7 Management Options for Dryland Salinity

7.1 Overview of Agricultural Management Options

This section provides an overview of the on-ground management options for salinity within the North East. This overview presents some of the strengths and weaknesses (including negatives) of the options and specific application within the North East. The options used to implement this plan within specific salinity priority areas are explored later.

These options are based on a number of reports and documents, especially the review of the NESS (Allan C & Curtis A, 2002) and the report 'Managing Dryland Salinity with Vegetation in North East Victoria' by Clifton et al 2000. The options can be broken down in to a number of categories. The information presented here is a range of management options, methods for implementation (such as extension and whole farm planing are listed later in the implementation plan.

Biological

- Well managed/enhanced deep rooted perennial pastures (including natives)
- Improved water use in crop lands, rotational cropping with perennial pastures and perennial pasture inter-cropping
- Improved water use in horticulture and viticulture
- High density tree planting (large scale not targeted) eg farm forestry
- High density trees targeted at recharge
- Trees and perennial pastures (combination)
- Protection and enhancement of native vegetation
- Natural regeneration

Engineering:

- Surface Drainage /Raised beds
- Groundwater Pumping

Living with Salinity:

- Salt tolerant plants (grasses, legumes, woody shrubs and trees)

Do Nothing

- Do not change current practices

Requires further investigation

The following options are not currently used within the region nor have they been investigated, however they may be useful and should not be eliminated from the options list until they have been further considered.

- Sub-Surface Drainage (mole, tile etc)
- Raised bed pastures
- Halophytic Vegetation
- Saline Horticulture and Silviculture
- Saline aquaculture
- Raised beds on saline land

In recent time there has been a broader approach taken in the understanding of how to manage dryland salinity across wide areas of south eastern Australia. The CRC for Plant Based Management of Dryland Salinity is developing a range of options that consider the implications of the biophysical and socio-economic aspects of salinity management.
A number of options may have potential implications such as changes to fresh water flows in to rivers. This is further discussed in section 6.2. In particular options that include large scale revegetation across wide areas of cleared agricultural land may have the potential to reduce the yield from catchments and further increase in stream salinity concentration. Modelling work using 2CSALT program is reviewing the implications of some of the management options including in this section. There is other work looking at the impact of

climate change processes on assets in the region. Therefore it is important to be aware that management options for salinity will need to be flexible as more information comes to hand.

There are a range of programs, which could be aligned to work already being undertaken by NE staff including EverGraze. This is a joint program of Meat & Livestock Australia (MLA) and the Cooperative Research Centre for Plant-based Management of Dryland Salinity, EverGraze is investigating perennial-based grazing systems to reduce groundwater recharge and increase productivity for producers in the high rainfall zone. There is considerable potential to incorporate the program within the actions of this Plan.

7.2 Perennial Pastures

Most agricultural land use across North East Victoria is based on grazed annual pastures. This is likely to continue for the foreseeable future, even with the likely expansion of plantation forestry and horticulture in the region. Effective management of dryland salinity across the region's catchments is likely to continue to depend largely on the characteristics and management of its pastures. Broad-scale establishment and effective management of perennial pastures is required across the region, although by itself this measure is unlikely to be sufficient to fully contain dryland salinity.

The effectiveness of pastures in managing dryland salinity is influenced by the environment in which they grow (eg, climate, soil conditions, aspect and slope). It also varies between species and the way in which they are managed. Together, these factors determine the availability (or excess) of water, the amount of leaf present for water use and how this changes over the growing season, the relative abundance of perennials and annuals in the pasture, rooting depth and long-term persistence of the perennial species. The influence of these factors is discussed briefly below.

The effectiveness of any vegetation system in dryland salinity management will vary with climate. The risk of any soil profile becoming saturated and leaking to groundwater increases with rainfall. The point at which leakage commences varies according to the capacity of the pasture to dry the soil profile and the rate at which it is filled by rainfall. A range of studies have shown that the capacity of deep rooted perennial grass pastures to contain leakage or groundwater recharge progressively diminishes once average annual rainfall exceeds approximately 600 mm. However, there is no single point at which these pastures become ineffective in salinity management. Rather, there is a progressive decline in effectiveness as rainfall increases.

Soil type influences both the availability of water to plants and the tendency for it to leak to groundwater. Physical soil factors such as structure, texture, depth and rockiness determine the capacity of the soil profile to store water. The availability of water to the plant (the effective soil water storage capacity) depends on these factors as well as those of soil acidity and sodicity, which have the potential to impede root growth and development. The risk of recharge will be greater where effective storage capacity is low. Low effective storage capacity places plants at greater risk from drought and can, in the long-term, be implicated in poor persistence of perennial pastures.

Perennial pasture species vary considerably in their suitability for the landscapes of north-east Victoria and their likely effectiveness in salinity management. Key requirements for an effective pasture species are:

- capacity to develop a deep root system – to maximise the depth to which the soil profile can be explored and dried and to aid the plants survival of summer droughts;
- growing season that extends into summer – to ensure plant water use takes place during the time of year when potential evaporation is high and that summer and early autumn rains are used productively by plants rather than allowing the soil profile to refill and recharge;
- tolerance of the highly acid soils that are common across north-east Victoria;
- persistence and productivity under grazing - to ensure that the pastures are a viable and long-term option for land managers.

