriate.

Conservation farming practices that promote soil health: increase soil organic matter and improve soil structure; permit greater soil water holding capacity; and improve plant health and production.

Recent modelling in the Back Creek Catchment of Tasmania predicts excessive leakage is likely when crops harvested green, such as broccoli, are included in crop rotations. In this situation, the soil profile cannot dry out prior to water dominant rainfall. The incorporation of long fallows before the sowing of spring crops can also cause excessive leakage.

Leakage factors – vegetation

Leakage under different vegetation types on similar landscapes

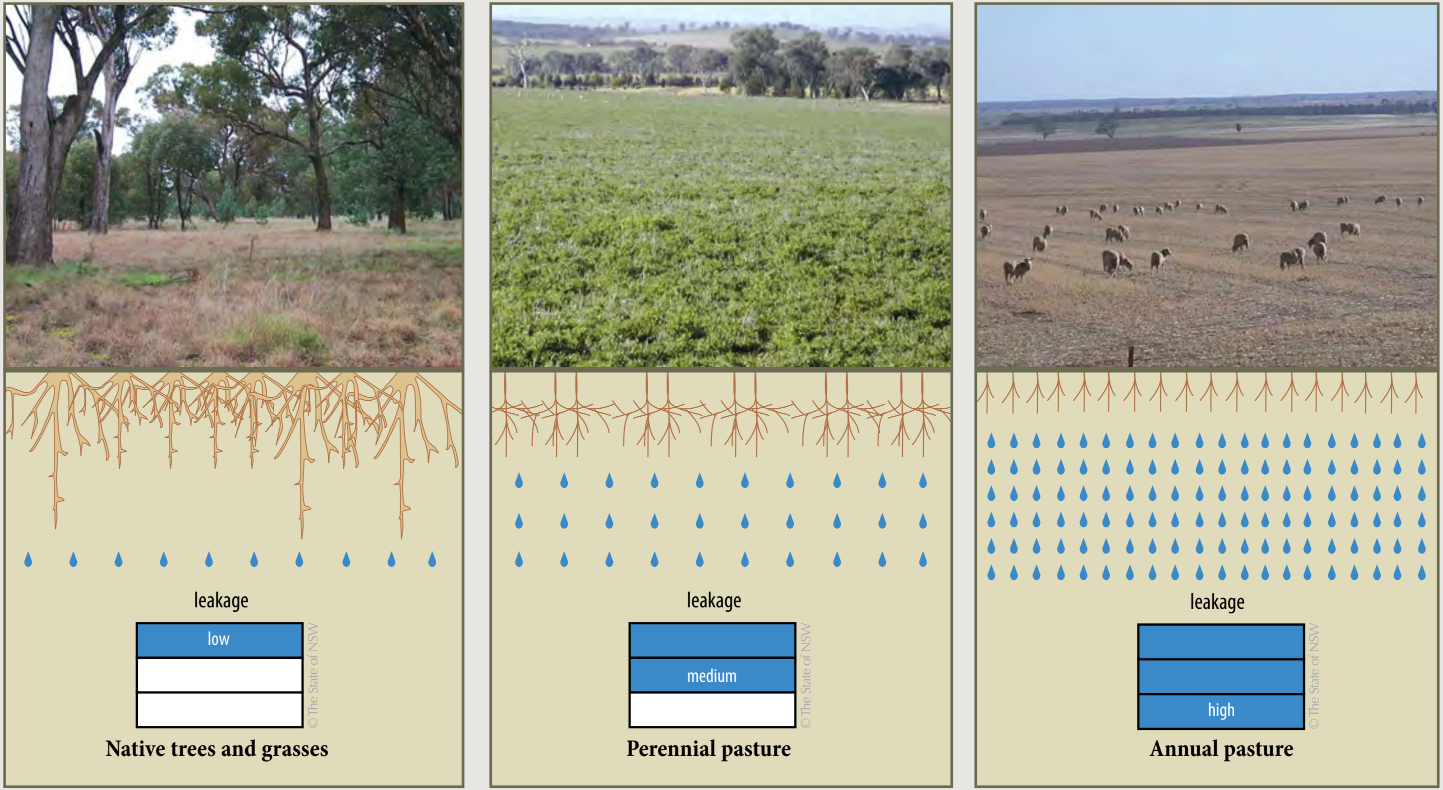


Figure 14 Leakage comparison between vegetation types on similar landscapes. Source: NSW Agriculture (2003)

Leakage factors – climate

The potential for leakage to a watertable is increased when rainfall exceeds evaporation. In Tasmania this generally occurs in the winter months (May to September) especially in regions receiving more than 700 mm per annum rainfall. Climatic variations can have a long-term effect on recharge.

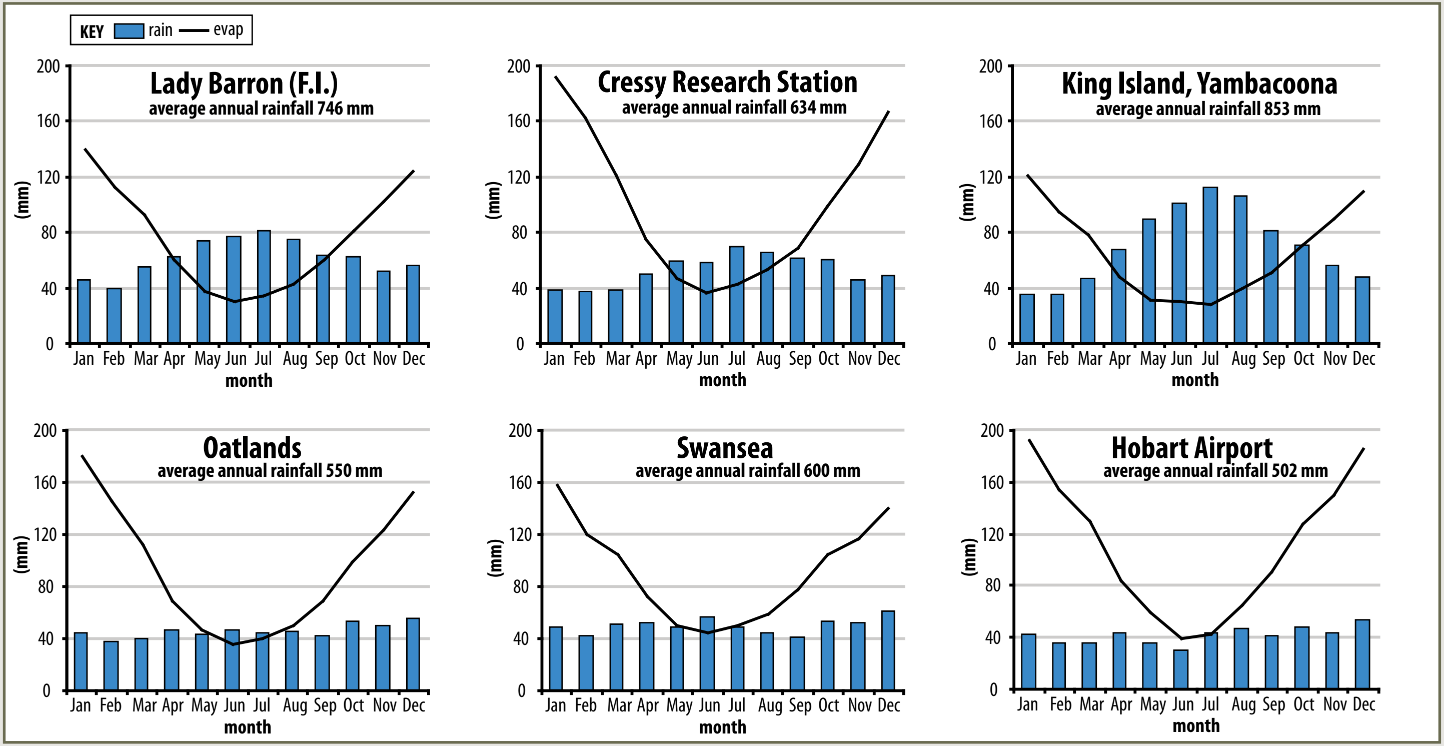


Figure 15 Average annual rainfall and evaporation data for some regions in Tasmania affected by salinity. Source: Armstrong, D. (2008)

Salinity in dolerite landscapes

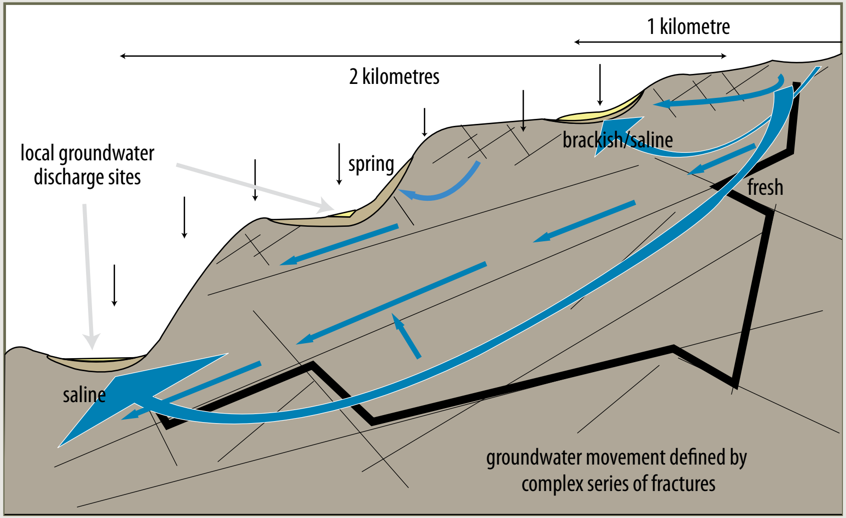


Figure 16 Water movement and salinity in a dolerite landscape. Source: Adapted from Hocking et al. (2005)

Plate 10 Exposed dolerite rocks in the Fingal Valley, Tasmania.
Source: Finnigan, J. (2009)

Location: Dolerite landscapes occur in the central, south eastern and central northern areas of Tasmania. Typical landscapes are Mt Wellington, Tunbridge and the Western Tiers.

Features: Convex slopes and rounded hills feature in these landscapes. Rock outcrops are generally limited to steep hills and in most instances a thin soil layer overlies the intrusive geology.

Water movement: Groundwater in dolerite is usually stored in rock fractures. The level of fracturing and weathering, combined with landscape relief, determines the rate of groundwater movement. **Groundwater flow** generally increases with higher relief and intensive fracturing.

Groundwater and salt commonly discharge in drainage lines or midslope regions where fractures intersect the terrain or groundwater flow is impeded by distinct changes in soil texture.

Groundwater quality in dolerite landscapes is variable, largely determined by annual rainfall and the level of fracturing and weathering that determines rate of movement.

Salinity in layered/fractured landscapes

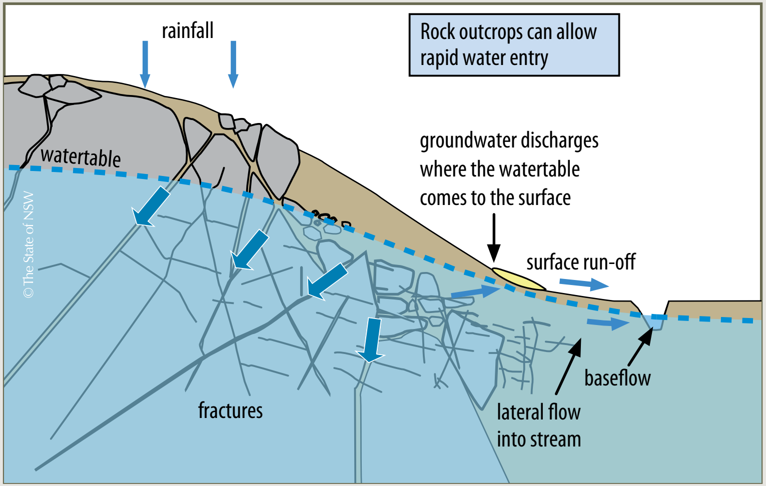


Figure 17 Water movement and salinity in layered/fractured landscapes.
Source: Adapted from Smithson, A. (2003)

Plate 11 Deeply weathered **layered/fractured sediments** near Bridport.
Source: Hocking, M. (2008)

Location: Layered/fractured landscapes occur in:

- Southern Tasmania as **Permian/Triassic** age sediments (e.g. Hobart, Melton Mowbray, Oatlands)
- North-eastern Tasmania and Flinders Islands as **Palaeozoic** age sediments (e.g. Mathinna, Lebrina, Brougham–Sugarloaf).

Features: Geological fracturing caused by faulting and folding are features of this landscape. Mudstone and sandstone are the most commonly occurring Permian and Triassic rocks. These landscapes have relatively gentle slopes and broad valleys.

Water movement: Extensive fracturing within these landscapes provides preferential pathways for large volumes of water movement. Discharge locations can be variable, occurring at break-of-slope and lower lying areas of the landscape.

Layered/fractured landscapes have high to moderate salt stores.

Salinity in unconsolidated landscapes

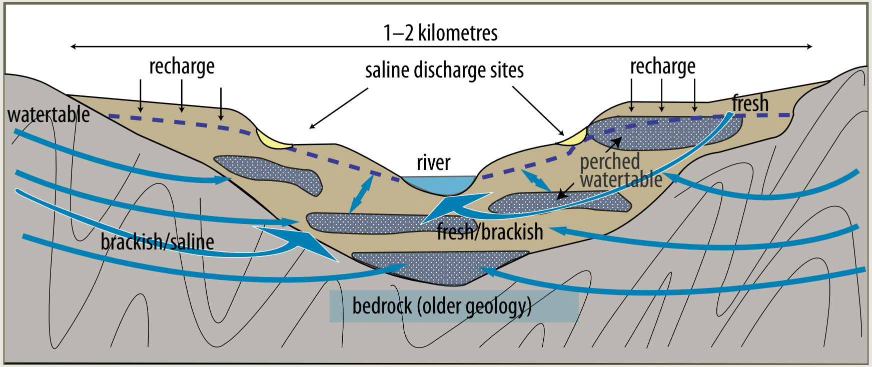


Figure 18 Example of water movement in an **unconsolidated landscape.** Source: Adapted from Hocking et al. (2005)

Plate 12 Salt visible in waterlogged alluvial sediments during a dry period. Source: Hocking, M. (2008)

Location: Unconsolidated sediments occur in the mid and northern areas of Tasmania. Typical landscapes include:

- the Longford Basin–an ancient river valley stretching from Ross to Launceston
- the edge of the eastern and western Tiers, occurring as **talus** (colluvium) and **alluvial** materials
- wind blown sand **dunes** of north east Tasmania and Flinders Island.

