3. Management options

This section describes some of the management options available to mitigate land and water salinity caused by a high water table. Some of this information comes from the West Gippsland Salinity Management Plan (WGCMA, 2005). The discussion below is far from comprehensive but rather introduces the reader to some of the key concepts in choosing salinity control options. The discussion provides the basis for the choice of salinity management options for each of the groundwater flow systems described in Section 4. A summary of the salinity control options suited to the particular groundwater flow systems is provided in Section 5.

The key categories of salinity control options are:

- Recharge control – addressing the cause of the problem by reducing the amount of water entering the water table;
- Groundwater discharge – addressing the symptoms of the problem by increasing groundwater discharge through pumping or interception
- Living with Salt – increasing the productivity of saline land through the planting of salt tolerant crops and pastures

There are many management options available for mitigating salinity. Some of these options treat the causes (by reducing recharge) while others address the symptoms (enhancing groundwater discharge). In dryland areas where the economic benefits may be significantly lower than in irrigated areas, it will be necessary to choose management options that have multiple benefits. Tree planting in recharge areas for salinity mitigation may also increase biomass, provide habitat and corridors for wildlife and sequester carbon.

3.1 Recharge reduction

Recharge reduction treats the cause of salinity resulting from a high water table. There are four main types of recharge control options:

- Pasture/crop options: sowing higher water using pastures or crops
- Trees: planting of high water using trees
- Engineering: surface or sub-surface drains may be constructed to intercept and redirect water to drains or streams before it has the opportunity to leak to the water table.
- Irrigation management: ensuring more efficient irrigation

A further management option that prevents future salinity is the protection of remnant vegetation, which also has other environmental benefits.

3.1.1 Pasture options

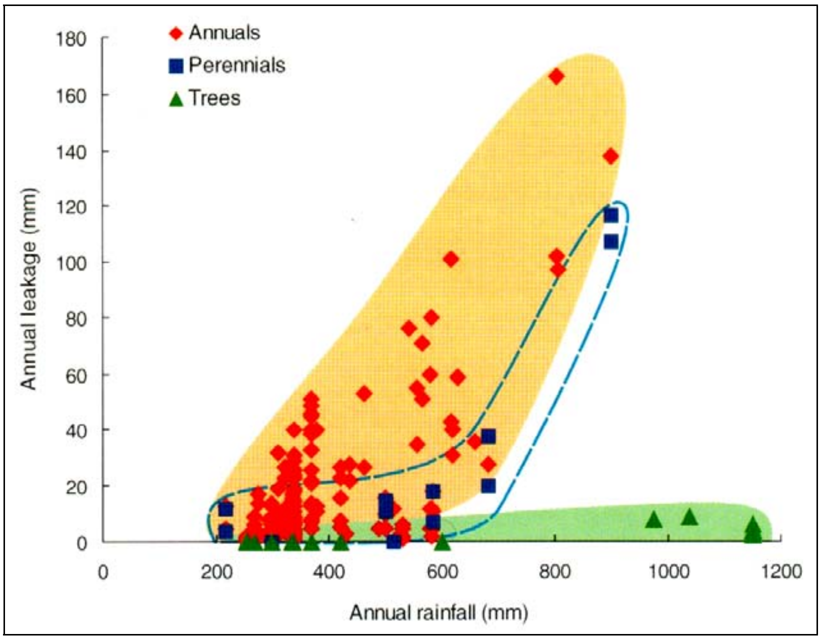
Agronomic options can be used to increase plant water use and decrease the amount of water passing the root zone and adding to the groundwater store. As such agronomic options address the cause of salinity resulting from a high water table. The key agronomic option used for salinity control is the replacement of annual pastures with perennial species, which have deeper roots and a longer growing season. In some parts of South Gippsland where annual rainfall is above 750mm, perennial rye grass grows almost year round (Gavan Lamb, DPI, *pers. comm.*, 2004). Perennial pastures can dry the soils to a greater extent than annual pastures, allowing more of the infiltrated rainfall to be stored in the soil profile during the higher rainfall winter and spring periods. The result is less recharge to the water table. Differences in water use between annual and perennial pastures are most pronounced in inland areas receiving less than about 600mm annual rainfall (Walker *et al*., 1999).