Unfortunately there is a limited range of suitable pasture species, with few satisfying all of the above criteria. There is a number of strengths and weaknesses of the main pasture species that have potential to play a role in recharge management (Table 30).

Pasture and grazing management has potential to influence perennial pasture composition, persistence, growing season length, and leaf area and root depth – all of which may, in turn, influence the water balance. Implications of each of these factors are discussed briefly below.

- Composition - studies with phalaris have shown that continuous grazing favours annual grasses in a mixed pasture at the expense of this perennial, whereas rotational (or strategic or tactical grazing) tends to favour the perennials and result in a greater drying of soil profiles during spring and summer.
- Persistence – lucerne will generally only persist if rotationally grazed. Although phalaris is more tolerant of continuous grazing, its persistence can be jeopardised by regular close grazing. Soil acidity is a major challenge to the persistence of many pasture species, particularly lucerne and phalaris;
- Growing season length – continuous over grazing of phalaris pastures can reduce the length of its growing season. Once annuals die off in a mixed pasture, stock selectively graze the green shoots produced by the phalaris plants. Since they are continuously exposed to grazing pressure, these shoots are unable to develop sufficient leaf area to maximise water use or pasture production.
- Leaf area – grazing results in the removal of leaves, the main plant organ responsible for water use. Heavier grazing can result in lower levels of leaf area accumulating and reduced water use. In the short term, spelled pastures have greater rates of water use than heavily grazed pastures, as they support more leaf. However in the long-term ungrazed pastures become rank and unproductive and may support less green leaf than grazed pastures. In most species tiller development is stimulated by grazing which exposes the crown of the pasture plant to light. Rotational grazing, in which there are cycles of spelling to accumulate leaf area and cycles of grazing to encourage tiller development (and allow productive use of the pasture), appear to provide a satisfactory compromise between long-term water use and production;
- Root depth – continuous and excessively heavy grazing of pastures leads to little development of leaf area and have restricted root systems. This will reduce opportunities for the plant to dry out the soil profile at depth.

Table 30 – Strengths and weaknesses of main pasture species for recharge management in the North East.

Pasture species/type	Strengths	Weaknesses
Lucerne	▪ deep root system ▪ summer growing season – response to summer rainfall ▪ highly productive on good sites, palatable fodder ▪ high water use	▪ susceptible to acid soils, particularly those with greater acidity and aluminium in the sub-soil ▪ susceptible to water-logging ▪ long-term persistence depends on pastures being rotationally grazed
Phalaris	▪ moderately deep root system ▪ growing season may extend into summer under appropriate management ▪ highly productive on good sites, palatable fodder	▪ susceptible to acid soils, particularly those with greater acidity and aluminium in the sub-soil ▪ summer dormant and largely unresponsive to summer rainfall – reduces summer water use ▪ Potential weed risk if not

	▪ moderate to high water use, reduces run-off ▪ tolerant to a broader range of grazing management than lucerne	managed especially near roadsides and waterways and high value biodiversity assets
Cocksfoot	▪ acid soil tolerant ▪ moderate water use ▪ moderately productive pasture ▪ responsive to summer rainfall, remains green through summer if water available	▪ more susceptible to drought than phalaris ▪ intolerant of heavy grazing in summer
Native grasses	▪ already present in many hill country pastures and have shown to be persistent under grazing ▪ many species respond positively to grazing and modest levels of fertiliser (eg. weeping grass, wallaby grass) ▪ drought and acid soil tolerant ▪ moderate water use ▪ moderately deep rooted ▪ many species summer active and/or utilise summer rainfall (eg. weeping grass, red grass, kangaroo grass)	▪ some species relatively unproductive or not persistent under grazing ▪ limited information on establishment for many species ▪ little seed available at realistic prices for broad acre establishment ▪ limited information on pasture and grazing management.

There has been considerable research into the use of perennial pastures in the management of dryland salinity. There are several examples in Victoria of water tables falling following the establishment of lucerne pastures, but fewer examples of similar responses to the establishment of phalaris pastures. Most reports of water tables falling in response to perennial pasture establishment are from areas receiving less than about 550mm average annual rainfall. Landscapes in higher rainfall areas are likely to remain leaky, even with good quality perennial pastures.

Perennial pastures will play a role in the management of dryland salinity in North East Victoria. However their role in the higher rainfall areas of this region, that is the land generally south and east of the Hume Freeway, will be less when compared to the lower rainfall areas of the west and north. Plant water use (evapotranspiration) should be greater and recharge reduced, relative to annual pastures. It is expected that lucerne might be quite effective in containing water table recharge along the margins of the floodplain of the Ovens and King Rivers and the hills and flats of the Rutherglen area. Phalaris pastures (and most other perennial grasses) are unlikely to be as effective, either in these locations or in more hilly country with higher rainfall. Integration of this type of grass pasture with trees will be required to provide an agricultural system that is more effective in reducing the risk of groundwater recharge and salinity. The expansion of the EverGraze project into high rainfall low input systems in North East Victoria will allow greater opportunity for landholders and agency staff to promote the role of native grassed based systems in salinity management.