Features: The valley floors and plains consist of layers of sediments that vary in size from coarse gravel to fine clays.

Water movement: Sediment features influence recharge and groundwater movement. Some commonly occurring groundwater features include: **groundwater mounds,** an elevation of the groundwater system due to high recharge at specific locations (such as irrigated areas) and; local **perched watertables** that can occur above an impervious layer such as heavy clay which limits the downward flow of water.

Waterlogging and salinity can occur in unexpected locations due to the complexity of the sediment distribution.

High salt stores are typically found in the older landscapes of deeply weathered sediments.

Groundwater restrictions

There are landscape and geological features beneath the ground that can influence groundwater movement. These features need to be understood when developing salinity management strategies.

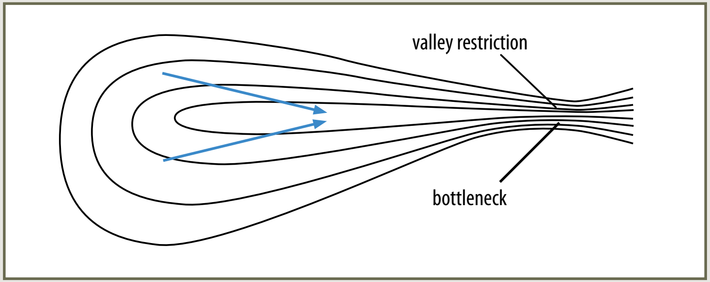


Figure 19 Valley constrictions may result in groundwater discharge. Where a bottleneck occurs groundwater is restricted and may discharge onto the surface. For example valleys near the towns of Hamilton and Ouse.
Source: Anderson, Britten & Francis (1993)

Plate 13 Typical valley at Ouse in southern Tasmania with topographic constriction.
Source: Hocking, M. (2007)

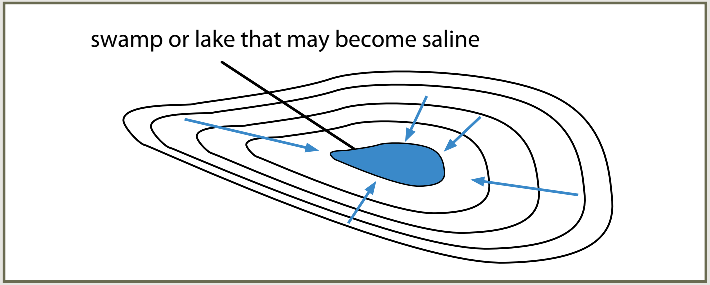


Figure 20 A closed drainage system has no outlet such as a stream for groundwater discharge. Salts are concentrated by evaporation. For example areas in the midlands and southern highlands such as Woodbury and Bothwell.
Source: Anderson, Britten & Francis (1993)

Plate 14 A closed drainage system in Bothwell, southern Tasmania. Salts transported to this area by surface flows are stored in this low-lying depression.
Source: Hocking, M. (2007)

Groundwater restrictions

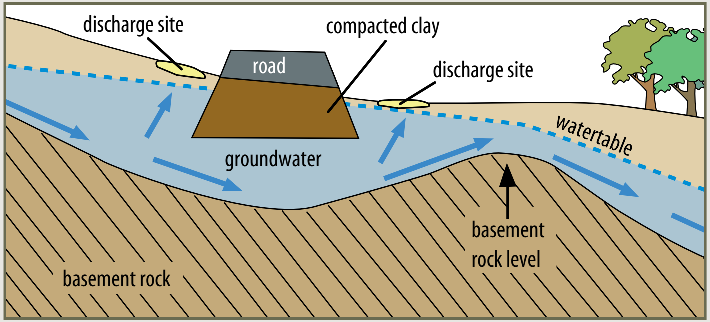


Figure 21 A change in basement rock level restricts groundwater causing a damming effect. Groundwater rises each side of the road resulting in a discharge area where salt is often visible. Source: Adapted from Salas, G. (2003)

Plate 15 Soil compaction for road construction impedes groundwater movement and may restrict surface water drainage. The result is waterlogging and salt concentration beside the road. Source: Southern Salt Action Team (2003)

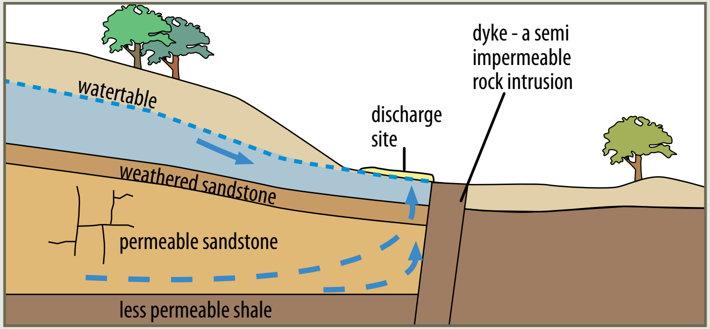


Figure 22 Groundwater movement may be restricted where a rock intrusion is present. As groundwater is forced to the surface and evaporates, salts are deposited.
Source: Adapted from Salas, G. (2003)

Plate 16 Rock structures can force groundwater to the surface as lateral flow is impeded.
Source: Southern Salt Action Team (2004)

General salinity symptoms

Plate 17 Bare areas or poor plant growth in crops often indicate saline and/or waterlogged soils. Source: Finnigan, J. (2007)

Plate 18 Green areas during summer are a sign of groundwater discharge sites. Source: Southern Salt Action Team (2003)

Plate 19 Waterlogged soil is often one of the first signs of a potential salinity problem. Source: Southern Salt Action Team (2003)

Plate 20 Dark greasy patches may appear on the soil surface due to salts causing the destabilisation of organic matter. Source: Southern Salt Action Team (2003)

General salinity symptoms

Plate 21 Stock congregate on a discharge area and lick the surface salt.
Source: Southern Salt Action Team (2003)

Plate 22 Trees along a shelterbelt die due to shallow groundwater and saline soils.
Source: Finnigan, J. (2008)

Plate 23 Sea barley grass, a mildly salt-tolerant plant dominating a saline paddock in the southern highlands. Source: Finnigan, J. (2008)

Plate 24 Salt-affected grazing land – pasture degraded to buck's horn plantain, sea barley grass and bare eroding ground. Source: Finnigan, J. (2006)

General salinity symptoms

Plate 25 Salt crystals become visible when soil surfaces are dry. Source: Finnigan, J. (2007)

Plate 26 Bare soil is 'puffy' to walk on when dry. Source: Southern Salt Action Team (2003)

Plate 27 Very clear water in dams and waterways may be due to salt settling the fine sediment. Source: Southern Salt Action Team (2003)

Plate 28 Saline areas are prone to erosion from run-off. Source: Finnigan, J. (2008)

Urban salinity symptoms

Salinity in urban environments can be evident in buildings, parks, ovals, pavements, roads, gutters and underground services (damages gas, water and sewerage pipes). Excavation works will often unearth signs of high watertables and salinity. It is important in both urban and agricultural environments not to draw conclusions from one symptom but examine the whole environment that surrounds the building, road or park.

Plate 29 Salt damage to bricks and mortar in northern Tasmania. Source: Armstrong, D. (2007)

Plate 30 Damaged road surfaces in the greater Launceston area due to salinity. Source: Armstrong, D. (2007)

Plate 31 Launceston golf course with saline scalds. Source: Armstrong, D. (2007)

Plate 32 Galvanised pipes corrode prematurely. Source: Southern Salt Action Team (2004)

Indicator plants

The first sign of salinity is often a change in the composition of plant species present. These are known as **indicator plants** and some examples are listed in Table 2.

Plant species commonly found on saline and waterlogged areas in Tasmania are listed below. The occurrence of these plants does not always indicate saline soil or a groundwater discharge site. For example, Buck's Horn Plantain can commonly grow on bare soil that is neither saline nor waterlogged. However, leaf colour of Buck's Horn Plantain changes from green to burgundy and plants become stunted as soil salinity increases.

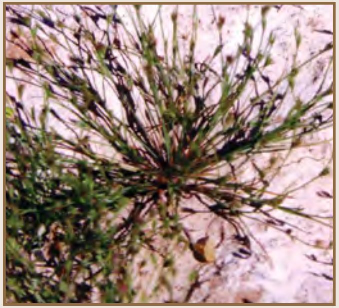
Table 2 Plants that indicate waterlogging and/or salinity. **key** 📷 = pictured page 31

Plant indicators of waterlogged soils and varying soil salinity levels			
Non-saline waterlogged conditions	**Moderate salinity EC_e (2 – 6 dS/m)**	**High salinity EC_e (6 – 5 dS/m)**	**Extreme salinity EC_e (> 15 dS/m)**
Spike/Spiny Rush *(Juncus acutus)* 📷	Spike/Spiny Rush *(Juncus acutus)* 📷	Spike/Spiny Rush *(Juncus acutus)* 📷	Sea Barley Grass *(Hordeum marinum)* 📷
Phragmites *(Phragmites australis)*	Sea Barley Grass *(Hordeum marinum)* 📷	Sea Barley Grass *(Hordeum marinum)* 📷	Glass Wort *(Pachycornia species)*
Paspalum *(Paspalum dilatatum)*	Paspalum *(Paspalum dilatatum)*	Annual Beard Grass *(Polypogon monspeliensis)* 📷	Buck's Horn Plantain (*Plantago coronopus*) 📷
Yorkshire Fog *(Holcus lanatus)*	Toad Rush *(Juncus bufonius)* 📷	Water Button/Marsh Daisy *(Cotula coronopifolia)* 📷	Water Button/Marsh Daisy *(Cotula coronopifolia)* 📷
Smart Weed *(Polygonum hydropiper l.)*	Swamp/Common Couch Grass *(Cynodon dactylon)*	Swamp/Common Couch Grass *(Cynodon dactylon)*	Coastal Sand-spurrey (*Spergularia media*) 📷
Cumbungi (*Typha* species)	Cumbungi (*Typha* species)	Buck's Horn Plantain (*Plantago coronopus*) 📷	
Common Rush *(Juncus usitatus)*	Common Rush *(Juncus usitatus)*	Mat Saltbush (*Atriplex prostrata*) 📷	
Curled Leaf Dock *(Rumex crispus)*	Buck's Horn Plantain (*Plantago coronopus*) 📷		
Barnyard Grass *(Echinochloa crus-galli)*			
Buck's Horn Plantain (*Plantago coronopus*) 📷			

Source: Adapted from NSW Agriculture (2005)

Salinity indicator plants

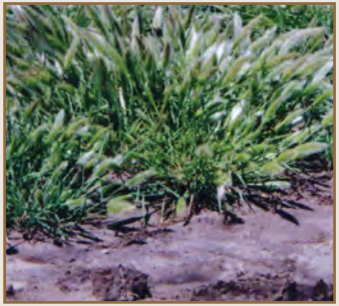
Sea Barley Grass
(Hordeum marinum)
Source: Finnigan, J. (2007)



Toad Rush
(Juncus bufonius)
Source: Southern Salt Action Team (2003)

Mat Saltbush
(Atriplex prostrata)
Source: Finnigan, J. (2008)

Spike or Spiny Rush
(Juncus acutus)
Source: Southern Salt Action Team (2003)



Annual Beard Grass
(Polypogon monspeliensis)
Source: Southern Salt Action Team (2003)

Water Button or Marsh Daisy
(Cotula coronopifolia)
Source: Finnigan, J. (2008)

Coastal Sand-spurrey
(Spergularia media)
Source: Rudman, T., DPIPWE (2009)

Buck's Horn Plantain
(Plantago coronopus)
Source: Finnigan, J. (2008)

Plate 33 Salinity indicator plants found in Tasmania.

Water and soil electrical conductivity

Electrical conductivity (EC) measures the electrical current conducted by water and soil. The reading depends on the concentration and composition of dissolved salts.

EC is the term used to describe units of salinity.

EC_w is the salinity of water *(field test)*.

$EC_{1:5}$ is the initial testing to determine EC_e soil salinity. It is determined by mixing 1 part soil to 5 parts **deionised water**. This figure can be used in the EC_e test *(field or laboratory test)* refer Figure 30, page 41.

EC_e *(field or laboratory test)*. The estimated EC_e is the amount of salt in the soil. It can be estimated by multiplying $EC_{1:5}$ by an appropriate factor related to the **soil texture** group *(field or laboratory test)* refer page 41.

EC_{se} is the saturated extract conducted by National Association of Testing Authorities (NATA) accredited labratory *(laboratory test)*.

EC_a the Apparent Electrical Conductivity is a measure of bulk electrical conductivity of undisturbed soil in the field. It can be measured with an electromagnetic instrument (EM 38 and EM 31) in a soil survey.

Note: EC_a measures salinity but also is sensitive to soil texture, soil depth and groundwater depth.

Table 3 lists the four most common units of salinity measurement and how to convert between the different units. The most commonly used unit of measurement in Tasmania is dS/m.

Plate 34 Quad bike mounted with combined EM31 and Global Positioning System (**GPS**) tracking system.
Source: Department of Primary Industries, Parks, Water and Environment (2001)

Table 3 Units of salinity measurement and EC conversion table.

decisiemens per metre (dS/m)	millisiemens per centimetre (mS/cm)	microsiemens per centimetre (µs/cm)	parts per million (ppm*)
1	= 1	= 1000	= 640
e.g. 4	= 4	= 4000	= 2560

Source: NSW Agriculture. (2003)
* ppm is only an estimate and is dependent on the sample's temperature and types of salt present.

Electromagnetic induction (EMI) surveys

Electromagnetic induction (EMI) surveys are a rapid assessment method commonly used to measure the electrical conductivity of the soil. The electrical conductivity of the soil is influenced by the relative amount and types of clay, salt, soil moisture, organic matter and depth to bedrock.

Two useful ground-based instruments are the EM 38 and EM 31. The EM 38 can read soil conductivity/salinity to 1.5 m soil depth (root zone salinity) and the EM 31 to a depth of 6.0 m.

Electromagnetic induction surveys require ground truthing (validation) with soil samples and datasets. When combined with additional data in the form of soil maps, crop yield maps, topographic maps and aerial photos, EMI can be used to assist with the management and monitoring of land and soil resources.