Pastures across much of the West Gippsland region are already based on perennial species (especially perennial ryegrass) (Source: GFS workshop). Given the predominance of perennial pastures and the relatively high rainfall in the region, there is only limited scope to increase water use and decrease groundwater recharge by agronomic means.

Some of the key perennial pasture species suitable for reducing groundwater recharge include Lucerne, Cocksfoot, Phalaris and some of the native grasses such as Kangaroo Grass.

Figure 9 shows the relationship between annual rainfall and leakage below the root zone for annual and perennial pastures and trees. It shows that in areas where rainfall is less than 600mm per year, replacing annual pastures with perennial pastures can significantly reduce the amount of leakage below the root zone. The lower the leakage below the root zone, the lower the recharge to the water table. In areas where the rainfall is greater than 600mm per year, perennial pasture is less effective, though it still results in a recharge reduction. Replacement of annual pasture with trees reduces the recharge much more significantly than perennial pasture under all rainfall volumes, but particularly in areas where rainfall is greater than 600mm per year.

- **Figure 9: Relationship between annual rainfall and leakage below the root zone for different vegetation types (Walker *et al*., 1999)**



3.1.2 Tree planting options for recharge control

Tree planting options include:

- Forestry plantations (farm forestry, commercial forestry, alley farming) and
- Native vegetation (retention of remnant vegetation and revegetation using species of local provenance).

As Figur shows, recharge under trees is significantly less than under annual or perennial pastures under all rainfall volumes but particularly under rainfall of greater than 600mm per year. In high rainfall regions (>600mm/year) replacing annual pastures with perennial pastures is unlikely to result in a significant reduction in recharge. In these areas trees are the management option most likely to result in a significant recharge reduction and siting these trees in recharge zones will be an important management issue.

To ensure a multi-benefit outcome, trees are best planted in conjunction with either biodiversity or forestry programs. Tree planting for salinity control alone is not likely to be cost effective without the added benefit of increased biodiversity of increased economic output associated with forestry activities. In the West Gippsland region, there are significant opportunities to combine salinity control with both biodiversity and forestry outcomes.

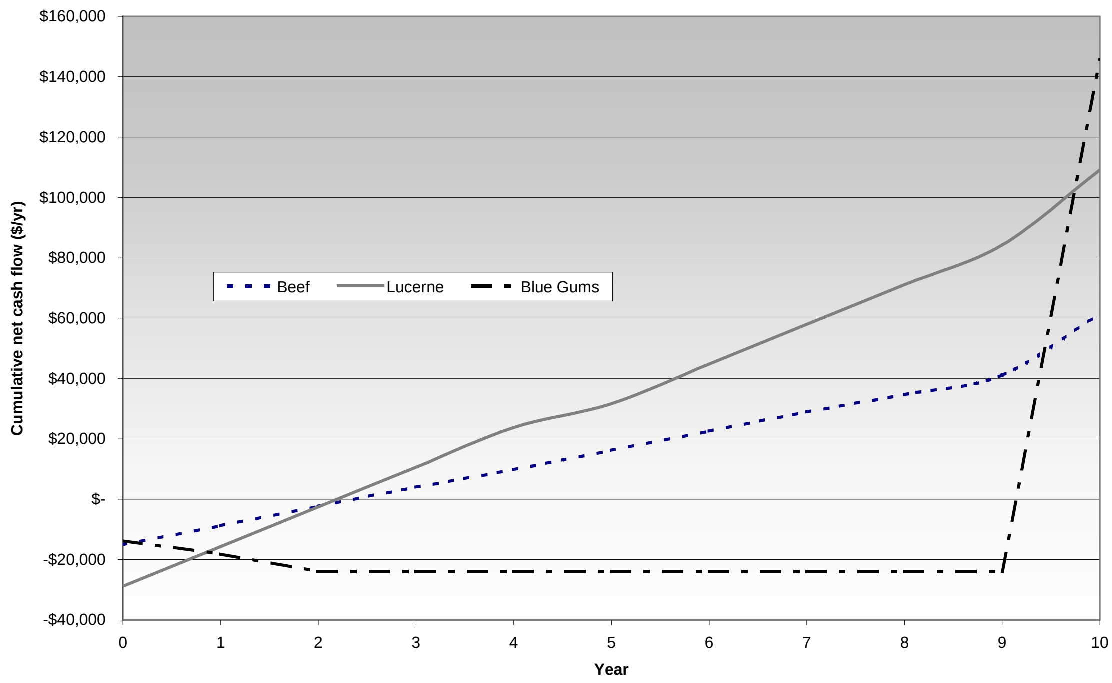
The water use by trees can vary as a result of the species, the age of the stand and the density of planting. Species selection is an important consideration from both a recharge reduction and a biodiversity perspective. The most effective plantings will be in recharge zones or at break of slope. There may be an opportunity for incentives such as greenhouse credits as forests are known to sequester carbon.