7.3 Dryland Winter Cropping

Crop production is an important land use in some of the priority areas within the North East. Options for improving the water balance of annual cropping are limited. Considerable effort has been invested in increasing the water use efficiency of crop production. Crops are managed more intensively, with timely and effective use of herbicides, fertiliser etc. to maximise the conversion of growing season rainfall into grain. "Water use efficient" crops may use more water than lower yielding crops, but not in all cases. The extent to which water use can be increased is limited, as with all annual plant systems, by a short growing season.

Substantial improvements in the water balance of cropping systems can only be achieved by incorporating perennial vegetation. Three main options exist (Table 31) with a variety of strengths and weaknesses for each option.

The most promising system for incorporating perennial vegetation into cropping rotations appears to be phase farming with lucerne. Three years of lucerne appears to be sufficient in the cropping areas of the Rutherglen district to dry the soil profile of water to a depth of 3-3.5 m. This may provide protection from recharge for up to three years into the cropping phase, depending on rainfall.

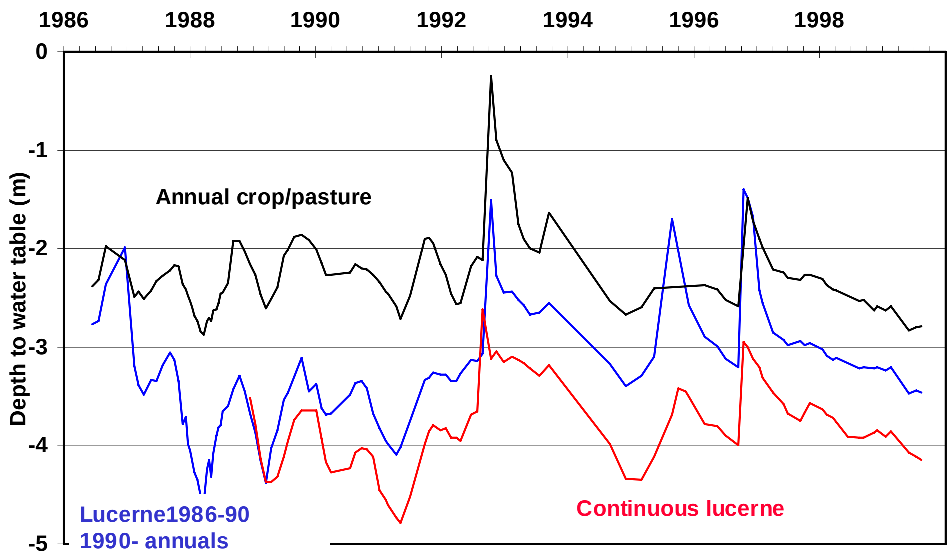
Table 31 –Relative strengths and weaknesses of options for incorporating perennial vegetation into cropping systems

Option	Strengths	Weaknesses
Phase farming – perennial pastures (particularly lucerne) form the ley pasture phase of the cropping rotation. The pasture dries the soil profile of water over several years, allowing several years of cropping before being refilled.	▪ Lucerne phase farming systems have been demonstrated in the Rutherglen area and can offer protection against recharge for up to three years following the lucerne phase. ▪ Summer fodder produced by lucerne can support a prime lamb enterprise. ▪ Nitrogen fixed by lucerne provides a boost to crop growth in at least the first year of the cropping phase.	▪ In higher rainfall cropping zones of north-east Victoria, the soil profile may refill in the year following the lucerne phase if rainfall is well above average. ▪ Length of cropping phase (based on risk of soil profile refilling with water) may be too short to be economically viable. ▪ Yield loss under dry conditions will be exacerbated for crops sown on former lucerne pastures. ▪ Acidic soils of NE Victoria mean that lime is frequently required for successful lucerne establishment – hence increasing costs. Acidity may also reduce production during the lucerne phase.
Intercropping – crops are sown into existing lucerne stands. Lucerne plants are sprayed to suppress growth during crop establishment, but begin to grow during the latter part of the crop growing	▪ Technology for establishment and management of intercropping systems exist. ▪ Land managers can take advantage of cropping opportunities, without serious detriment to long-term pastures. ▪ Intercropping can help to maintain drier soil profiles than annual cropping alone. This may reduce recharge	▪ Reduced yield in some crops because of lack of water. ▪ Lucerne burrs can cause vegetable degrade in grain sample (if not used for stock feed). ▪ Lucerne may not persist in the more acid cropping soils.

season.	and can help to reduce water-logging in higher rainfall cropping areas.	
Alley cropping - crops are sown in alleys between belts of trees or perennial shrubs.	▪ Alleys may provide shelter for crops and/or stock. ▪ Edge trees may take up unused water from below crops. ▪ Cropping phase of rotation can be longer and incorporate greater choice of species than with phase farming or intercropping	▪ Difficult to fit system in with farm machinery. Alleys need to be multiples of machine widths. ▪ Competition between crops and trees or shrubs. ▪ At alley spacing likely to be adopted by crop producers, alley farming unlikely to reduce water table recharge.