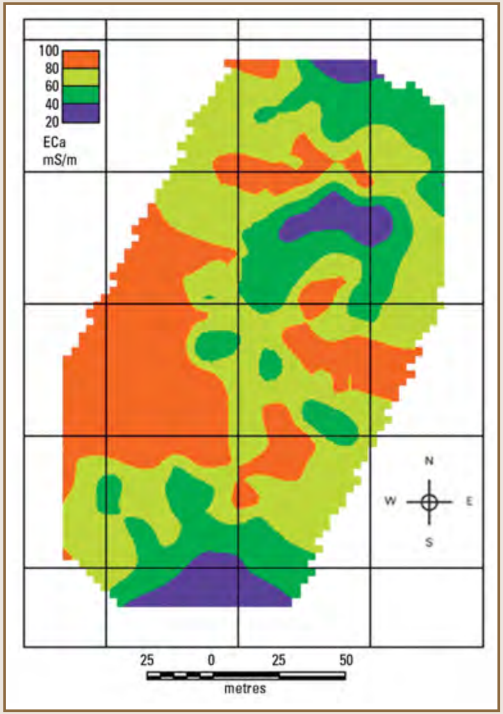


Plate 35 An EM 38 (vertical) survey map identifying apparent EC. The areas in the paddock of highest conductivity are represented by red colours on the map output.
Source: NSW DPI & Namoi CMA (2005)

EMI applications

Electromagnetic technology can be used for the following purposes:

- **identifying salinity:** estimating root zone salinity and crop and pasture response to salt
- **land resource assessment and planning:** regional and whole farm soil and salinity surveys including salinity hazard and risk maps
- **precision farming:** combining EMI maps with yield maps to determine paddock management zones and variable rate technology
- **locating subsoil constraints**.

Determining EC_w

You will need the following equipment to determine water salinity (EC_w):

- salinity electrical conductivity (EC) meter
- calibration solution (note: it is important to regularly **calibrate** your meter)
- deionised water (or rainwater)
- clear, straight sided, clean screwtop container with graduated measures (refer Figure 29, page 40).

Sampling procedure

1. Calibrate the meter before any testing.
2. Thoroughly mix the water to be tested before taking a sample.
3. Dip a water sample container into the water and rinse thoroughly.
4. Allow the container to half fill with water.
5. Remove the EC meter cap and switch on the meter.
6. Immerse the salinity meter in the sample so that the electrodes are covered.
7. Swirl the meter slowly and allow the display to stabilise (for up to 20 seconds), then read the number on the meter. Check the units on the salinity meter. If you need to convert the units (refer Table 3, page 32).
8. Clean the meter's electrodes with deionised water, dry, switch off and replace cap.
9. Contact your regional NRM organisation, Department of Primary Industry, Parks, Water and Environment or your independent adviser for advice or access to relevant testing equipment.

Plate 36 Contents of the Industry & Investment NSW Salt Bag used for salinity monitoring. Source: Madden, E. (2009)

Use the test as a guide and if you suspect there is a problem, seek advice and a more comprehensive laboratory test.

Groundwater monitoring

Monitoring bore

A monitoring bore (often called a piezometer) is a tube inserted into the groundwater system. It is used to measure groundwater levels and collect groundwater samples. A Fact Sheet detailing how to install a bore or piezometer is available from your local NRM organisation (refer Figure 23).

Water level

Measurement is taken from the top of the casing down to the water level (A), minus the measurement from the top of the casing down to ground level (B).

Standing water level (SWL) = A–B from ground surface (refer Plate 37).

SWL is measured using a 'plopper' or fox whistle attached to a tape measure or rope.

When to monitor

The standing water level (SWL) should be measured regularly throughout the year. This allows monitoring of any variations in water level due to seasonal conditions and landuse change. The salinity of the groundwater should be measured at the same time.

Recording SWL and groundwater salinity over extended periods of time will determine important trends in watertable depth and salinity.

Water quality testing (salinity)

To obtain an accurate EC_w:

1. Ensure all equipment used to sample and test groundwater is thoroughly rinsed with fresh water prior to use.
2. Bail out and discard three volumes of water and keep the fourth sample retrieved. This removes stagnant water that may be sitting on the surface in the pipe.
3. Measure your kept sample using a calibrated conductivity meter.
4. See page 46 for water quality guidelines.

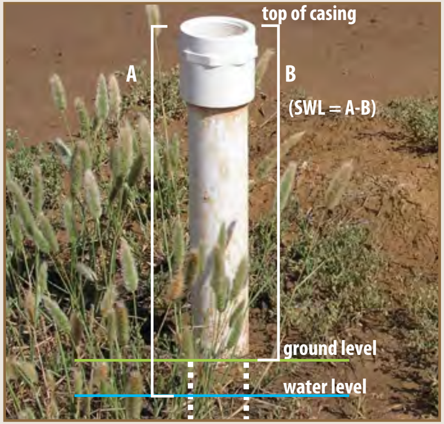


Plate 37 Monitoring bore.
Source: Southern Salt Action Team (2004)

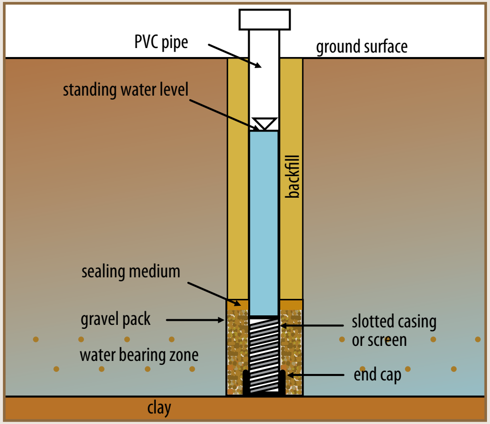


Figure 23 Monitoring bore structure.
Source: Francis, Britten & Tuckson (1993)

Plate 38 Measuring watertable depth using a monitoring bore.
Source: Sherriff, L. (2009)

Saline soil

A saline soil has soluble salts in sufficient quantities to adversely affect plant growth.

Table 4 Generalised salinity classes commonly used in Tasmania.

Class	Level of salinity	EC_e (dS/m)
Class 1	low	2–4
Class 2	moderate	4–8
Class 3	high	8–16
Class 4	severe	> 16

Source: Hazelton & Murphy (1992)

These salinity classes are broad and should be used as a guide only. Salinity levels should be assessed on a site-by-site basis and in association with specific tolerance levels of the particular pastures, crops, trees and shrubs in question.

What salts are in the soil?

A salt is a group of electrically-charged atoms (ions). A salt consists of a **cation** (positive charge) and an **anion** (negative charge). The cations and anions commonly found in soil and the salts they form are shown in Table 5.

Chloride is the most soluble anion followed by sulphate, bicarbonate and carbonate.

Of the cations, sodium is the most soluble anion followed by magnesium and then calcium. With rising watertables and capillary rise (page 11), the most soluble salts will accumulate on the soil surface. Usually sodium chloride is the first to accumulate. Calcium carbonate is relatively insoluble, so it does not build up at the soil surface.

The effects of salt can be:

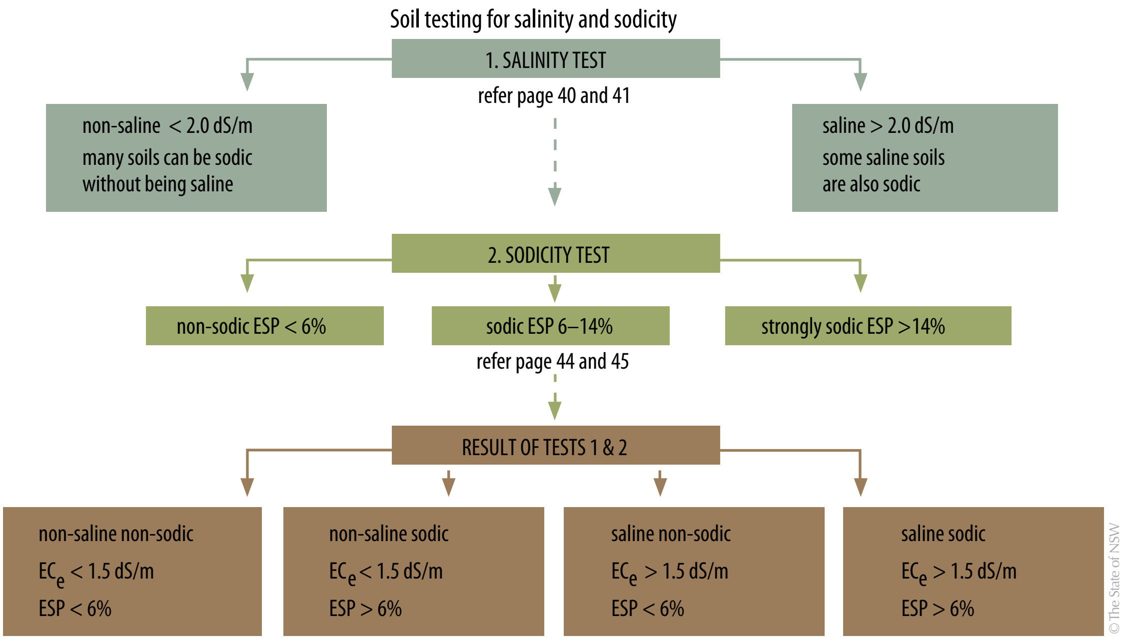
- **osmotic**: salts of any sort in a large enough quantity will prevent plants taking water from the soil
- **toxic**: specific ions may affect plants for example high chloride levels in spray irrigation water cause leaf burn
- **specific soil effects:** sodium and magnesium can destroy soil structure whereas calcium carbonate may improve soil structure (due to calcium) and soil pH (due to carbonate).
- **specific nutrient effects:** the balance of ions in soil and water can reduce plant nutrient uptake, e.g. high calcium can inhibit iron uptake and high sodium can exclude potassium uptake.

Table 5 The risk to plants and soil from different salts.

RISK	High	Anions			
	Medium	chloride (Cl)	sulphate (SO_4)	bicarbonate (HCO_3)	carbonate (CO_3)
	Low				
Cations	sodium (Na)	sodium chloride (NaCl) Table salt	sodium sulphate (Na_2SO_4)	sodium bicarbonate ($NaHCO_3$) Baking soda	sodium carbonate (Na_2CO_3)
	magnesium (Mg)	magnesium chloride ($MgCl_2$)	magnesium sulphate ($MgSO_4$) Epsom salts	magnesium bicarbonate ($Mg(HCO_3)_2$)	magnesium carbonate ($MgCO_3$)
	calcium (Ca)	calcium chloride ($CaCl_2$)	calcium sulphate ($CaSO_4$) Gypsum	calcium carbonate $Ca(HCO_3)_2$)	calcium bicarbonate ($CaCO_3$) Lime

Source: Wild, J., Howarth, C. and Conyers, M. (2004)

Soil testing for salinity and sodicity



Note
- Field tests should be backed up by laboratory tests and sound agronomic advice before management decisions are made.
- Salinity readings vary according to the soil texture. Some clay-dominated soils may not display salinity and/or sodicity constraints until values well over recommended thresholds are reached.
- It is important to note that this is a guide only and should be used with other available techniques and advice to determine appropriate management options.

Figure 24 Testing for salinity and sodicity. Source: NSW DPI (2005)

Soil sampling

Field testing for saline and sodic soils

During an initial investigation, field testing should be undertaken as a guide to the need for further, more intensive laboratory testing. Field tests allow the extent of the problem to be measured and identified quickly and easily.

Saline soils

$EC_{1:5}$ – soil can be tested in the field using a hand-held salinity meter. Field testing is useful for initial salinity testing to see if a problem exists. This soil test does not give you an 'absolute' value for soil salinity, but is useful for determining if a problem exists and monitoring any change in soil salinity over time (refer page 40).

Field texture – determining soil texture will allow you to estimate the EC_e from $EC_{1:5}$ (refer page 41 to 43).

Sodic soils

Sodicity – a simple visual dispersion test, will determine if the soil is sodic (refer page 44 to 45).

Where to sample

An auger sample taken from each of the sections indicated in Figure 25 is adequate as a first measure. For paddock sampling (refer page 39).

When using soil sampling to validate EMI surveys, take the soil samples at the depth to which the EM 38 or EM 31 measures.

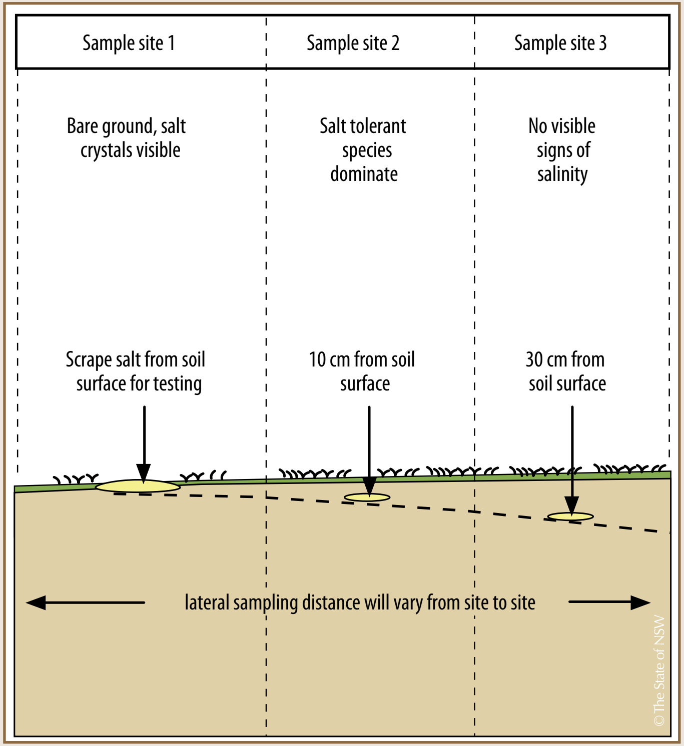


Figure 25 Soil sampling method for potential saline discharge site.
Source: NSW Agriculture (2003)

Soil sampling for laboratory tests

Why laboratory test?

Soil chemical and physical laboratory tests are carried out to verify field observations particularly when field tests indicate that soil may be saline and/or sodic.

For monitoring purposes it is advisable to collect 20 samples in a defined pattern so sampling can be repeated over time (refer Figure 26 and 27).

These samples can be bulked together for an overall picture of the paddock or left separate and tested individually for a detailed site assessment.

Collect separate samples from the saline and non saline area for comparison (refer Figure 28).

Where to sample

Refer to the following information, if available, when selecting a suitable sampling method:

- EM (electromagnetic) mapping – EM 38 or EM 31 instruments are used to estimate and map areas of high and low electrical conductivity
- aerial photos showing waterlogged or saline areas
- cut and fill maps showing sodic or saline subsoil
- visual indicators of salinity.

