Water Resources Act 1997

WATER ALLOCATION PLAN
for the
ANGAS BREMER
PRESCRIBED WELLS AREA

I Mark Brindal, Minister for Water Resources, hereby adopt this Water Allocation Plan pursuant to Section 104 of the *Water Resources Act 1997*

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Hon Mark Brindal MP
Minister for Water Resources

Date :

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1. THE ANGAS BREMER PRESCRIBED WELLS AREA

Pursuant to clause 2(1)(b) of schedule 3 to the *Water Resources Act 1997*, the proclamation under section 41 of the *Water Resources Act 1976* declaring the Angas Bremer Proclaimed Region, by Notice in the South Australian Government Gazette dated 23 October 1980, is in force as though it declared the Angas Bremer Prescribed Wells Area pursuant to the *Water Resources Act 1997*.

The Angas Bremer Prescribed Wells Area (PWA) comprises those portions of the hundred of Strathalbyn, Freeling and Bremer as described in the South Australian Government Gazette Notice dated October 23, 1980 appearing at page 1192. The Angas Bremer Prescribed Wells Area is illustrated in Figure 1.

1.1 The prescribed water resource

The Angas Bremer prescribed water resource is a body of underground water contained principally within two aquifers:

- a shallower, unconfined aquifer; and
- a deeper, confined aquifer.

A series of (probably) discontinuous, unconfined aquifers have developed within 10-20 metres of Quaternary clays, silts and sands, overlying a sequence of confined Tertiary limestone and sand aquifers of up to 100 metres thick.

A fault to the northwest of the area marks the northern extent of the Tertiary confined aquifer. Fractured rocks lie under the Tertiary sediments. The upper sands of the confined aquifer are hydraulically connected to the Angas and Bremer rivers in the northwest.

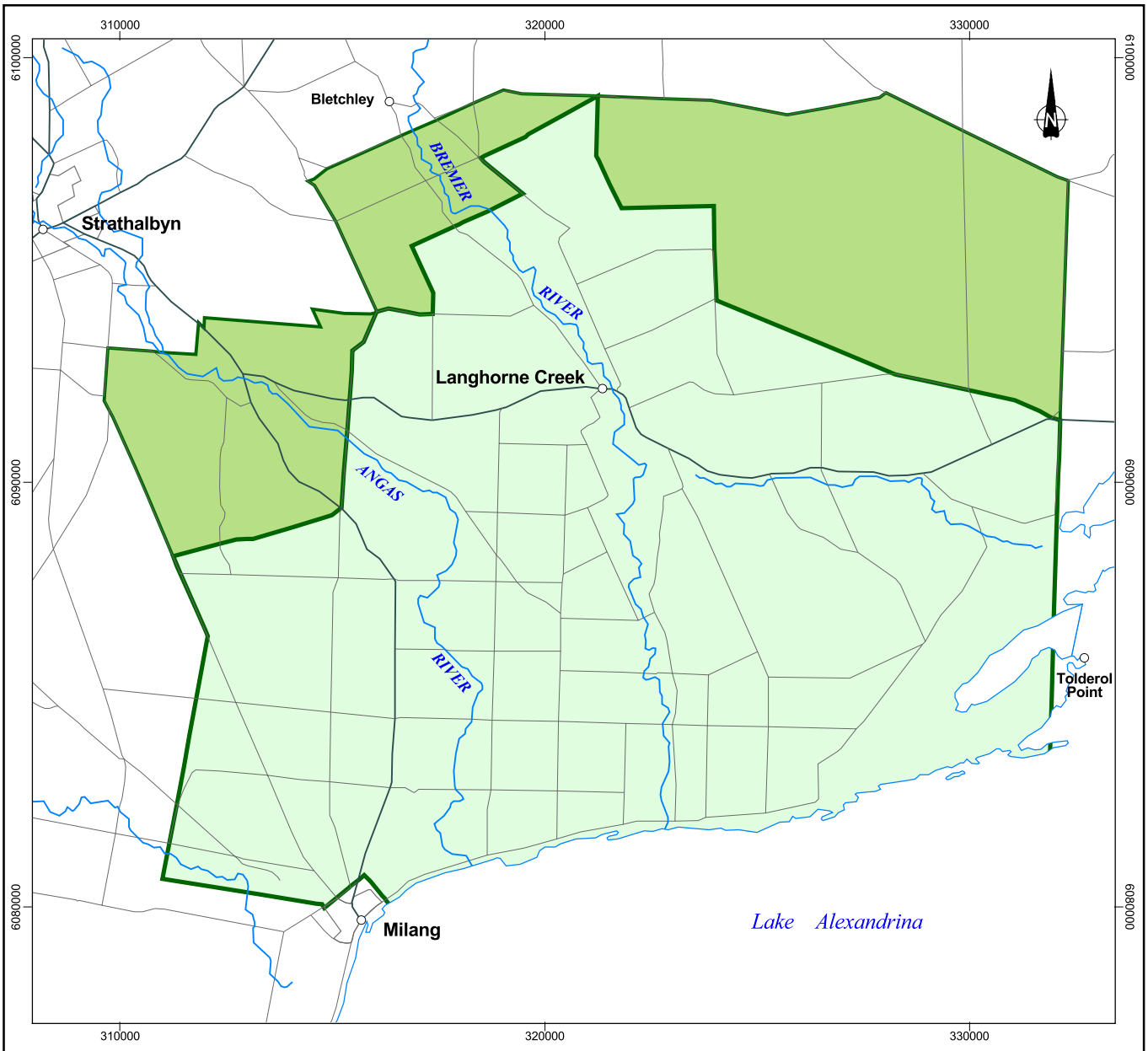
Stream flow from the rivers recharges both aquifers in this vicinity.