Lucerne at Marnoo in the Avon-Richardson catchment in north-central Victoria (Figure 27) was able to lower water tables by up to 2 m within three years of establishment. This effect of the lucerne persisted for 3-5 years into the cropping/annual pasture cycle. A continuous lucerne pasture maintained the water table at about 4 m depth, well beyond the depth at which the soil is likely to become salinised.

Figure 27 - Changes in groundwater levels in response to cropping and lucerne pasture establishment, Marnoo.



Source: Centre for Land Protection Research (now PIRVIC)

7.4 Horticulture and Viticulture

Horticulture is an increasingly important land use in the North-East region. Like other key wine producing regions of Victoria, the area of land under vineyard is expanding rapidly. Most development is taking place on river flats and the lower slopes of hills. Vineyards are generally irrigated. The NESS encouraged the use of high water use horticultural crops and recommended that the groundwater impacts of large scale horticultural developments be monitored.

Little is known in Victoria about the impact of recent horticultural developments on water tables and salinity processes in what were previously dryland agricultural areas. Historically, much of the horticultural development has been in irrigation areas and has probably contributed to elevated water tables and soil salinisation in those areas. There is some recent evidence from the Wimmera catchment of water tables falling below vineyards. Seepage from on-farm dams used to irrigate horticultural crops has been implicated in local saline discharge in some regions.

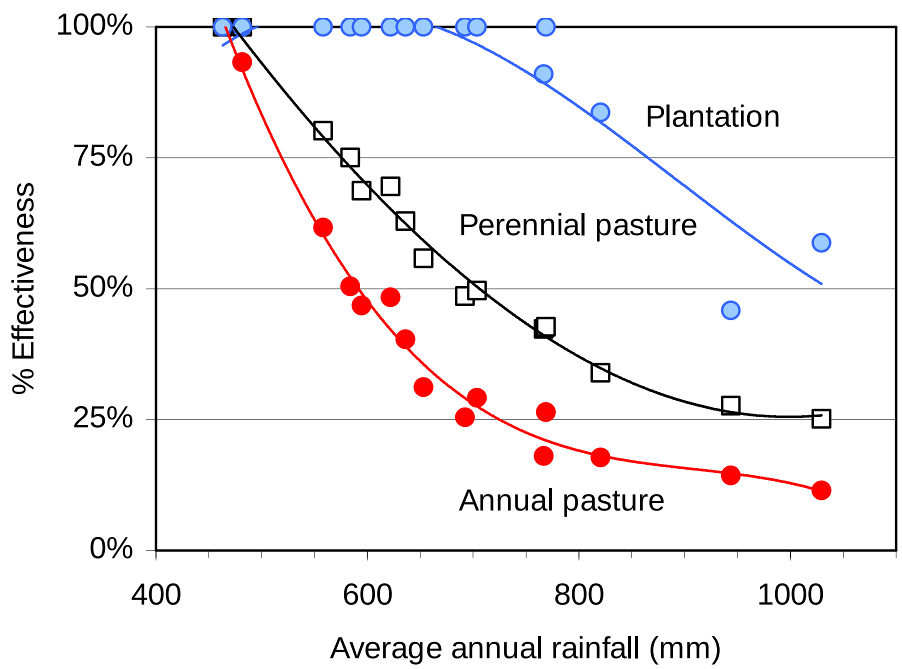
The impact of horticultural development will vary with the type of crop (deciduous or evergreen, shallow or deep rooting etc.), its management and the extent to which the crop water requirement is supplied by irrigation. Crops with deep root systems, relatively large, leafy crowns and an irrigation deficit should have a beneficial impact on the water balance relative to annual pastures. Horticultural crops that are over-irrigated (i.e. irrigation supply exceeds plant requirements) may serve to increase the risk of salinity. Options may include improved irrigation systems, crop rotations, incorporating perennials into cropping systems, whole farm planning, interception plantings and monitoring of groundwater.

7.5 Revegetation and Remnant Vegetation Protection

There has always been a strong interest in the use of trees and revegetation in the management of dryland salinity. This is based on a belief that changing land use from pasture back to native vegetation in at least part of the catchment will reverse the changes in water balance that gave rise to dryland salinity. The NESS recognised the potential benefits of trees and native vegetation in the management of dryland salinity by recommending that existing remnant vegetation cover be retained and that landholders consider strategic revegetation (of high recharge areas and at breaks of slope in some landscapes) and farm forestry.

The effectiveness of trees in the management of dryland salinity is influenced by soils and climate in similar ways to pasture. The capacity of trees to dry soil profiles of water and prevent leakage also declines as rainfall increases and soils become shallower and more freely drained. However, the decline in effectiveness with increasing rainfall occurs less rapidly and commences at higher average rainfall than for pasture. Effectiveness of annual and perennial pasture and eucalypt plantations at drying the soil profile of water declines with increasing annual rainfall (Figure 28).