If none of the above are available an ‘x’ or ‘z’ pattern could be used.

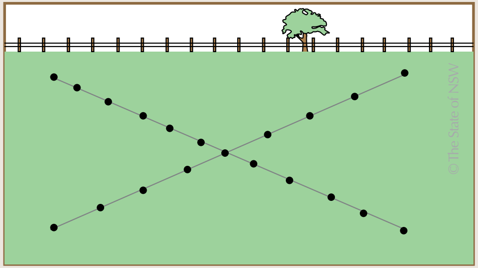


Figure 26 ‘X’ pattern for bulk sampling.
Source: NSW Agriculture (2003)

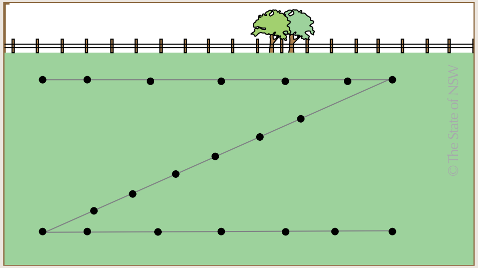


Figure 27 ‘Z’ pattern for bulk sampling.
Source: NSW Agriculture (2003)

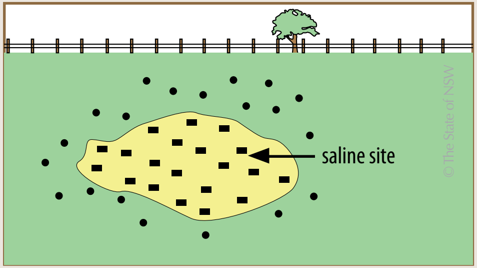


Figure 28 Sampling a potential saline site.
Source: NSW Agriculture (2003)

key ● = sampling points ▬ = saline sampling points

Determining $EC_{1:5}$

You will need the following equipment to determine soil salinity ($EC_{1:5}$):

- salinity electrical conductivity meter
- calibration solution (note: it is important to calibrate your meter regularly)
- deionised water (or rainwater)
- clear, straight sided, clean screwtop container with graduated measures (refer Figure 29).

Testing procedure

Take a soil sample from each of the sites recommended in the soil sampling diagram (refer page 38) and conduct a separate $EC_{1:5}$ test for each location.

1. Ensure each soil sample is air dried by leaving the soil sample in a warm dry room for 24 hours.
2. Crush the dried sample so there are no aggregates larger than 2 mm. Remove foreign bodies such as grass and stones.
3. Fill the container with soil to the 20 ml mark (one part soil).
4. Pour 100 ml of deionised water or rainwater into the container (five parts water)
   i.e. soil 20 ml + water 100 ml = 120 ml
5. Replace container lid and shake for at least three minutes and up to ten minutes, to ensure salts dissolve.
6. Allow sample to settle for up to ten minutes.
7. Test the solution with a calibrated salinity meter. Immerse the salinity meter in the liquid and allow the reading to stabilise.
8. Record the reading.
9. Wash the salinity meter electrodes and container with distilled water or rainwater and dry.
10. Ensure that you regularly obtain fresh calibration solution. Calibration solution becomes contaminated over time and may change concentration due to evaporation.

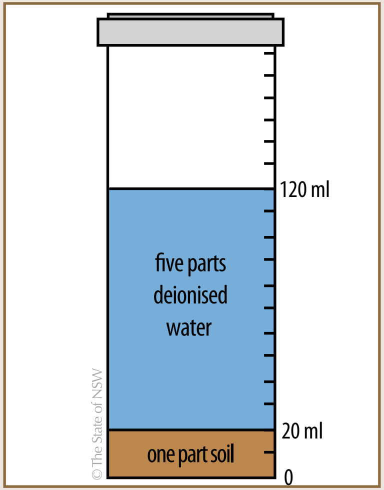


Figure 29 Clear, straight sided, clean screw top container for testing $EC_{1:5}$.
Source: Southern Salt Action Team (2003)

This measurement will not give an 'absolute' value of soil salinity. The values should NOT be used to make costly management decisions. Use the test as a guide and if you suspect there is a problem, seek advice and a more comprehensive laboratory test.

Determining EC_e

To convert soil salinity $EC_{1:5}$ to a figure for soil salinity EC_e the $EC_{1:5}$ result is multiplied by a conversion factor based on the soil-texture group of the soil sample.

1. You have already determined $EC_{1:5}$ as described on page 40.
2. Texture your soil sample (refer page 42 and 43), to determine the soil texture group.
3. Once you have identified the soil-texture group (from texturing), use the conversion factor shown in Table 6.
4. Multiply the $EC_{1:5}$ field test result by the soil-texture group conversion factor. The result will give you soil salinity in EC_e, (refer Figure 30).

Table 6 Conversion factor for soil-texture groups.

Soil-texture group	Conversion factor (multiply by)
Sand	17
Sandy loam	11
Loam	10
Clay loam	9
Light medium clay	8
Medium clay	7
Heavy clay	6

Source: Hazelton & Murphy (1992)

Step 1

Carry out $EC_{1:5}$ of soil sample

X

Step 2 and 3

Determine soil texture of sample

=

Step 4

EC_e

Multiply by the texture conversion factors in Table 6

EXAMPLE				
0.2 dS/m ($EC_{1:5}$)	X	6.7 (medium clay)	=	1.34 EC_e (dS/m) (low salinity) * Refer to page 47 for information on salinity tolerances

Figure 30 Example of the conversion of $EC_{1:5}$ to EC_e. Source: Southern Salt Action Team (2003)

Use the test as a guide and if you suspect there is a problem, seek advice and a more comprehensive laboratory test.

Determining soil texture

Texture is an estimate of the proportion of sand, silt and clay particles in a soil. To convert your soil salinity ($EC_{1:5}$) test to soil salinity (EC_e) you need to texture your soil sample.

Follow the steps below and refer to the photos opposite. Refer to the texture table on page 43.

Step 1 – Take a sample of soil that comfortably fits in your palm. Crush any clods and remove stones and plant material.

Step 2 – Moisten the soil with distilled water or rainwater. Add only a little water at a time and knead the soil into a ball about 3 – 5 cm in diameter, ensuring there are no lumps. Add more soil or water if necessary. The sample should not be too wet or dry, just uniformly moist.

Continue kneading (and moistening if necessary) until there is no apparent change in the feel of the ball. About 3 minutes should be enough. Assess the ball for coherence and feel (refer Table 7, page 43).

Step 3 – Ribbon the soil ball by pressing it between your thumb and forefinger. Attempt to keep the ribbon about 2 mm thick and continue ribboning until the ribbon breaks. Carry out this process 3 times on this soil sample.

Step 4 – Measure the length of your 3 ribbons and take an average (refer Table 7, page 43).

Plate 39 **Step 1** – Take a sample of crushed soil. Source: NSW Agriculture (2004)

Plate 40 **Step 2** – Roll the moist soil into a ball. Source: NSW Agriculture (2004)

Plate 41 **Step 3** – Squeeze a soil ribbon between thumb and forefinger. Source: NSW Agriculture (2004)

Plate 42 **Step 4** – Measure length of soil ribbon to determine texture. Source: NSW Agriculture (2004)

Determining soil texture

Table 7 Soil texturing.

Soil texture group	Coherence	Feel	Other features	Approx. ribbon length	Approx. % clay content
sand	nil to slight	sandy, gritty	unable to form a stable ball; single sand grains stick to fingers	less than 15 mm	up to 10
sandy loam	slight to just firm	sandy	sand grains can be seen and/or felt	15–25 mm	10–15
loams	firm	spongy, may be greasy	ball is soft with spongy feel; silky or sandy	approximately 25 mm	20–30
clay loams	firm to strong	smooth	ball is smooth and plastic; may be slightly silky or sandy	40–50 mm	30–35
light clays	firm to strong	plastic	smooth like soft plasticine	50–85 mm	35–45
medium and heavy clays	strong	plastic	smooth; handles like plasticine; resists rolling out and shearing	greater than 85 mm	greater than 45

Source: NSW Agriculture (2003)

Terms used in soil texture groups

Coherence: describes how the particles in the soil ball hold together.

1. **Strong:** the soil ball holds its shape well. Only a small amount of water is needed to form a ball. Clays act in this manner.
2. **Firm:** the soil ball needs water to hold together. Loams act in this manner.
3. **Nil to slight:** soil particles will not hold together or remain in a moulded ball shape. Sands act in this manner.

Feel of the ball

1. **Sandy:** ball feels gritty and coarser sand grains are visible. Fine sand grains make a grating sound as you rub the soil between your thumb and fingers.
2. **Spongy:** a feature of loam soils. High organic matter content gives spongy feel and may discolour fingers.
3. **Greasy, silky:** a smooth, soapy, slippery feel is typical of silty soils.
4. **Plastic:** the ball can be squeezed and holds its new shape strongly. Feels sticky when wet. Typical of clays.

Resistance to shearing: describes a soil's resistance to being formed into a ribbon shape. Test for resistance to shearing by placing the soil ball between your thumb and forefinger and squeeze while sliding your thumb across the soil. The soil's firmness is a good way to distinguish between light, medium and heavy clays. A light clay is easy to shear, a medium clay is stiff, a heavy clay is very stiff and often takes two hands to squeeze into a ribbon.

Determining soil sodicity

Dispersion testing

The first step to determining if a soil needs treatment for sodicity is to conduct a soil dispersion test.

Take a soil sample from each of the sites recommended in the soil sampling diagram (refer Figure 25, page 38) and conduct a separate dispersion test for each location.

1. Half fill a clear plastic test dish with deionised water or rainwater.
2. Place a few air dried (not moist) soil crumbs of the test soil (3 – 5 mm diameter) into the dish.
3. Leave dish in an undisturbed place (out of the wind, do not bump).
4. After 10 minutes score dispersion by referring to Table 8, page 45 and the accompanying Plates 43 – 46. These explain each category and suggest management options.
5. After 2 hours re-examine the soil crumbs in the test dish and score dispersion using Table 8. If the crumbs are left for two hours they may completely break down to form a cloudy halo, with just sand grains remaining. Stable soil may not show dispersion even after a day.
6. If the dispersion test described above gives a score of between 2 – 4, the soil may respond to an application of gypsum, seek specialist advice.

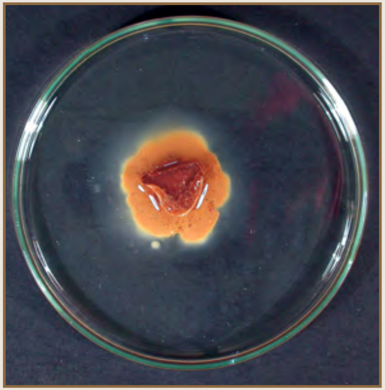


Plate 43 Slight dispersion.
Source: NSW DPI (2006)

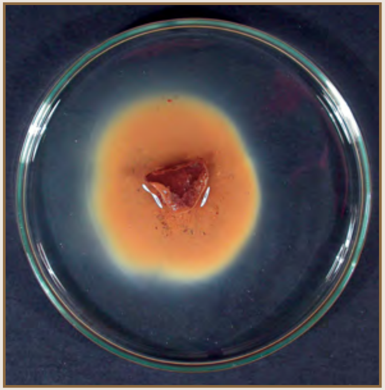


Plate 44 Moderate dispersion.
Source: NSW DPI (2006)

Determining sodicity

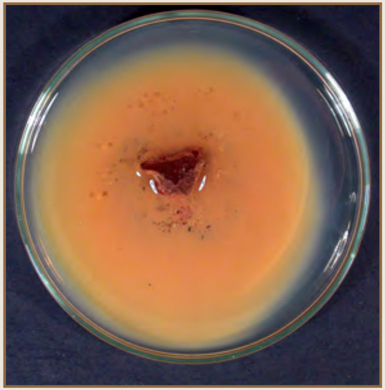


Plate 45 Strong dispersion.
Source: NSW DPI (2006)

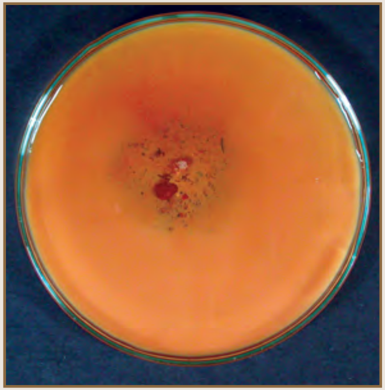


Plate 46 Complete dispersion.
Source: NSW DPI (2006)

Soil dispersion scores indicate the degree of soil sodicity. Testing for soil sodicity is an important step to guide the land manager in making sound soil management decisions.

Table 8 Interpreting dispersion scores.

Dispersion score on wetting	Observation	Results and options
0	no dispersion within 2 hours	Soil does not disperse on wetting. Unlikely to form crusts or hard blocks on drying.
1	slight dispersion within 2 hours	Unlikely to form crusts or hard blocks on drying.
2	slight dispersion in 10 minutes or strong dispersion within 2 hours	Gypsum may help stabilise any muddiness.
3	strong dispersion within 10 minutes and complete dispersion within 2 hours	A score of 3 or 4 means soil disperses easily and will form crusts or set hard. Gypsum and/or lime may reduce clay dispersion and improve structure.
4	complete dispersion within 10 minutes	

Source: NSW Agriculture (2003)

Use the test as a guide and if you suspect there is a problem, seek advice and a more comprehensive laboratory test.

Yardsticks – water salinity

Salinity yardsticks estimate the suitability of water and soil for agricultural, domestic and environmental use. Salinity levels in soil and water will vary over time and change according to weather conditions. Long dry periods may lead to an increase in salinity while rainfall may dilute salt levels.

Table 9 Water quality yardstick EC_w (water salinity).

Water quality classes	EC_w (dS/m)
Saline	> 4.8
Brackish	1.6–4.8
Marginal	0.8–1.6
Fresh	< 0.8

Source: AWRC (1976)

* Note: samples should be taken and sent to a laboratory for full chemical analysis.

Note	Irrigation water
Water used for irrigation should be sent to a laboratory for full chemical analysis and results discussed with a water quality specialist. Soil type, plant species, stage of growth, climatic conditions, types of salt and irrigation system are variables that need to be considered.	

Table 10 General yardstick EC_w (water salinity).

Water	EC_w (dS/m)
Dead sea	550.0
Sea water	50.0
Maximum for mixing herbicides	4.7
Maximum for human consumption	2.35
Desirable limit for humans	0.8
Deionised water	0.0

Source: Taylor, S. (1993)

Table 11 Animal yardstick EC_w (water salinity).