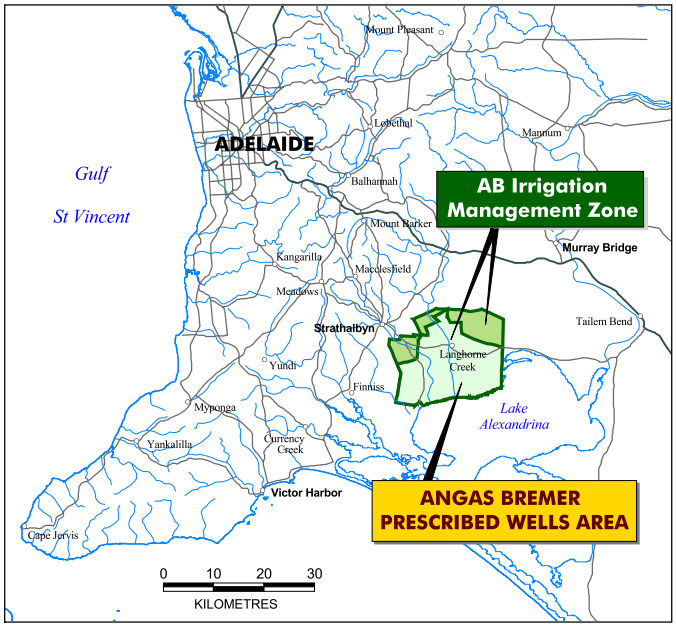
There appears to be little interaction between the two aquifers in the area immediately south of Langhorne Creek, owing to the presence of an extensive (but locally discontinuous) clay aquitard within the Quaternary sediments. Further south towards the edge of Lake Alexandrina, the hydraulic connection between aquifers is again better.

Both the confined and unconfined aquifers are recharged along a fault zone by surface run-off generated in the Mount Lofty Ranges. The unconfined aquifer is recharged along the length of the Angas and Bremer rivers, particularly after high flow/flood events.

In turn, the confined aquifer is probably recharged by downward leakage from the Quaternary sediments in zones where there is good hydraulic connection between the aquifers.

Within the PWA the Angas and Bremer rivers are “losing rivers”, that is, they recharge the underground water aquifers. Consequently, there does not appear to be any base-flow component of the Angas and Bremer rivers that is driven by underground water discharge from the aquifers within the Angas Bremer PWA.





Angas Bremer Prescribed Wells Area

AB Irrigation Management Zone

TOPOGRAPHIC FEATURES

River / creek

Locations

Main road

Minor road

0 1 2 3 4 5
KILOMETRES
MAP PROJECTION - AMG ZONE 54

Angas Bremer Prescribed Wells Area and AB Irrigation Managment Zone

LOCALITY PLAN

Figure 1

The direction of underground water flow within both aquifers is, in general, from north to south across the PWA.

The aquitard that separates the two aquifers in the vicinity of Langhorne Creek has established a perched underground water mound within the upper (unconfined) aquifer. In general, shallow underground water appears to flow laterally towards the boundaries of this mound, where it drains over the edge of the aquitard and slowly leaks into the underlying confined aquifer. In a few discrete zones along the Angas and Bremer rivers, the aquitard appears to be absent, thus permitting downward leakage of good quality water from the unconfined to the confined aquifer.

Underground water leaves the confined aquifer through upward leakage in the south, and through lateral flow in the aquifer beneath Lake Alexandrina.

Underground water from the unconfined aquifer leaks down into the confined aquifer in the northern and central parts of the PWA, evaporates from the water table near the Lake margin, and discharges into the Lake.

1.2 The quality of the prescribed water resource

The underground water resource is of variable quality. Water in the unconfined aquifer is generally more saline than water in the confined aquifer.

The salinity of the unconfined aquifer water ranges from 1,600 to 130,000 EC (≈1,000 to 80,000 mg/L total dissolved solids (TDS)) and is generally unsuitable for irrigation. However, good quality water is found in the unconfined aquifer in the vicinity of the two major rivers.