Figure 28 - Relative effectiveness of plantations and perennial and annual pastures in drying soil profiles with change in average annual rainfall.



It was shown that vegetation was 100% effective at being able to dry the soil profile sufficiently (on average) to store at least the average annual rainfall. High effectiveness of tree plantations was achieved up to 750 – 800 mm rainfall. Effectiveness of pastures declined rapidly with rainfall above about 500-550 mm. This data was derived from water balance modelling for 15 locations throughout Victoria.

In the long-term, water use of plantations, like that of pastures, also depends on persistence. Maintaining tree and plantation health is essential for long-term impact on salinity processes. Species selection, management of adjoining paddocks, grazing of plantations and the presence and composition of any understorey all have potential to impact on the persistence of trees in farmland.

The effectiveness of tree plantations in the management of salinity may also be determined by the design of the plantation and its placement in the landscape. Tree growing for salinity management has traditionally concentrated on the most leaky parts of the landscape (areas of high potential recharge). This was based on the understanding that planting these strategic, but relatively restricted, areas out to trees could achieve a relatively large impact on controlling total landscape recharge.

There are a range of tree growing options that have been used in the management of dryland salinity. The most suitable options for the North East region are alley farming, interception plantings and traditional recharge area plantings as either high, low density or farm forestry plantings (Table 32).

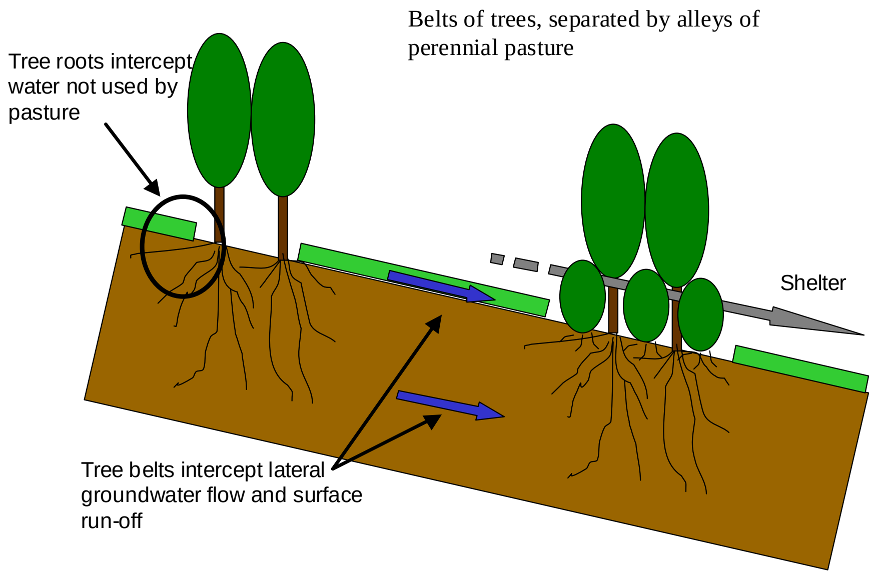
Table 32 – Strengths and weaknesses of tree growing options in the North East.

Options	Strengths	Weaknesses
Alley farming system – narrow (2-5 row) belts of trees established either across the slope or in a north-south direction. Trees closely spaced within belts and may include shelter and timber trees. Belts of trees separated by alleys up to 50 m wide.	▪ Design maximises opportunity for trees to intercept water that is not used by pastures within alleys. ▪ Use of water from adjacent pasture alleys can supplement that available from rainfall and increase growth rate. ▪ With good fencing layout, provides opportunity to closely control grazing to maximise productivity of improved pastures. ▪ Provides additional shelter and environmental benefits, if belts incorporate low growing shrubs as well as trees.	▪ Expensive to fence by conventional means. ▪ Maximises competition between trees and adjacent pasture and may result in reduced yields due to both shading and lack of water. ▪ Narrow belts may require more intensive management for production of high quality timber. ▪ Little local experience with alley farming. ▪ Trees occupy land suited to pasture.
Interception plantings – belts of trees established across breaks of slope between steep hills and mid slopes and potentially at other locations where there is a noticeable change in slope. Tree belts to be a minimum 5-10 rows wide and are to be planted at densities of at least 1000 trees/ha.	▪ Break of slope is an area of the landscape where water accumulates. Trees planted here can dispose of this water before it contributes to salinity or other forms of land degradation further downslope. Tree belts can reduce recharge and may directly extract groundwater. ▪ Can provide additional shelter benefits for stock. ▪ Water from further upslope effectively increases rainfall and may boost tree growth. ▪ Location of tree planting will generally be consistent with land	▪ Multiple tree belts may be difficult and expensive to fence by conventional means. ▪ Competition for water and/or light adjacent to tree belts. ▪ Trees occupy land suited to pasture.