Animals	EC_w (dS/m)
Maximum drinking water for adult sheep on dry feed	23.0
Acceptable level for adult sheep on dry feed	15.6
Maximum drinking water for adult cattle	16.6
Maximum drinking water for adult pigs	9.4
Acceptable level for adult cattle	7.8
Acceptable level for adult pigs	6.6
Maximum drinking water adult poultry	5.8
Acceptable level for adult poultry	4.7

Source: Taylor, S. (1993)

Table 12 Freshwater biota yardstick EC_w (water salinity).

Freshwater biota	EC_w (dS/m)
Macroinvertebrates significant reduction	15.0
Aquatic plants upper limit for mature plants	6.2
Adult fish tolerance	4.6
Macroinvertebrates reduced diversity	3.0
Macroinvertebrates reduced emergence	3.0
Fish eggs and juveniles less tolerant	2.0
Seed germination impact on aquatic plants	1.5
Macroinvertebrates impact	1.5

Source: Nielsen, D. et al. (2003)

Yardsticks – soil salinity

Table 13 Pasture yardstick of maximum limit before yield decrease EC_e (soil salinity).

Pastures	EC_e (dS/m)
Puccinellia	25.0
Tall Wheat Grass	7.5
Couch Grass	6.9
Perennial Ryegrass	5.6
Phalaris	4.6
Fescue	3.9
Lucerne	2.0
Paspalum	1.8
Strawberry Clover	1.6
Most other Clovers (White, Red)	1.5

Source: Taylor, S. (1993)

Table 14 Commercial timber yardsticks EC_e (soil salinity).

Commercial timber	EC_e (dS/m)
Shining Gum (*Eucalyptus nitens*)	2–4
Pine species (*Pinus radiata*)	5
Blackwood (*Acacia melanoxylon*)	2–4
Tasmanian Blue Gum (*Eucalyptus globulus*)	2–4

Source: NSW Agriculture & Finnigan, J. Private Forests, Tasmania (2007)

Table 15 Crop yardstick of maximum limit before yield decrease EC_e (soil salinity).

Crops	EC_e (dS/m)
Barley	8.0
Canola	6.5
Triticale	6.2
Wheat	6.0
Oats	5.0
Olives	4.0
Peaches	3.2
Maize	1.7
Grapes	1.5
Pea	2.5
Potato	1.7
Apricot	1.6
Onion	1.2
Green bean	1.0
Poppies	0.4*
Cherries	1.3**

* Estimated figure only. ** Blaylock, AD. (1994)
Source: McMahon & Bell (1992)

Table 16 Amenity tree/shrubs yardsticks EC_e (soil salinity).

Amenity tree/shrubs	EC_e (dS/m)
Swamp Gum (*Eucalyuptus ovata*)	2–4
White Gum (*Eucalyptus viminalis*)	2–4
Silver Gum (*Eucalyptus crenulata*)	2–4
Black Peppermint (*Eucalyptus amygdelina*)	1–10*
Swamp Peppermint (*Eucalyptus rodwayii*)	2–4
Blackwood (*Acacia melanoxylon*)	2–4
Yellow Bottlebrush (*Callistemon pallidus*)	1–10*
Slender Honey Myrtle (*Melaleuca gibbosa*)	1–10*
Bracelet Honey Myrtle (*Melaleuca armillaris*)	4–8
Swamp Paperbark (*Melaleuca ericifolia*)	4–8
Tea Tree (*Melaleuca stypheloides*)	4–8
Paperbark (*Melaleuca squarrosa*)	2–8
Woolly Tea Tree (*Leptospermum lanigerum*)	1–10*
South Esk Pine (*Callitrus oblonga*)	1–10*
Sheoak (*Allocasuarina verticilata*)	4–16
Mediterranean Saltbush (*Atriplex halimus*)	1–25*
Native Saltbush (*Einadia nutens*)	1–15*

* Estimated trial figures.
Source: Marcar & Crawford (2004) : Finnigan, J. Private Forests Tasmania (2007)

It is important to note that these figures are guides only and may vary from site to site. Where figures are not available, local condition is stated.

Managing salinity

Salinity management is based on asking, **‘What parts of the hydrological cycle can we manage to reduce leakage?’**

Salinity management aims to minimise groundwater recharge by maximising plant water use to reduce leakage past the plant-root zone. Through correct vegetation management we can increase transpiration and evaporation, and decrease run-off and leakage.

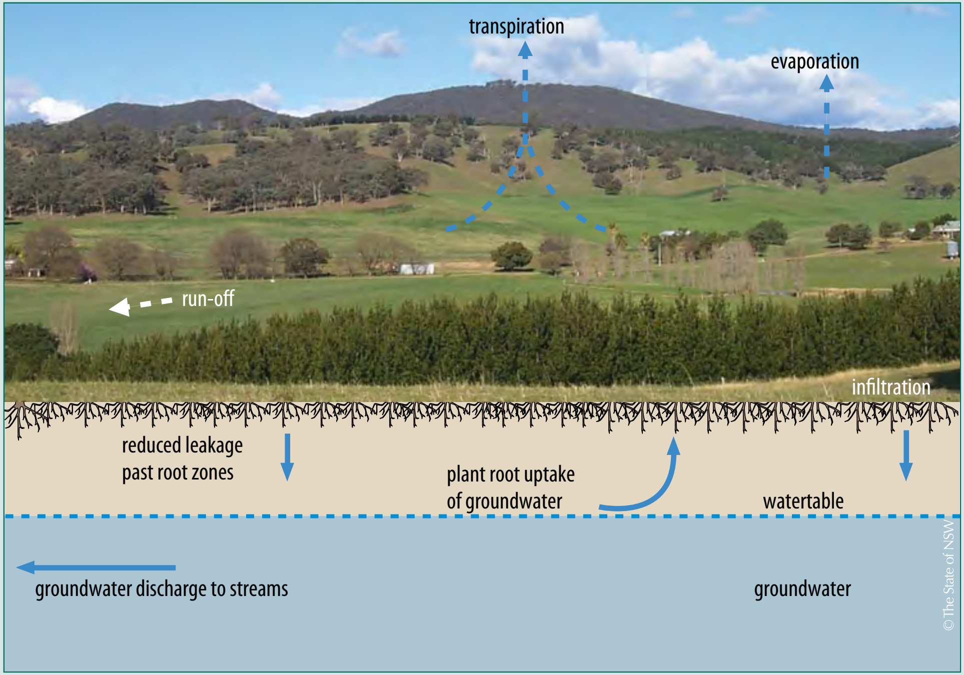


Figure 31 Parts of the hydrological cycle we can manage to reduce leakage.
Source: NSW Agriculture (2003)

Managing subsoil salinity

Subsoil salinity, mainly in the form of sodium chloride, is inherent in many parts of the landscape across the salt-affected areas of Tasmania.

Learning to live with the problem by adapting management may be the best option for dealing with subsoil salinity.

Crop rooting depth can vary significantly across most of Tasmania's cropping regions. Both chemical and physical characteristics such as salinity and waterlogging can limit effective soil depth. These sites are referred to as 'constrained'.

Understanding the impact of saline subsoils on plant growth is an important management tool. Knowing the depth of soil above these 'constraining' subsoils is important when planning future crop/pasture rotations.

Highly constrained sites are those with extremely high concentrations of salt near the soil surface. On these sites, limited only by shallow 'effective' soil depth, consider alternative land uses including forage crops and permanent pasture. Some native grass pastures are well adapted to these environments.

Paddock management options

- Minimise fallow length to allow for the reduced amount of rain required to refill the 'effective' soil profile. Constrained sites have a smaller 'bucket' to fill as soluble salts prevent crop roots from accessing moisture at depth.
- Match farming inputs (seed, fertiliser, chemical) to yield potential. There is no use over applying inputs to areas with low potential. The use of EMI technology and yield maps can help create paddock management zones for reduced inputs.
- Barley and wheat are the best adapted winter crops for growing in saline subsoils. Varietal differences exist for **salt tolerance**.
- Summer crops and oilseed crops play a key role in rotations on constrained sites.
- Disease and weed management are essential along with crop rotations to avoid growing the same crop type in the following season.
- Use wide row or skip row spacing to account for the limited rooting depth on constrained sites.

Plate 47 A crop species and variety evaluation near Garah, NSW. These trials help determine the crops most suitable for constrained subsoils. Source: Schwenke, G. (2005)

Managing soil sodicity

Soil sodicity can result in hard layers of soil that are impenetrable to plant roots and limit the plant-available water content (PAWC) of the soil. Long-term aims in managing sodicity are to replace exchangeable sodium with calcium and increase organic matter content which is a soil binding agent.

Incorporate organic matter

As it breaks down, organic matter produces humus which binds clay particles into larger aggregates. This improves soil structure and promotes soil organisms. Best practices include:

- Crop and pasture selection – select deep rooted species promoting efficient water use and nutrient cycling. Permanent pastures contribute organic matter as leaves and roots breakdown. Species with extensive root systems also break up clay and create root channels for air and water movement.
- Stubble retention – burning stubble destroys surface organic matter and soil organisms. Ploughing in stubble destroys old root channels.
- Green manure crops – these add large quantities of organic matter to the soil as slashed materials break down over time.
- Rotations – rotating crops and pasture helps build levels of organic matter. Pasture phases must be long enough to allow roots time to improve soil structure.
- Conservation farming – sustainable farming practices such as minimum tillage and direct-drill sowing into crop stubbles can promote soil health and organic matter and conserve soil structure.
- Deep ripping of sodic soils should be minimal or avoided if possible, to prevent the incorporation of sodic subsoils into surface soils.

Replace excess salts

While sodium causes clay particles to disperse, other salts such as calcium are beneficial to soil structure. The application of gypsum (calcium sulphate) allows the replacement of sodium cations with calcium, causing flocculation (refer page 10). Calcium rich clays are less prone to swelling and dispersion.

Plate 48 Direct-drill sowing via controlled traffic into the previous season's crop stubble helps build organic matter and reduce physical soil disturbance. Source: Rowling, L. (2005)

Dryland salinity management

Dolerite landscape management

Dolerite landscapes tend to have complex fractured geology. The level of fracturing, weathering and landscape relief determines the rate of lateral groundwater flow or storage in the more permeable **regolith**. Vegetation may be placed to both intercept this lateral flow and reduce recharge.

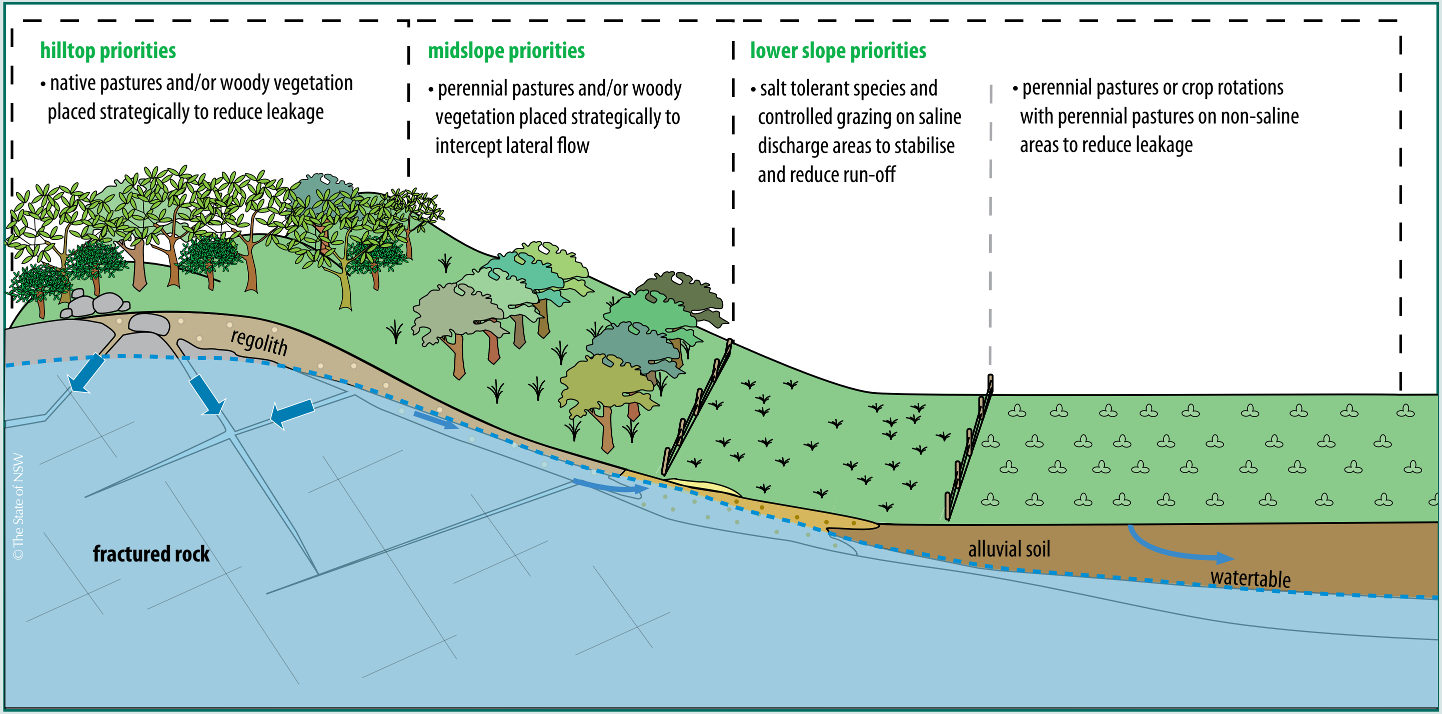


Figure 32 Dolerite landscape vegetation options for salinity management. Source: Adapted from Walker, Gifelder & Williams (1999)

Dryland salinity management

Layered/fractured landscape management

Layered/fractured landscapes tend to have fractured geology. As a result, groundwater may fill and flow through both the bedrock and regolith. Vegetation should be placed to reduce recharge as a first priority.