The South Gippsland Salinity Management Strategy (DNRE, 2000) recommended extension of private forestry as a way of reducing recharge. The minimum rainfall in the South Gippsland area (covered by the Foster and Port Albert Salinity Management Areas) is 600mm increasing to as much is 1200mm in parts of the region. The land is relatively flat, still tractable in winter and there are several mills catering to the extensive private hardwood and softwood plantations in the area. Few farmers have invested in private forestry in the area, despite the suitability, mostly due to the long lead-time before a profit can be realised. The South Gippsland Salinity Management Strategy identified the Giffard Plain as an area particularly well placed for plantations, particularly given the current and recent low returns to sheep farmers. Over a timeframe of 10 years plantations can have a higher net economic value than beef or lucerne, but the benefits are not realised until the final year (Figure 10– from DNRE, 2002). There is a higher risk to landholders with this management option than conventional farming despite the higher potential returns.

The planting of indigenous trees and shrubs can have significant biodiversity benefits. Plantings can enhance the population of threatened species, increase habitat for native fauna and increase the overall biodiversity of the area. Therefore, there is a strong need to ensure that planting trees for salinity control is coordinated with activities associated with the various native vegetation action plans (eg West Gippsland Native Vegetation Plan).

In addition to reducing groundwater recharge to the water table aquifer, planting trees and woody indigenous shrubs may also affect the recharge to deeper aquifers where they outcrop and decrease runoff to stream and rivers. Although these effects are not likely to be significant enough to result in trees not being suitable for salinity control, natural resource managers need to be aware of these secondary effects when planning tree planting activities.

- **Figure10: Cumulative net cash flows for the beef, lucerne and Blue Gum woodlot enterprise options (from DNRE, 2002)**



3.1.3 Surface drainage

Improving surface drainage prevents water from ponding and causing excessive recharge. It also reduces the opportunity for water logging, which often coincides with land salinity. In areas with a high water table, deeper drains can intercept groundwater throughflow and enhance discharge, helping to remove salt from the landscape and reduce the area of salt affected land. However, when mobilising salt, care needs to be taken to ensure that there are no significant impacts to receiving waters.

3.1.4 Improved irrigation management

Irrigation management as a salinity control option is mainly applicable to the Macalister Irrigation District but is also relevant to the irrigation areas in the Port Albert and Bengworden Salinity Management Areas and any new "greenfield" irrigation developments. Increasing irrigation efficiency reduces the volume of groundwater recharge and decreases the risk of salinity. The key activities that potentially have a recharge benefit include:

- *More efficient flood irrigation.* Most of the irrigation in the Macalister Irrigation District is flood irrigation especially on the lower permeability soils. Flood irrigation can become more efficient through:
  - Laser grading of irrigation bays to ensure an even topographic grade (many irrigation layouts in the MID are already laser graded but the proportion and distribution are unknown);
  - Ensuring appropriate 'cut off' points for irrigation events (ie not allowing the flood irrigation front to progress too far down the bay before cutting off the water flow);
  - Increasing flow rates to the tops of bays. Recent work on the IBIS flood irrigation trial near Newry has shown that increased flood irrigation flow rates can decrease overall water use and groundwater recharge. Preliminary figures suggest that on the high permeability soils, the volume of recharge can be reduced by 46mm/irrigation or approximately 322mm/year (G. Lamb, DPI, *pers. comm*., 2004).

- *Conversion of flood to spray irrigation* – Significant reductions in recharge, runoff and water consumption can be achieved through conversion from flood to spray irrigation especially on the higher permeability soils. A Sinclair Knight Merz (2001c) study calculated the approximate recharge reduction achieved by converting from flood to spray irrigation on various soil permeabilities based on survey results of farmer irrigation practices. Table 5 shows that conversion from flood to spray irrigation can result in a recharge reduction of between 57% and 82%.