	class fencing. ▪ Paddock subdivisions may help to gain improved control over grazing.	
High recharge area plantings – blocks or belts of trees established at moderate densities 200-500 trees/ha) on land of high potential recharge	▪ Tree growing concentrated on the leakiest parts of landscape and so proportional reduction in catchment recharge may be greater than area planted. ▪ Once well established, plantation should reduce recharge to low levels. ▪ Planting trees in blocks can allow economical fencing designs and fit with land class fencing. ▪ Often takes place on land of low productive capacity	▪ Steep and/or rocky terrain can make tree establishment difficult and may hamper subsequent commercial use of timber produced. ▪ Tree growth may be slow and substantial water balance impact only slowly achieved (5-15 years).
Low density tree growing or wide-spaced agroforestry – individual trees planted at wide spacings (to give 20-50 trees/ha) into existing pastures. Trees may be managed for timber production.	▪ Should allow continuation of existing land use patterns in grazing areas.	▪ Individual trees very expensive to establish and must be individually guarded. ▪ Wide-spaced trees generally have poorest establishment and survival rates and have poor form and branching unless carefully managed. ▪ At very wide spacings (<50 trees/ha), time taken for trees to have major water balance impact may be 20-50 years or more. ▪ Not suited to cropping or hay cutting
Farm forestry plantings – extensive blocks of eucalypt or pine plantation across suitable land. Plantation density >800 trees/ha	▪ High establishment density and rapid early growth allow water balance impact within 2-3 years of establishment. ▪ Recharge should be reduced to very low levels over life of plantation. ▪ Economical fencing designs possible. ▪ Financial returns may be equivalent to or better than for wool growing or beef.	▪ Impact on recharge generally confined to area planted. ▪ Large financial investment. ▪ Long harvest rotation before a dollar return. (Costs associated with farm forestry have been reduced with better practices and may not be an issue).
Protection and enhancement of remnant vegetation (including natural regeneration)	▪ Reduced financial input. ▪ Multiple benefit of retaining remnants. Linked to existing programs (CORIS).	▪ Location within the landscape may have minimal impact on recharge. ▪ Size and density of the patch may have minimal impact on recharge.

Alley farming is a system which incorporates relatively narrow belts of trees, established at regular intervals, across crop or pasture paddocks (Figure 29). For maximum impact the alleys between the belts of trees should support productive perennial pastures, such as phalaris, cocksfoot and lucerne. Trees on the edge of the belt would extend their root systems into the pasture alley and help to empty the soil profile of water. Over time tree roots might extend10-20 m into the pasture belt. Regularly spaced belts of trees oriented across the slope will help to intercept any lateral flow of surface water across (run-off) or through (interflow) the soil.

Figure 29 – Concept diagram of alley farming systems in dryland salinity management.

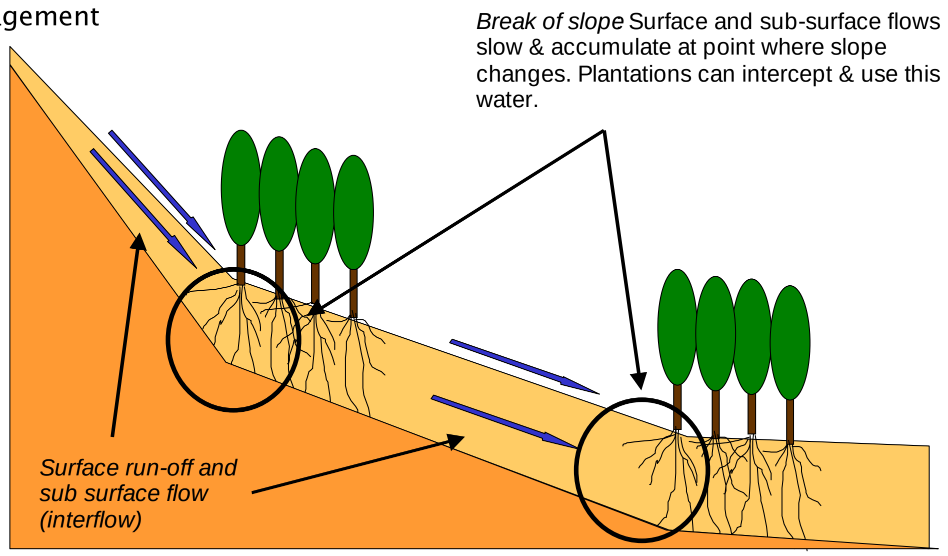


Source: Clifton et al (2000b)

Low growing shrubs may be established with the trees to improve the shelter properties of the belt. The shrubs may also encourage better stem form and branching as the trees develop and reduce the need for intervention if the trees are eventually to be harvested for timber. Belts will need to be fenced to maintain shelter benefits. However the cost of using conventional fencing would be prohibitive. Therefore electric or other forms of light fencing are recommended.

The effectiveness of alley farming in recharge reduction will increase with the proportion of the hill slope over which the edge trees in the belts have extended their roots. Thin belts (2-4 rows), separated by relatively narrow alleys will be more effective in achieving this than wider belts (5-10 rows) separated by much wider alleys. Interception plantings differ from alley farming, in that the belts of trees are located strategically, along breaks of slope (terrace, junctions), rather than at regular intervals (Figure 30).