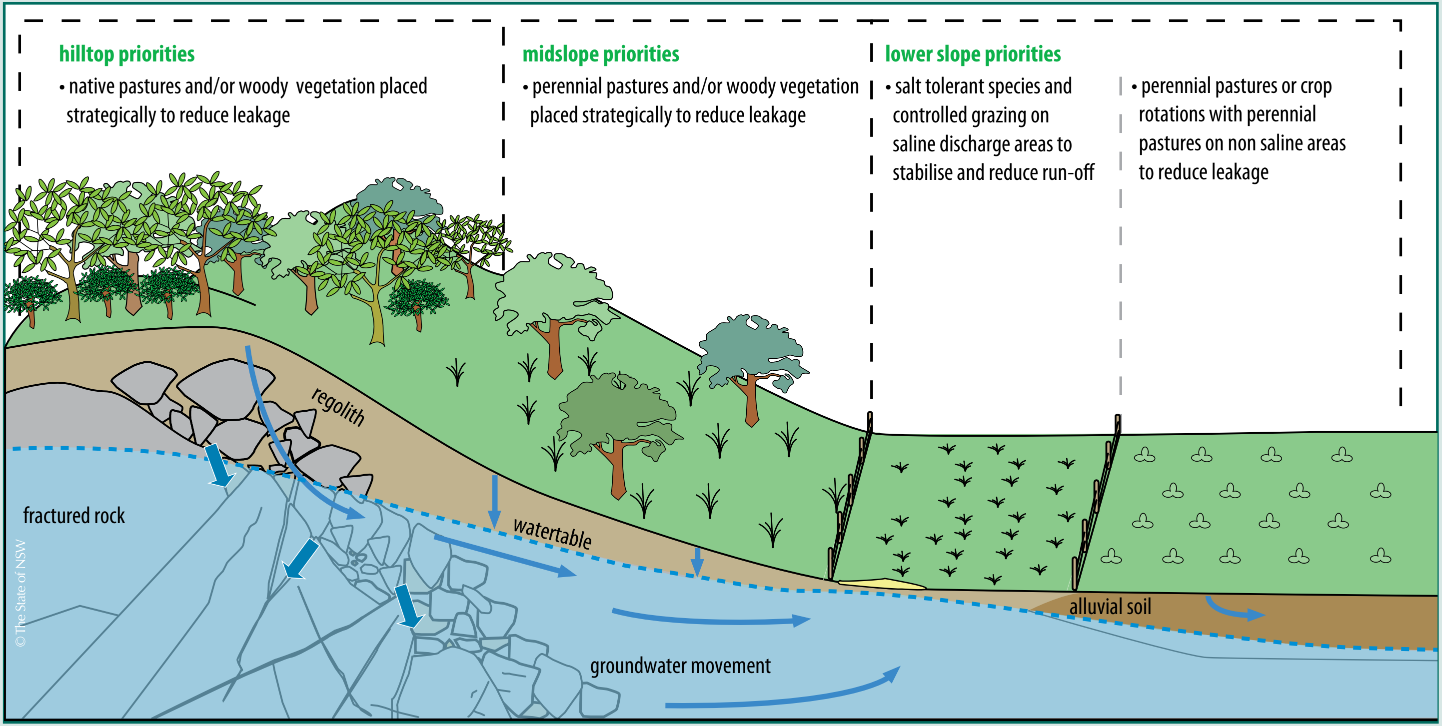


Figure 33 Layer/fractured landscape vegetation options for salinity management. Source: Adapted from Walker, Gifelder & Williams (1999)

Irrigation salinity management

Unconsolidated landscape management

Soils in unconsolidated landscapes tend to consist of layers of sediments that vary in size from coarse gravels to clays. The aim is to reduce leakage by efficient irrigation management and effective surface drainage. Increasing perennial vegetation cover across the landscape will also reduce recharge. Drainage should be carefully considered, taking into consideration off-site impacts, disposal, soil sodicity etc. Specialist advice should be sought prior to implementing some irrigation management activities, such as groundwater pumping. Groundwater pumping is not a viable solution in many of Tasmania's saline agricultural regions.

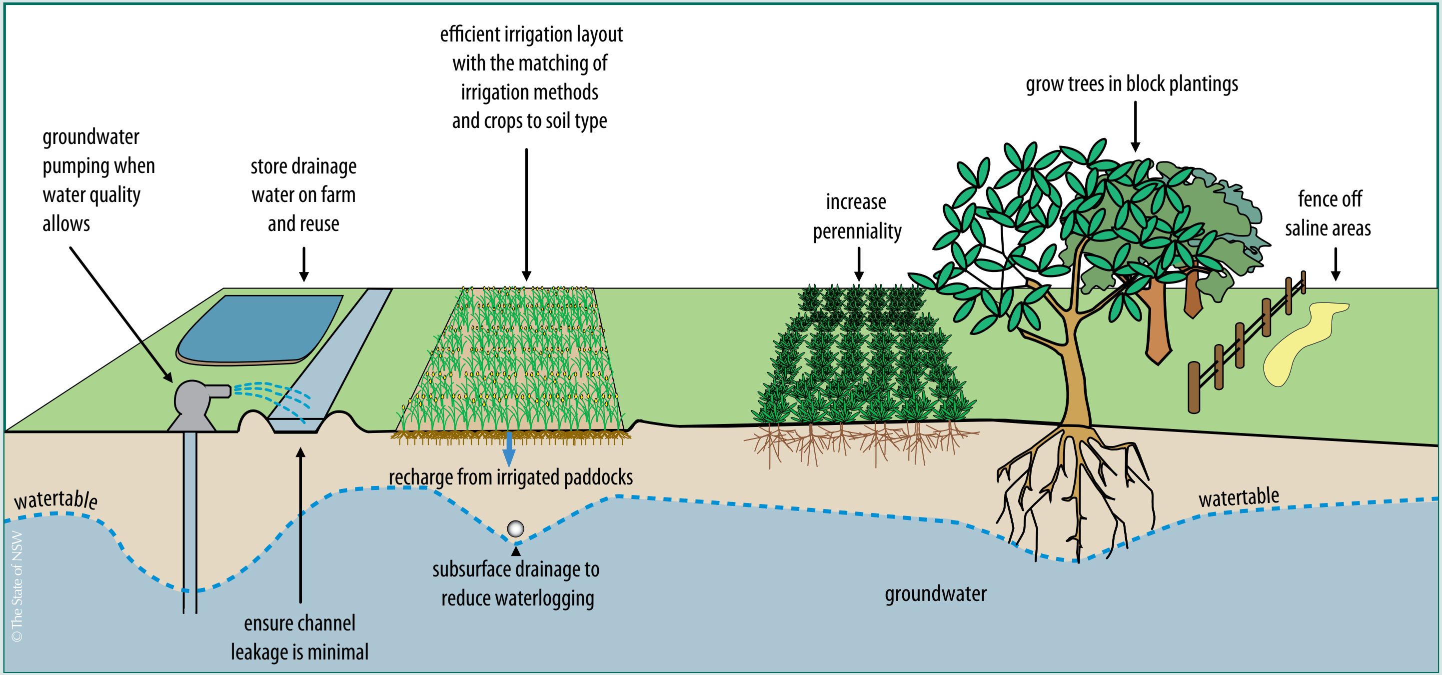


Figure 34 Recharge control in unconsolidated landscapes. Source: Southern Salt Action Team (2003)

Management – irrigation and drainage

Some irrigation practices and paddock layouts result in too much water being applied to the land which increases recharge rates and wastes valuable water.

Recommended practices for irrigation management include:

- Matching irrigation timing or water scheduling to soil type and crop requirements.
- Monitoring the soil water status of paddocks.
- Rapid watering and draining of paddocks to limit leakage.
- Recycling drainage water. Property Management Plans need to consider how drainage water should be managed to minimise potential adverse effects on the environment.
- Minimising leakage from distribution channels and reservoirs.
- Regularly monitor the quality of your irrigation water prior to application.
- Regularly monitor the quality of your on-farm water storages prior to use.

Recommended practices for irrigation design include:

- Using efficient irrigation technologies for general irrigation, for example micro-jets, drip and sub-surface irrigation where appropriate.
- Undertaking soil surveys of paddocks to match crop to soil type before designing irrigation systems.

Plate 49 Centre pivot irrigation, northern Tasmania.
Source: Finnigan, J. (2008)

Plate 50 Irrigated centre pivot cropping, northern Tasmania.
Source: Private Forests Tasmania (2008).

For further assistance contact your local NRM organisations, DPIPWE, or your local adviser.

Urban management

Overwatering lawns and gardens can lead to excessive leakage. Some urban areas show evidence of developing salinity. A number of activities may be promoted in urban areas to avoid excess leakage.

Recommended management practices include:

- practising water conservation techniques by matching plant needs to water application
- using tap timers to avoid overwatering
- mulching to protect the soil and plants from evaporation
- repairing leaky water and sewerage mains
- reducing the need for irrigation by using waterwise plants and reducing lawn areas
- removing storm water infiltration devices such as rubble pits
- selection of suitable vegetation species matched to the local environment (**endemic** natives)

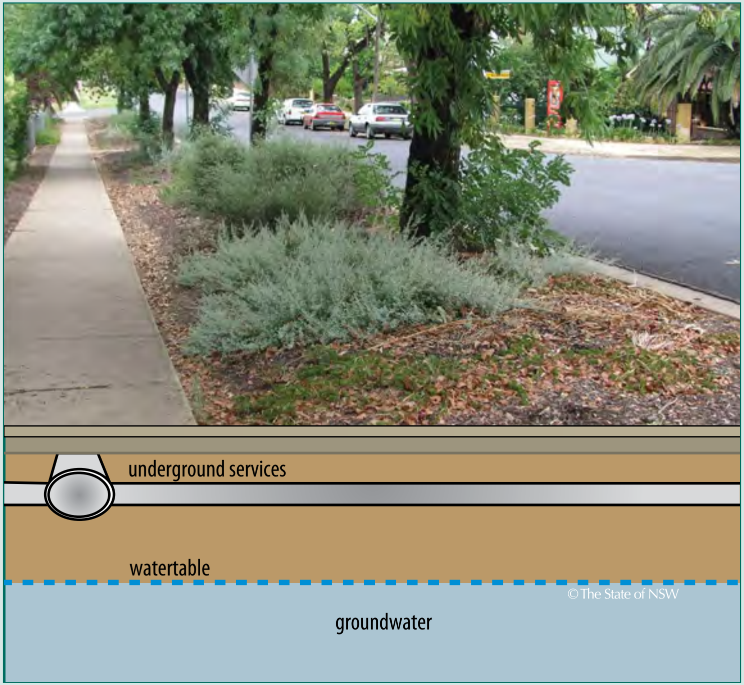


Plate 51 A waterwise nature strip is part of urban salinity management in Wagga Wagga, NSW.
Source: Southern Salt Action Team (2004)

For further assistance contact your local NRM organisations, DPIPWE, or your local adviser.

Management – urban development

The urban environment

The design, construction and management of storm water, town water and sewerage systems, road networks, buildings, parks and gardens may impact on salinity processes.

Many of these urban activities result in changes to the landscape. Two examples are:

- The soil profile is altered by cut, fill and compaction of soil for new developments.
- The hydrological cycle is affected by increased recharge rates due to lateral and vertical movement of water through the soil.

These changes affect the volumes, movement and stores of water and salt in the landscape. Management of urban salinity therefore includes limiting adverse changes to the hydrological cycle as well as designing the urban landscape to minimise salinity impacts.

Recommended management practices include:

- conducting site investigations to understand salinity processes
- carry out strategic landuse planning that considers land and water issues including salinity
- consider salinity and waterlogging in the design, construction and maintenance of infrastructure (adhering to building standards)
- limit landscape changes that may contribute to salinity development such as cut-and-fill and changes to natural drainage patterns

For further local information, refer to the urban salinity Code of Practice, found in Armstrong, D. (2007) *Salinity Management Plan for the Greater Launceston Area.*

Plate 52 The NSW Local Government Salinity Initiative includes a series of booklets to aid the identification, understanding and management of urban salinity. These booklets are available from the NSW Government Online Shop, search under salinity. Source: Urban Salt Action Team (2004)

Management – native perennial pastures

Perennial native pastures are the most important component of native pastures and cover many parts of the landscape. They are drought tolerant and efficient water users and can therefore play an important role in recharge control.

Due to the expense and difficulty of re-establishing native pastures it is important to maintain existing native pastures.

Recommended management practices include:

- controlling weeds and pest animals
- strategically graze native pastures to encourage species diversity, seedling recruitment, seed set and efficient water use
- providing a number of watering points to utilise pasture to minimise overgrazing, tracking and erosion problems
- maintaining groundcover between 70%–100% to reduce soil erosion
- increasing stocking rates on fertilised native pastures in early spring to prevent smothering of native perennials by winter growing annuals

For more detailed information regarding Tasmanian native pastures, refer to Mokany et al. (2006).

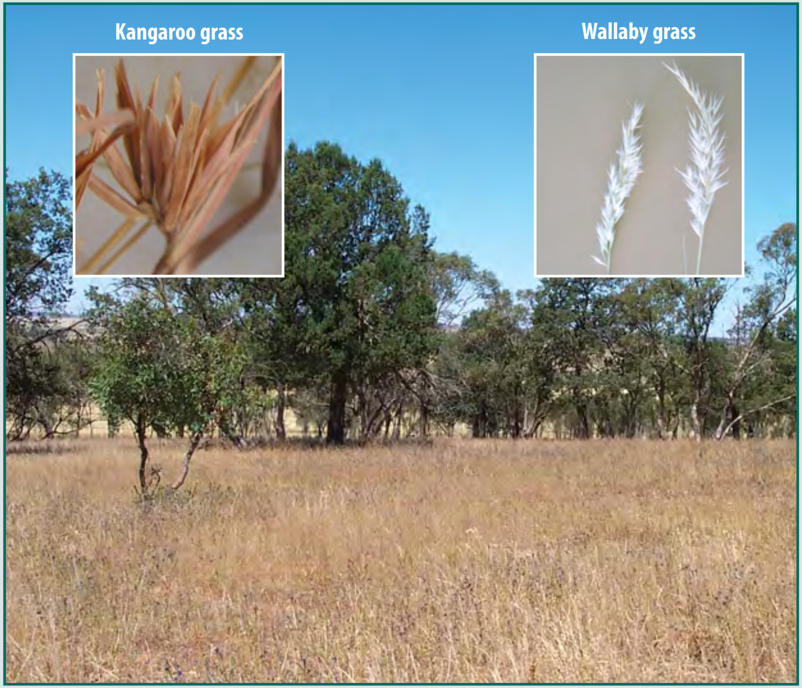


Plate 53 Native grasses can survive in low fertility soil and use summer rainfall effectively.
Source: Southern Salt Action Team (2003)

For further assistance contact your local NRM organisations, DPIPWE, or your local adviser.