- *Appropriate leaching fractions* - It is possible to irrigate with saline water without resulting in a pasture yield decline provided the volume of water applied is sufficient to flush the salts through the soil profile. Irrigation management extension can highlight the importance of ensuring appropriate leaching fractions for irrigated land to prevent salinity caused by irrigation with saline water.

- **Table 5: Estimates of average recharge reduction achieved in the Macalister Irrigation District by converting from flood to spray irrigation (From SKM, 2001c)**

Soil permeability	Average recharge rates for flood irrigation (mm/year)	Average recharge rates for spray irrigation (mm/yr)	Reduction in recharge rate by flood to spray conversion	% Reduction in recharge rate by flood to spray conversion
High to very high	795	144	651	82%
Moderate to high	307	114	193	63%
Low to very low	63	27	36	57%

*Soil permeability classes are relative only and modified from mapping undertaken by Sargeant and Imhof (2000) and Sargeant and Imhof (in press). The distribution of soil permeability classes is shown in Figure 8.

3.2 Groundwater discharge enhancement

Discharge enhancement treats the symptoms of a high water table and/or influx of saline water from the ocean by increasing the volume of groundwater being discharged resulting in a reduction in the water table level. There are two main types of discharge enhancement options:

- Sub-surface drainage (engineering options such as groundwater pumping and tile drains)
- Trees used at break of slope to intercept groundwater prior to discharging further down-gradient

3.2.1 Sub-surface drainage (especially groundwater pumping)

The most obvious engineering option to engender discharge enhancement is groundwater pumping. Groundwater pumping is used extensively in the Macalister Irrigation District and surrounds for salinity control. The main advantage of groundwater pumping is the very rapid effect on watertable levels and land salinity, which are achieved less rapidly through the application of recharge control measures.

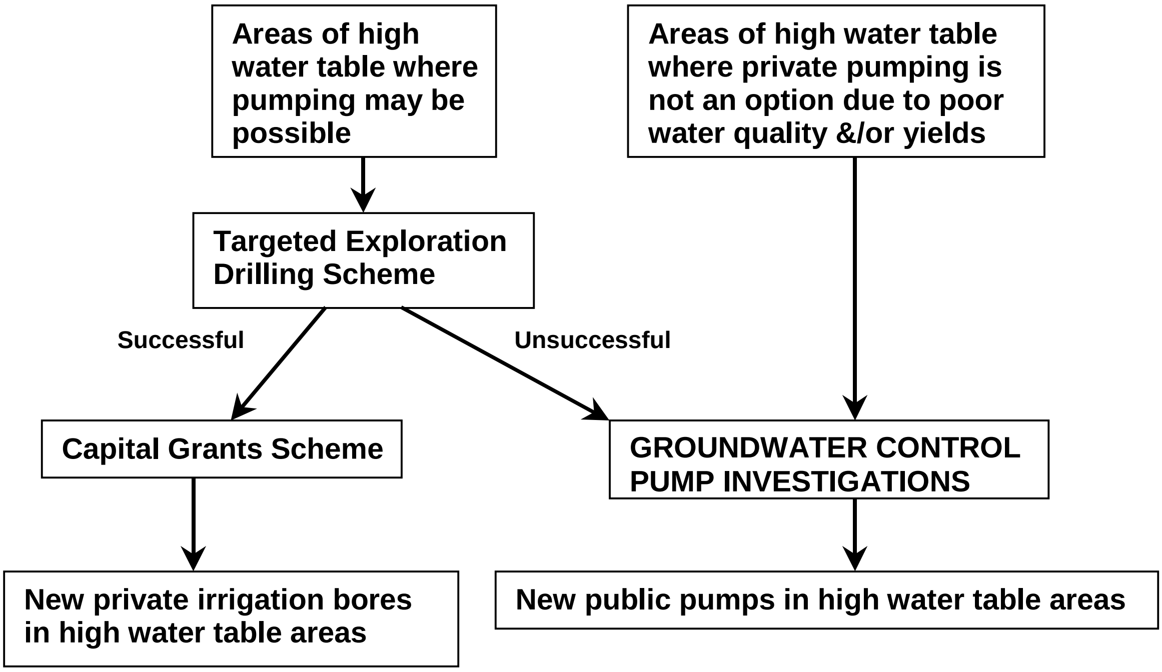
There are two types of groundwater pumps that reduce the water table levels in the Macalister Irrigation District:

- Private irrigation bores pumping from the shallow aquifer; and
- Public Groundwater Control Pumps, which are Government owned bores specifically designed to reduce water table levels for salinity control purposes. Groundwater from these bores is discharged to drains, rivers, or channels.