Figure 30 - Concept diagram for use in interception plantings break of slope in dryland salinity management



Source: Clifton et al (2000b)

The change in slope in this part of the landscape results in water slowing and accumulating as it moves down hill. This can include both surface run-off and interflow. In some geological settings it may also include groundwater.

Belts of trees can intercept and evaporate this water, drying out what would otherwise be a water-logged and potentially salt-affected area of land. The width of the belt would be greater than for alley farming to ensure that all of the available water was intercepted. The additional water available in this part of the landscape may allow improved tree growth above what might be expected on the basis of rainfall alone.

Multiple belts of trees may be used if there are several breaks of slope. A single interception belt could be used where there is one break of slope and an alley farming system established over the remainder of the slope. Perennial pastures are recommended for land between interception plantings.

Some of the early salinity management works focused tree growing on saline discharge areas. Trees were established in the saline areas with the expectation that they could reduce discharge groundwater and achieve a sustained reduction in the water table level. However, even when salt tolerant trees were established, such plantations were often unsuccessful. Water-logging and salinity often slowed the growth of trees and reduced long-term survival. Water uptake was relatively low and so there was little impact on the water table. Tree planting on saline discharge areas has not been recommended in North East Victoria. There has been significant investigation by the CRC for Plant Based Management of Dryland Salinity into the role of salt tolerant trees in saline discharge areas. This may have benefits in the region as an additional option, although specie would not be indigenous.

In some cases, trees planted immediately up slope of discharge areas may be able to help contain their spread. The trees are more likely to establish successfully, as the water table will be deeper than in the discharge area.

Recent studies have suggested that if large areas of agricultural land in North East Victoria were to be converted to tree plantations there would be a reduction in run-off and stream flow from the region. While groundwater recharge and the risk of salinity would be reduced by such action, the expected decline in stream flow would have important consequences for the quantity and quality of water in the entire Murray River system.

7.6 Salt tolerant plants

If inappropriately managed, the productivity of saline discharge areas declines and they become covered with unpalatable weeds (eg. spiny rush), unproductive salt tolerant pastures (eg. sea barley grass) or become bare, salt scalded and exposed to the risk of erosion. While focussing attention and on-ground activity on the cause of salinity (excessive groundwater recharge) rather than the symptoms (discharge areas) is an attractive philosophy, in the medium term it is likely to result in the condition of saline land worsening. In local GFS in North East Victoria it would take at least 5-10 years for effective recharge area management to be expressed as a lower water table and improved soil health.

Active management of groundwater discharge areas is increasingly being recognised as an important component of salinity management. Several management systems are available that can return salt-affected land to productive use and reduce the risk of further land degradation.

Pastures based on salt-tolerant species such as tall wheat grass and puccinellia appear to be the most applicable to the North East (Table 33). When sown in combination with moderately salt-tolerant clovers (balansa, strawberry) and managed appropriately, they should form stable and productive systems. This type of pasture has been able to support 8-10 dse/ha in South West Victoria. Management of the pasture focuses on maximising long-term production from the clover (through spelling during flowering and seed set and heavy grazing prior to the autumn break) and preventing the site becoming pugged by grazing when the soils are wet. There is a potential for non-native salt tolerant species such as tall wheat grass to become an environmental weed. However from South West Victoria studies have indicated that good management is critical to prevent these species from becoming a threat (DPI 2005).

Table 33 - Salt tolerance of common pasture species.

Category	Species
Sensitive Plants	Many clovers including, white clover, red clover, subterranean clover
Moderately Sensitive Plants	Strawberry clover, balansa clover, persian clover, lucerne
Moderately Tolerant Plants	Tall fescue, phalaris, perennial ryegrass, wimmera ryegrass
Tolerant Plants	Tall wheat grass, puccinellia, salt bush

Salt bush has been widely used in Western Australia to improve the productivity of salt affected land. Its use has been less successful in most places in Victoria, with the species appearing to perform poorly on the acid soils and high rainfall common to North East Victoria.

If water tables are not too shallow, groundwater discharge areas may become recharge areas at certain times of year. Having a dense coverage of perennial vegetation on these areas may reduce the rate at which this occurs. Deep-rooted salt tolerant pastures (eg. tall wheat grass) may take up and effectively utilise groundwater during the warmer months. This may help to lower water tables in these areas, at least temporarily. In some landscapes, pastures in discharge areas may be able to achieve a sustained lowering of the water table and contribute to the rehabilitation of salt-affected land.

7.7 Do nothing

This may be considered an option by many landholders who do not have the economic ability or social interest in managing salinity. Factors such climate variation may mean this option are seen to be acceptable.

This doesn’t take into account the multiple benefits of salinity management options or the protection of regional assets. It only considers the immediate site benefits of doing nothing.

7.8 Options that require further investigation

These options are not currently used within the region and many have not they been investigated, they may be useful and should not be eliminated from the options list until they have been further considered.