Management – introduced perennial pastures

Recommended management practices include:

- establishing pastures using minimum tillage to reduce soil erosion
- using a mix of pasture species with differing growth periods to maximise water use throughout the year
- establishing well-managed, summer-active vegetation such as lucerne and tall fescue (where appropriate) to create a **dry soil buffer** prior to winter
- addressing other soil limitations such as acidity, through the use of acid tolerant species and **ameliorants** (for example lime)
- maintaining soil fertility for pasture productivity and profitability through regular fertiliser application
- managing grazing (for example Prograze™ principles) to maximise plant growth and water use throughout the year
- maintaining groundcover of at least 70% and up to 100% on steeper slopes, to reduce the risks of soil erosion
- controlling weeds, pest animals and insect pests such as surface feeding cockchafers and corbies
- ensuring stock have enough watering points to prevent tracking, over grazing and to better utilise pasture growth.

Prograze™ is a grazing management skills course for sheep and beef producers. The course links pasture and animal management skills to improve grazing decisions and more effectively meet production and sustainability goals.

Plate 54 Phalaris mixed with strawberry clover and ryegrass. Deep-rooted phalaris helps dry the soil profile and reduce leakage. Source: Southern Salt Action Team (2003)

Plate 55 Lucerne growing on mid slopes above a wheat crop in a granitic landscape, NSW. Source: Southern Salt Action Team (2003)

Management – trees

Well planned and strategically located forest plantings can play a significant role in addressing the hydrological imbalance that leads to dryland salinity in some landscapes. On individual farms planting trees could impact on local, intermediate and even regional hydrological systems.

Trees are relatively deep rooted and can reduce leakage and enhance the use of groundwater. They are capable of using water all year round and can intercept a significant fraction of rainfall before it passes the active plant root zone.

Targeted tree planting for multiple benefits include linking remnant woodlots, alley farming, shade and shelter belts, windbreaks and forage shrubs.

Designing and targeting tree planting for salinity control requires an understanding of key hydrological features on a farm including:

- the scale (local or intermediate) of the groundwater system that the planting will influence
- the discharge capacity of the groundwater system
- how recharge rates vary across the farm and catchment
- the salinity of the groundwater.

Strategic tree planting can contribute significantly to controlling rising watertables and subsurface flow through an increased use of water in the landscape. Tree planting must be targeted so as not to reduce fresh water movement in catchments.

Targeted tree planting options include:

- recharge plantings – tree planting in targeted recharge areas
- interception plantings – tree planting to intercept subsurface lateral water flows and in break-of-slope positions
- discharge site planting – revegetation using **saltbush** to reduce saline sub-surface flows and surface run-off
- irrigation plantings – planting trees to utilise groundwater or the drainage water from other irrigated crops.

For further local information refer to Finnigan & Poulton (2005).

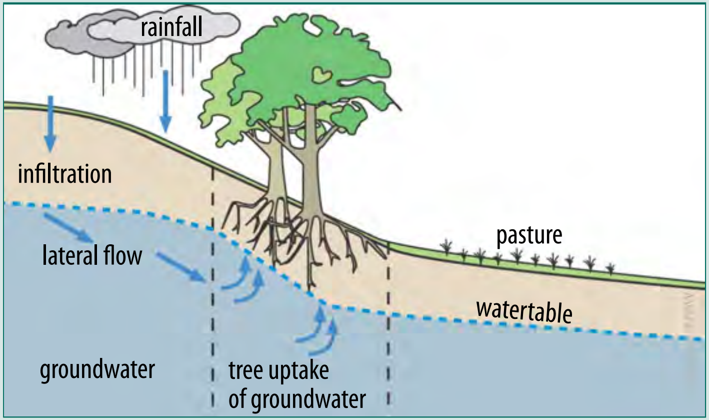


Figure 35 Tree belts strategically placed at the break-of-slope can capture water flow. This may reduce waterlogging and salinity in the lower landscape.
Source: NSW Agriculture (2003)

Management – native vegetation

Native vegetation consists of trees, shrubs and groundcovers and has a key role in salinity management. The most suitable native plants are local (endemic) species as they have adapted to local conditions such as climate, soils and pests. Retaining or replanting native vegetation in appropriate areas within a catchment can help manage salinity by reducing leakage to the groundwater system. Native vegetation provides the additional benefits of providing shade and shelter, controlling wind and water erosion, increasing biodiversity and recycling minerals.

A property's revegetation program can be designed to link isolated areas of **remnant vegetation** with corridors and gain wildlife refuge, wind break, and salinity control benefits.

Plantings can also be set out for commercial benefits such as farm forestry.

Planting of native vegetation above salinity discharge sites to control lateral flow of groundwater can be effective.

Recommended management practices include:

- fencing areas for protection from stock
- planting endemic species that are suited to the local conditions
- judicial grazing management to exclude stock during native plant flowering and seeding times
- controlling weeds and pest animals.

Plate 56 Strategic planting of native plant species can assist in salinity management.
Source: Southern Salt Action Team (2004)

For further assistance contact your local NRM organisations, DPIPWE, or your local adviser.

Management – crops

Recommended cropping management practice aims to reduce leakage to the groundwater system by maximising plant water use and soil health.

Recommended management practices include:

- selecting crops to fit rotation requirements and salinity conditions.
- avoiding the use of long **fallowing** to minimise the risk of leakage to groundwater systems
- changing from a fixed or set cropping rotation to a flexible system
- retaining stubbles to reduce erosion and increase soil organic matter
- controlling traffic to reduce compaction and increase efficiency of operations
- maintaining satisfactory levels of fertility for maximum crop growth
- adopting weed management practices that are effective and prevent herbicide resistance
- using perennials such as Lucerne in the rotation to dry the soil profile and create a buffer against excess leakage in the cropping phase
- practising response **(opportunity) cropping** – a strategy to use stored soil moisture when it occurs rather than having a set (winter) cropping sequence.

Plate 57 Lucerne in rotation with wheat increases the perennial pasture component and creates a dry soil buffer zone. Source: Southern Salt Action Team (2003)

Plate 58 Healthy well managed wheat crops reduce leakage during the growing season. Source: Southern Salt Action Team (2003)

For further assistance contact your local NRM organisations, DPIPWE, or your local adviser.

Management – drainage

Drainage is an important step in the management of saline and waterlogged soils. Waterlogging causes oxygen deficiencies in soils, impacting on plant survival and growth. Waterlogging can also damage the ability of plant roots to exclude salt uptake. This can double or triple the effect of salinity in some cases, further decreasing plant survival.

Installation of appropriate drainage can lead to marked improvements in plant growth and survival, however consideration must be given to potential off-site impacts. The formation of **raised beds** in areas prone to waterlogging also helps to increase plant health and crop yield.

Questions to consider prior to drainage installation include:

- Are your soils sodic?
- How saline is your drainage water?
- Where is your drainage water going to?
- Will salinity levels impact on freshwater biota?
- Do I need surface or subsurface drains?
- Are surface drains likely to cause soil erosion?
- Can I legally drain water off this land?

Plate 59 Spoon drain installed to direct surface water off a paddock, northern Tasmania. Source: Finnigan, J. (2008)

Plate 60 Formed raised beds help provide drier soil conditions in areas prone to waterlogging. Source: Finnigan, J. (2008)

For further assistance contact your local NRM organisations, DPIPWE, or your local adviser.

Discharge site management

An integrated approach

Discharge site management should be carried out in conjunction with the management of recharge and groundwater movement throughout the landscape. Discharge sites can be managed to make use of accumulated surface water and groundwater. Salt tolerant pastures tap into excess moisture and can be utilised as a green or 'out of season' feed resource.

Options for treatment include:

- controlling soil and salt movement from the site using structural earthworks, for example **diversion banks**
- fencing off and de-stocking the area until groundcover is established
- planting **perennial** pastures, for example lucerne and/or salt tolerant trees and shrubs where salinity levels allow
- mulching scalded areas to reduce the evaporation and concentration of salt. This also assists vegetation establishment and prevents soil erosion
- building mounds and/or raised beds in rows on wet saline sites to reduce the impact of waterlogging and salt concentration on trees and shrubs for establishment
- selecting suitable salt tolerant species – (refer Table 17, page 64)
- grazing strategically to maintain the perennial groundcover that has been established
- grazing only when the site is dry to prevent pugging and compaction by livestock
- maintaining fertility through regular fertiliser application
- controlling invasive weeds prior to establishment
- taking opportunities to sow when sites are dry enough to handle machinery.

Plate 61 Addressing saline discharge sites through the establishment of saltbush on widely-spaced mounds. Source: Finnigan, J. (2008)

Plate 62 Mildly saline discharge site sown to salt tolerant pasture, northern Tasmania. Source: Finnigan, J. (2008)

Pasture mixes for discharge sites

Discharge sites vary in their severity of salinity. When sowing a pasture into saline sites it is best to sow a range of species. This allows for the various species to establish in the areas most suited to their growing requirements. The following table lists the various salt tolerant pasture species most commonly used for discharge sites in Tasmania. The mix of species used and the rate of sowing is variable, dependant on specific site conditions. Soil tests are recommended prior to species selection for successful site establishment.

Other pastures species and shrubs that may be incorporated into a salt tolerant mix include Perennial Rye Grass and Mediterranean Saltbush. While Perennial Rye Grass has moderate salt tolerance it is important to note that seedlings are very vigorous and will out-compete the other grass species. Mediterranean Saltbush seedlings establish well in saline areas of Tasmania. It is recommended that seedlings are planted into mounds to reduce the impact of waterlogging on survival.

Tall Wheat Grass has been quite successful in rehabilitating saline soils across many areas of Tasmania. A review of the potential invasiveness for this species now recommends its use with caution. Avoid planting in a buffer zone at least 20 metres wide adjacent to waterways, wetlands and stands of native vegetation and importantly, actively manage grazing so that plants do not set seed. Seek advice from DPIPWE weeds officers prior to purchasing seed.

Strawberry Clover and some Fescue cultivars are summer active and can provide high quality green feed during summer. They can be highly productive due to the added soil moisture in discharge areas. You could view shallow groundwater as sub-surface irrigation for these species.

Table 17 Pasture species suitable for discharge sites. Note: Use only one cultivar per species

Species	Salinity tolerance levels, EC_{se} (dS/m)
Puccinellia	> 25 Highly tolerant
Tall Wheat Grass cv Dundas (preferred variety)	12–25 Highly tolerant
Summer active Fescue cv Advance, Au Triumph, Demeter, Quantum	< 10 Tolerant
Winter active Fescue cv Fletcha, Prosper, Resolute	< 10 Tolerant
Strawberry clover cv Palestine, Onward	< 10 Tolerant
Balansa clover cv Bolta, Frontier	< 8 Moderate
Persian (Shaftal) clover cv Nitro plus, Prolific, Lusa	< 8 Moderate
Phalaris cv Australian, Sirosa, Holdfast, Uneta, Landmaster	< 6 Moderate

Sources: Borg, D. (2005) and Hall, E. (pers. comm., 2007) Tasmanian Institute of Agricultural Research.

Management

Management of salt tolerant pastures should include fertiliser application which can improve both germination and growth. Saltland pastures typically respond well to nitrogen applications and potassium may also increase the palatability of saltbush to sheep.

Importantly, newly established salt-tolerant pastures are best not grazed within the first 12 to 18 months to allow the plants to set seed.

For further information, refer to Knox, Thompson & Campbell, S. (2006) and Barrett-Lennard, E. (2003).

For further assistance contact your local NRM organisations, DPIPWE, or your local adviser.

Integrated salinity and property planning

A Property Management Plan assesses your goals, the environment, water and soil resources, finances and social issues.

A **Salinity Management Plan** summarises all relevant information, determines causes of salinity and salinity risk to your property and, in consideration of current farming practices, provides recommendations for appropriate salinity management. User friendly maps help to spatially interpret this planning information.

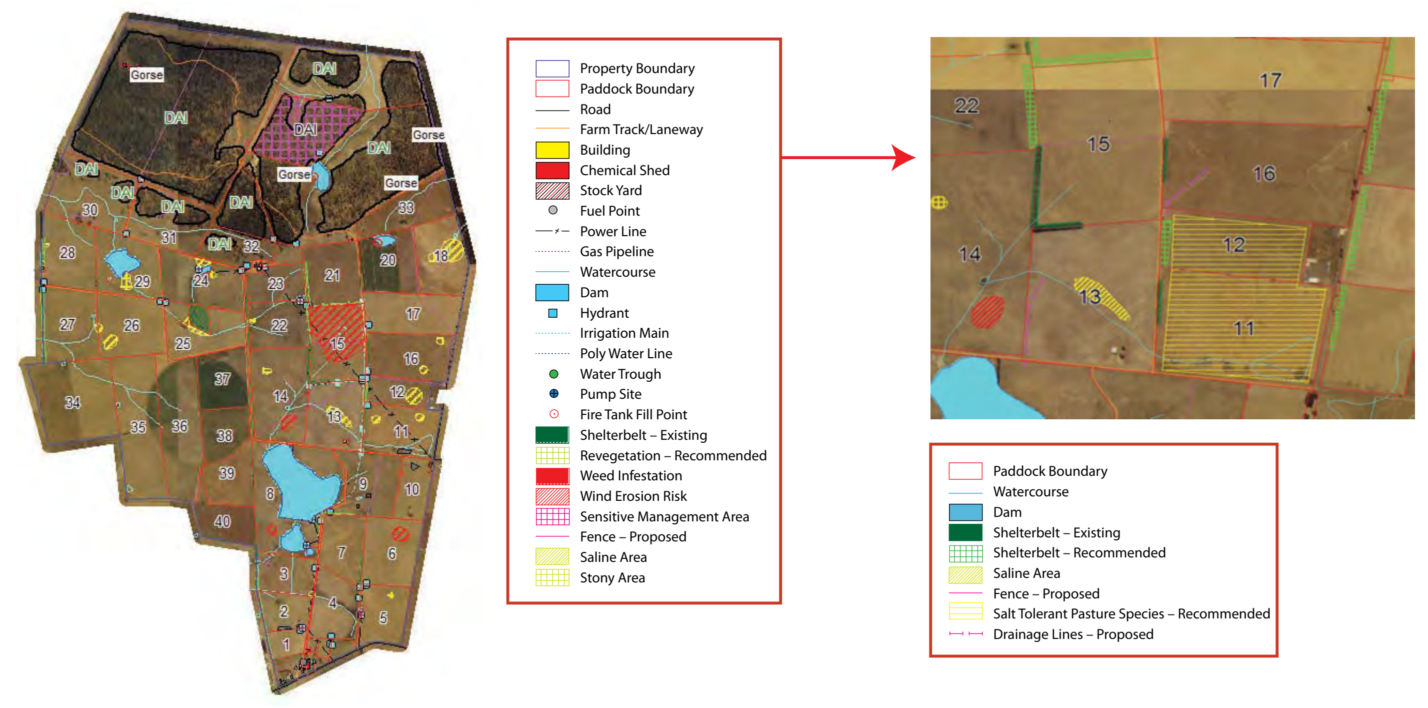


Figure 36 Integrating salinity and property management planning.