Both public and private groundwater pumps tap a shallow aquifer occurring at a depth of between 5 and 20 metres. This aquifer occurs over much of the region but can be variable in thickness, yield and water quality.

The key decision making process in the “MID salinity mitigation procedure” relating to choice of private or public groundwater pumps is illustrated in Figure 11. The “Targeted Exploration Drilling Scheme” and the “Capital Grants Scheme” referred to in Figure 11 are described below.

- **Figure 11: Decision process in choice of public or private groundwater pumping investigations (modified from the MID Salinity Mitigation Procedure)**



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Private irrigation bores

Reducing watertable levels by encouraging private pumping is preferable to the installation of new Groundwater Control Pumps for the following reasons:

- Private use of groundwater enables the groundwater resource to be used for productive purposes;
- On-going operating costs of Groundwater Control Pumps have to be borne by the local community;
- Pumping to drains, rivers and channels has adverse effects on water quality with environmental and diversion implications.

The recent increase in the number of private irrigation bores across the region has significantly reduced the water table level in some areas (especially in the Nambrok/Denison region).

A landowner incentives program was recently trialed in the area to encourage the installation of new shallow irrigation bores in high water table areas through two linked schemes:

- The Targeted Exploration Drilling Scheme (TEDS); and
- The Capital Grants Scheme.

The Targeted Exploration Drilling Scheme provides subsidised shallow groundwater investigations to locate suitable sites for new irrigation bores. The Capital Grants Scheme provides financial assistance to landowners for the installation of groundwater pumps. Both schemes are based on appropriate cost sharing arrangements between the landowner and the Government. The schemes are only available to landowners in high water table areas that have been specifically targeted by the implementation program.

Groundwater Control Pumps

Groundwater Control Pumps are installed to reduce the effects of a high water table only if private pumping is not a viable option either due to high groundwater salinity and/or low aquifer yield. There are currently 17 Groundwater Control Pumps operating in and around the Macalister Irrigation District. There is also one landowner who is paid to pump his private bore for salinity control.

Groundwater pumping from the shallow aquifer in the MID has been highly successful in reducing the watertable level and the effects of salinity, especially in the Nambrok, Denison and Clydebank areas. For example, in 1991, there were approximately 7,000 hectares of land in the Nambrok/Denison region with a water table depth of two metres or less. This has now been reduced to approximately 4,900 hectares. A dramatic improvement in the pasture quality and an improvement in soil salinity levels has been measured around Groundwater Control Pumps. This is confirmed by landowner comments about the improved productivity around these pumps.

Free flowing bores

The free flowing bore network in the MID was established in the 1960s and consists of 84 free flowing bores in the Nambrok-Denison area and 18 in the Cobains area. The bores provide a discharge point for the high water table in the area and discharge into drains. The only costs after installation are for maintenance, as they do not require electricity. The free flowing bores operate at a much lower pumping rate than Groundwater Control Pumps however, and only protect a limited area of land.

Tile/Mole Drains

Tile/mole drains buried underground intercept groundwater and flow into a discharge pond/drain. They help to relieve groundwater pressure but may conflict with drain management as salt or nutrient levels may be increased in downstream drains.

3.2.2 Tree planting options to intercept groundwater

Planting trees at the break of slope can intercept relatively fresh groundwater and use it before it discharges further down-gradient where it often becomes too saline for trees. The advantage of this option for salinity benefits is that surface water run-off and groundwater flows slow and accumulate at topographic breaks of slope resulting in these locations being wetter and more likely to leak than other locations. Trees planted here can store and use this water rather than allowing it to leak to the water table or discharge to the surface. Additionally, planting trees can provide shelter for stock.

3.3 Living with salt

Living with salt treats the symptoms of salinity caused by a high water table and/or influx of salinity from the ocean and makes use of the ‘opportunity’ that salinity represents. Agronomic options include salt tolerant pastures, crops and shrubs. Saline aquaculture or salt harvesting operations are also available options although the proximity to the coast and temperature variations make saline aquaculture unlikely to be viable. Salt harvesting operations require extremely saline water and sufficient supplies making it better suited to other regions.