Some options include:

- Sub-Surface Drainage (mole, tile etc) inc raised bed pastures
- Halophytic Vegetation
- Saline Horticulture and Silviculture
- Saline aquaculture maybe
- Raised beds on saline land

7.8.1 Surface Drainage/Raised Beds

The issue of surface drainage and salinity has received considerable attention throughout Victoria and interstate. The previous NESS highlighted that waterlogging was a major issue across the region. It estimated economics losses from waterlogging of crop land at $10million. NE CMA initiated a Regional Rural Drainage Management Strategy (RRDMS) in 1999 to consider the potential impacts and benefits across the region.

Rural drainage can provide a number of benefits including reducing waterlogging and improving farm access which leads to increased agricultural productivity (NECMA 1999). Rural drainage can however result in adverse impacts which include:

- an increase in the severity and duration of downstream flooding;
- an increase in the export of nutrients, sediment and saline water into downstream receiving waters
- damage or destruction of wetlands.

Specific objectives in the RRDMS for limiting the impact of proposed rural drainage activities on the health of downstream waterways, storages and wetlands are listed as follows:

- to limit the export of nutrient loads into downstream waterways, storages and wetlands;
- to limit the drainage of saline groundwater into downstream waterways, storages and wetlands;
- to limit the export of sediment loads resulting from erosion associated with drainage works into downstream waterways, storages and wetlands; and
- to ensure the health of significant existing wetlands.

This Action Plan has not undertaken further investigations to further consider these impacts and benefits. However the potential impacts on water quality within the MDB are noted.

There are potential benefits from using Raised Beds in cropping enterprises across the region are high in wet years. However this issue would need to be considered in the light of the North East RRDMS.

7.8.2 Engineering-Watertable Management

The has been no specific investigation of engineering options associated with salinity and groundwater management across the region to date apart from considering groundwater pumping in specific GFS.

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7.8.3 Groundwater Pumping

The previous NESS made recommendations to investigate this issue. In late 1999 the region received funding from to investigate groundwater pumping as an option for managing salinity in the Local Fractured Rock GFS region of the NE based around Everton Upper.

Everton Upper has been identified as one of high priority areas in the North East region in terms of salinity risk. Saline discharge area has been expending rapidly since the early 1980s even under dry conditions in last few years. To address the salinity problem, a five-phase groundwater pumping trial was conducted to investigate the benefits of pumping to lower the watertable for salinity control and for irrigation purposes. During the groundwater pumping trial, a significant amount of pumping and monitoring data was collected. This report characterised the aquifer system at the pumping site and analysed the pumping and monitoring data to determine the impact of the groundwater pumping on the watertable. The observed data showed that the pumping might have some local impact on the watertable, but there was very little evidence its impact extended to beyond 300m from the pumping well. To supplement the analysis of the observed data, the study also calculated theoretical drawdowns caused by pumping the well and estimated annual recharge volume in the area. The results of theoretical calculation also indicated that the pumping was unlikely to lower the watertable across a larger area (a radius of 500 m from the pumping well.

The role of groundwater pumping as an option to manage groundwater levels and to utilise low salinity water for commercial purposes across broader areas of the region has been identified as a research gap (refer Chapter 12).

7.9 Management options for urban salinity

Urban salinity is an emerging issue in the region, especially in new residential and industrial developments where land was previously used for agriculture. Salinity can affect both new and existing urban assets. Many of the characteristics of urban environments contribute to increasing groundwater levels and associated salinity it is therefore important to consider discharge and recharge areas in its identification and management.

The management of urban salinity is complex and involves a wide range of organisation and individuals, with local government being a key stakeholder. Currently there is no structured approach to managing urban salinity within the region. Therefore the first steps in managing urban salinity is to identify roles and responsibility of organisations that can then develop the management approaches to be taken.

Management options may include developing planning tools that consider recharge and discharge for new developments or identifying salinity hazard. Many of the impacts of urban salinity can be reduced and managed by changing some of the construction practices and methods and by considering salinity in planning developments. Management options may in fact be the establishment of guidelines to identify the approach that will be taken within a local government area.

Examples of management options that may be included in guidelines for construction in saline or recharge areas may include:

- undertaking an accurate site assessment to determine the extent and severity of the salinity.
- plan development around salt affected area not on them.
- limit or not use site cuttings.
- use alternate construction to concrete slab where possible.
- use 'exposure grade' bricks.
- identify potential additional sources of salt being brought onto the site eg, sand.
- limit or not use render (damp course must exceed render)
- damp course layer should be used in all walls.
- ensure all metal support are fully enclosed in concrete.
- don't use decorative tilled pavements for roads.
- ensure good site drainage
- consider design, location and construction materials of roads

Management options for urban salinity in developed areas includes:

- don't cover weepholes.
- don't have gardens against the house.
- don't hose the house walls.
- plant waterwise gardens (house and street scape).
- reduce or limit lawn areas.
- fix leaking pipes.
- revegetation of affected areas, such roadside.
- limit irrigation of sporting grounds and lawns.

Management of urban salinity they also include managing buildings and infrastructure that has become affected. This may include restumping houses, replacing parks and gardens with salt tolerant species, drainage or groundwater pumping.