Salinity management options

What I need to do!

- monitor groundwater and surface water conditions
- monitor stored water/irrigation water quality
- test soils for salinity and sodicity
- increase perennial vegetation cover
- sow salt tolerant pasture species in saline areas
- choose crop rotations carefully
- improve drainage of wet or waterlogged areas
- maximise soil health and sustainability
- manage native trees, shrubs and grasses for salinity and biodiversity outcomes.

Value to the landholder

- **improved knowledge of natural resource condition**
- **increased ability to manage change effectively**
- **increased biodiversity**
- **provision of green feed during dry months**
- **better use of rainfall across the property**
- **increased pasture and livestock production**
- **reduced erosion potential**
- **maintained or improved quality of on-farm water resources.**

Glossary of terms

The glossary of terms has been written for the target audience and may not always follow strict hydrogeological definitions.

Aeolian salt
Salt attached to soil particles which are transported by wind.

Agro-forestry
Land management practice in which farmers cultivate trees in addition to other agricultural activities.

Alluvial
Sediments transported by running water (for example rivers) and deposited in low lying areas and flood plains.

Ameliorant
A substance used to improve the chemical or physical qualities of the soil. For example, the addition of lime to increase pH to the desired level for optimum plant growth.

Anion
A negative ion.

Annuals
Plants that live for one growing season.

Aquifer
A saturated layer of rock or sediment that allows water to move through it. It is permeable enough to allow extraction of economic quantities of water through bores, wells and springs.

Baseflow
Groundwater that discharges into surface waterways such as streams and lakes.

Break-of-slope
The zone down a slope at which the gradient of the slope changes.

Buffer
The property of a soil profile that moderates or prevents infiltration from becoming leakage. The capacity of a soil profile to act as a buffer against leakage is a product of its soil water holding capacity and its dryness prior to a wet episode.

Calibrate
The process carried out on measuring equipment to ensure that all readings taken are aligned to a predetermined standard.

Calibration Solution
A solution of specific chemical composition used to calibrate conductivity meters. This is important for validating soil and water salinity measurements.

Capillary rise
Upward movement of water (and all that is dissolved in it) in the soil due to surface tension in soil pores. Similar to the way water moves up into a dry sponge.

Catchment
The area of land drained by a river and its tributaries.

Cation
A positive ion.

Colluvial
Sediments transported and deposited by gravity, usually found at the base of slopes.

Connate salt
Salt trapped in the pore space of sediment at the time of its deposition.

Convex
Slope with a rounded, outward bulging appearance.

Cyclic salt
Seasalts from ocean spray or pollution dissolved in rainwater and deposited inland.

Deionised water
Water that has had all ions and impurities removed.

Discharge
Flow of groundwater from the saturated zone to the unsaturated zone, land surface, or surface water body. This can happen via springs, seepage or through evaporation or transpiration.

Discharge area
The area from which the groundwater is discharged.

Glossary of terms

Dispersion
The process in which soil aggregates (crumbs) break down into their component parts (sand, silt and clay) when they become wet.

Diversion banks
Small banks to divert water from one area to another. Used to intercept surface run-off to protect drainage lines and earthworks from erosion, and to prevent water running across saline sites and moving salt.

Dolerite landscape
A landscape predominately consisting of dolerite material.

Drainage lines
Lowest point in the landscape down which run-off and surface drainage will flow. Can be natural or constructed.

Dry soil buffer
Is where a dry soil has the ability to store water and reduce leakage to the watertable.

Dunes
A hill or rise of sand and sandy sediments shaped by aeolian processes.

Duplex soils
Duplex soils display a strong contrast between the topsoil and subsoil layers, with the topsoil depth and texture varying greatly across paddocks. Duplex soils are quite common throughout much of Tasmania's salt affected regions.

Electrical conductivity (EC)
The ability of a substance to conduct electricity. The most widely used and convenient method of measuring the salinity of water is by electrical conductivity. The reading depends on concentration and composition of dissolved salts present.

Endemic
Plant that are native to the subject location.

Evaporation
The process of water changing from a liquid to vapour (gas).

Evapotranspiration
The movement of water to the atmosphere from combined sources of vegetation, soil and water bodies.

Exchangeable sodium percentage (ESP)
Commonly used as a measure of soil sodicity, ESP is the proportion of sodium absorbed onto the clay mineral surfaces as a proportion of total cation exchange capacity, expressed as a percentage.

Fallowing
The practice of leaving land without vegetative cover for a period of time before sowing a crop. Its purpose is to allow moisture and nutrients to accumulate in the soil.

Flocculate
Where clay particles stick together by positively charged cations such as calcium and magnesium.

Fractured rocks
Rocks that have deformed by cracking. The resulting fractures and joints provide space for groundwater storage and movement.

GPS
GPS refers to Global Positioning System, a fully functional Global Navigation Satellite System using many satellites to determine location, speed, direction and time. GPS was developed by the United States Department of Defence.

Groundwater
Subsurface water in the saturated zone, including water occupying pores, cracks and voids in soil and rock material.

Groundwater discharge
Removal of water from the saturated zone. Water exits the groundwater by surface seepage, baseflow and lateral flow in streams, evaporation and evapotranspiration.

Groundwater flow
Refers to the movement of groundwater through an aquifer.

Groundwater mound
Watertable bulge caused by excessive leakage over time from a confined area. For example under a lake or irrigation area.

Groundwater recharge
Water entering the groundwater from the saturated zone immediately above the watertable.

Groundwater system
The term groundwater system refers to the underground section of a hydrological system, including areas where water enters, is transmitted, stored and departs.

Halophyte
A terrestrial plant adapted to grow in saline environments.

Hydraulic head
A specific measurement of water pressure above a certain location, such as suface water elevation measured from the base of a piezometer.

Hydrogeology
The science that deals with subsurface water including the geology of water bearing rocks and the chemistry, physics and movement of groundwater.

Hydrological cycle
Collection of processes by which water moves from the atmosphere to the earth and back again.

Hydrology
The study of surface water and groundwater movement.

Impermeable
Layers of soil or rock which do not allow water to penetrate are called impermeable.

Indicator plants
Plants that are adapted to growing in saline environments and often replace existing species as the salinity level of a site increases. Their presence can be one of the early indications of salinity problems.

Infiltration
Surface water entering the soil profile and soaking downwards.

Ions
An ion is an atom or molecule that can have a positive or negative charge depending on the number of protons or electrons attached.

Landscape
An area of land and its physical features. A term that we use to describe an area that has common features.

Lateral flow (through flow)
Movement of groundwater laterally in the soil profile rather than vertical movement that results in rise and fall of watertables. Usually associated with slope or changes in hydraulic head.

Layered/fractured sediments
Commonly mudstones and sandstones that feature geological fracturing from faulting and folding.

Leakage
The movement of water downwards though the soil past the plant root zone or from below water bodies.

Monitoring bore
A pipe placed into a groundwater system to measure the level of the groundwater, and to allow collection of groundwater samples and geophysical data.

Native vegetation
Areas of plant communities within the landscape that have remained untouched, indicative of plant communities that existed prior to land clearing.

Opportunity cropping
The practice of sowing crops whenever soil water reserves are adequate.

Osmotic
The osmotic effect salt has on plants refers to the higher concentration of salts in the soil compared to the plant, causing water to move from the plant cells into the soil in order to balance the salt levels. This effectively leaves plants in highly saline areas suffering from lack of water.

Organic matter
The remains of plants and animals. Organic matter is important to both the physical and the chemical properties of the soil. It helps bond soil particles together, creating and maintaining soil structure.

Palaeozoic
One of the oldest geological eras dating back between 542 and 251 million years ago.

Glossary of terms

Perched watertable
A local watertable that sits above a low permeability layer of very limited extent such as clay, shale or unfractured rock that separates it from a deeper regional watertable.

Perennial
A plant that lives for several growing seasons.

Perenniality
The degree to which a vegetation community or geographical area is composed of perennial vegetation.

Permeable
Refers to the nature of a substance to allow fluids or gases to pass through it.

Permeability
The ease with which a porous media can transmit water. This is dependant on the connection of the pores and fractures.

Permian
This is the last geological period of the Paleozoic era dating back between 299 to 251 million years ago.

Piezometer
A type of monitoring bore that only allows measurement of groundwater level or head.

Porous
Refers to the network of pores present within a solid material such as rocks or sponges, allowing the storage or passage of fluids and gases.

Porosity
The ratio of the volume of the void spaces in a rock or soil to the total volume of the rock or soil.

Raised Beds
Permanent raised beds were developed by Southern Farming Systems in the 1990s. The raised beds, often 15 to 30 cm higher than the furrow base, help to improve soil structure and alleviate waterlogging, thereby allowing increased productivity.

Recharge
Flow of water into the saturated zone and entering the groundwater system.

Recharge area
The area where water can enter and move downward to the groundwater.

Regolith
The layer of loose or cohesive material that includes soils which sits over bedrock and forms the surface of the land.

Remnant vegetation
Native vegetation remaining after an area has been cleared.

Rock weathering
Refers to the breakdown of rocks by water, heat, ice, pressure or chemicals.

Root zone
The area below the ground surface occupied by plant roots.

Rubble pit
A hole in the backyard of suburban blocks where roof water is drained as a means of disposal.

Run-off
The proportion of rainfall that flows across the ground surface, generally to enter drainage lines.

Salinisation
The process by which land and water become salt affected or increasingly saline.

Salinity
Salinity is the excessive accumulation of salts (usually Sodium Chloride) in land and water to sufficient levels to impact on human and natural assets (e.g. plants, animals, aquatic ecosystems, water supplies, agriculture or infrastructure).

Salinity Management Plan
A salinity management plan provides information about salinity on your farm, including processes, extent, risks and future management recommendations.

Saltbush
A **halophytic** shrub well adapted to living in soils with high concentrations of salt. Saltbush has the ability to utilise salts in soils, providing both salinity rehabilitation and fodder production opportunities.

Glossary of terms

Salt load
The amount of salt carried in water flow in rivers, groundwater or off the soil surface, in a given time period.

Salt scald
Area of land which has become bare due to salinity induced loss of vegetation or erosion.

Salt tolerance
The amount of salt a plant or animal can be exposed to before its function is affected. Tolerance varies greatly from species to species and can also be effected by other factors such as growth stage and plant/animal health.

Saturated zone
The area below the watertable where all spaces in soil, sediment and rock are filled with water.

Sediment
Sand, gravel, silt or clay that has been transported by wind, water or gravity.

Seepage
Groundwater flowing or 'oozing' out of the soil surface. Creates an area of seasonal or permanent waterlogging.

Sodicity
The presence of a high proportion of sodium ions relative to other cations in water or soil.

Sodosols
Sodosols is the Australian Soil Classification name for soils that display a strong texture contrast between surface and subsoil horizons and the subsoil horizons are sodic.

Soil horizon
Is a specific layer in the soil with physical characteristics that differ from the layers above and beneath.

Soil particles
Refers to sands, silts and clays that are less than 2 mm in diameter. The amount of these soil particles present determines soil texture.

Soil pores
These are the spaces between soil particles that may be filled with air or water.

Soil profile
A vertical section of earth from the soil surface to parent rock material that shows the different soil horizons.

Soil texture
Is the relative amounts of sand, silt and clay in the soil.

Soil structure
Refers to the way sand, silt, clay and organic matter are arranged into crumbs (or aggregates).

Soil water holding capacity (SWHC)
The amount of water a soil profile is capable of holding after leakage of free water has occurred.

Subsoil
The layers of soil below the topsoil.

Standing water level (SWL)
The depth to groundwater in a non-pumping bore.

Summer active perennial
Perennial plants which grow most actively in the summer period.

Talus
Unconsolidated sediments and alluvium that are deposited at the base of slopes. These deposits may occur as a result of gravity and water movement.

Topsoil
The surface or upper level of soil.

Toxic
The poisonous effect of specific ions on plants for example high levels of salts such as some chlorides, sulphates and carbonates can be toxic to some species. Tolerance levels differ with species and types of salts.

Transpiration (see evapotranspiration)
Process where water taken up by plants is released through their leaves and then evaporated.

Triassic
The first geological period of the Mesozoic era that extends from about 251 to 199 million years ago.

Unconsolidated landscapes
A landscape primarily composed of unconsolidated sediments.

Glossary of terms

Unconsolidated sediments

Sand, clay, silt or gravel that is not held together by compaction or a cementing agent. For example river sand, gravel beds, clays and silt.

Unsaturated zone

The area between the ground surface and the watertable which is not fully saturated with water.

Water balance

A state of equilibrium when rainfall or irrigation water in a landscape is accounted for by the sum of run-off, plant water use, evaporation, recharge and changes in soil moisture content.

Waterlogging

Where the surface soil is saturated with water from rising groundwater or surface run-off collecting in low areas.

Watertable

The upper surface of groundwater and the level below which an unconfined groundwater system is permanentley saturated with water.

Woody vegetation

Plants which have a woody stem that livestock do not eat.

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www.daff.gov.au/brs

Department of Primary Industries, Parks, Water and Environment
www.dpipwe.tas.gov.au; go to Water and search on salinity

Future Farm Industries CRC
www.futurefarmcrc.com.au

Murray–Darling Basin Commission – Salinity
www.mdbc.gov.au

National Action Plan for Salinity and Water Quality
www.napswq.gov.au

National Dryland Salinity Program (NDSP) includes OPUS project: Options for Productive Use of Salinity
www.ndsp.gov.au

National Land and Water Resources Audit
www.nlwra.gov.au

Natural Resource Management in Tasmania
www.nrmtas.org

NSW Department of Environment, Climate Change and Water
www.environment.nsw.gov.au/salinity

Industry & Investment NSW
(formally known as Department of Primary Industries)
www.industry.nsw.gov.au

NSW Landcare
www.landcarensw.org

Private Forests Tasmania
www.privateforests.tas.gov.au

Tasmanian Institute of Agricultural Research
www.tiar.tas.edu.au

Tasmanian Landcare
www.taslandcare.org.au/tlca.html

Urban Salinity in NSW
www.wagga.nsw.gov.au/salinity/Index.html
www.waterwatch.org.au

Note that website addresses may change over time. Contact your regional NRM organisation for further assistance if required.

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