Water quality in the confined aquifer is substantially better beneath the Angas and Bremer rivers than it is just a few kilometres away. The salinity of better quality water ranges from 2,800 to 3,300 EC (1,700 to 2,000 mg/L), and the surrounding saline underground water averages around 5,000 EC (3,000 mg/L).

The salinity of underground water in the confined aquifer is mostly rising, at an average of around 65 EC (40 mg/L) each year. Conversely, however, the salinity of some confined aquifer borewater is falling. The rising trend persists despite the significant recharge following the floods in 1992 and the dramatic decrease in underground water use of the past 15 years.

It appears that the salinisation of the confined aquifer is strongly influenced by downward leakage of saline underground water from the unconfined aquifer, in response to irrigation.

2. ASSESSMENT OF THE NEEDS OF DEPENDENT ECOSYSTEMS

This assessment has been based on the best scientific information available at time of preparation of this plan. For the purpose of this assessment, it has been assumed that the management regime is to maintain the condition and distribution of the respective ecosystems in which they are found today.

2.1 Underground water dependant ecosystems

Ecosystems currently observed in the Angas Bremer PWA that depend on underground water from the prescribed resource include a small, permanent wetland on Mosquito Creek, the remnant red gum swamps scattered across the Angas Bremer floodplain, and Tolderol Game Reserve and other temporary wetlands fringing Lake Alexandrina. There is no documented evidence of hypogean or hyporheic species (that is, those species that live in underground water ecosystems) in the Angas Bremer PWA. However it is likely that, given the salinity of the shallow unconfined and deeper confined aquifers and composition of sediments, quite a diverse assemblage of species could live in some of the underground waters of the PWA.

1. Mosquito Creek Wetland

The wetland comprises a small pool and vegetation located beneath the bridge near the intersection of Mosquito Creek Road and West Creek Road. This wetland has elements of conservation significance including a species of the stonewort, *Chara* and the native fish, *Congolli* (*Pseudoaphritis urvillii*). The pool is relatively shallow and the water is generally very clear and saline. Native species present in or around this pool include, but are not limited to:

Melaleuca halmaturorum (Tea tree)
Eucalyptus camaldulensis (River red gum)
Chara sp. (Stonewort)
Triglochin striatum (Streaked arrow grass)
Distichlis distichophylla (River couch)
Halosarcia. sp. (Samphire)
Cyperus sp. (Club rush)

Chara sp. dominates the aquatic vegetation and covers 100% of the sediment under water. The other key plant species is *Triglochin striatum*, which dominates the vegetation around the perimeter of what is considered the permanent pool. Most of the plant species observed in and around the wetland can tolerate large variations in water level and salinity. *Congolli* have been observed in this pool and it may be an essential drought refuge site for this species which is known to spend part of its life cycle at sea and ascend the Angas and Bremer Rivers when in flood.

2. Red Gum Swamps

Remnant red gum swamps are restricted to areas along the Angas and Bremer Rivers and local depressions across the alluvial flats. The current extent of the red gum swamps near Langhorne Creek is approximately 50 hectares.

3. Tolderol Game Reserve and temporary wetlands fringing Lake Alexandrina

The hydrology of Tolderol Game Reserve and the temporary wetlands fringing Lake Alexandrina is poorly understood particularly in reference to the ecological underground water requirements of the system and the influence of raised water levels in Lake Alexandrina on the ecology of the system. However, it is likely that these wetlands are an important seasonal and spatial link between the ephemeral Angas and Bremer River systems and the permanent Lake Alexandrina for a number of aquatic organisms including migratory fish and birds.

The major plant associations in these wetlands include water couch, reeds, sedges, rushes, saw sedge, lignum, *Villarsia* sp., *Hydrocotyle* sp., samphires and *Wilsonia* sp.. A number of native freshwater fish also have been found in this area including, but not limited to:

Geotria australis (pouched lamprey)
Atherinosoma microstoma (smallmouth hardyhead)
Hypseleotris sp. (hybrid carp gudgeon)
Philypnodon sp. (dwarf flathead gudgeon)
Gadopsis marmoratus (river blackfish)

2.2 Quality of underground water needed by ecosystems

1. Mosquito Creek Wetland

Chara sp. can tolerate a wide range of salinity up to twice that of seawater, or 120 000 EC). *Triglochin striatum* can also tolerate a wide range of salinities and can be found in a range of aquatic habitats from freshwater to tidal systems or near saline underground water seeps. It appears that *Triglochin striatum* is living at the fresher end of its wide salinity tolerance and thus seasonal peak salinities should be moderate. The salinity of underground water entering the pool should not exceed 60 000 EC.

2. Redgum Swamps

The salinity of floodwaters on which the swamp red gums predominantly rely can rise up to 4 000 EC. Red gums can tolerate underground water with salinity levels up to 40 000 EC, provided the soil profile is refreshed by lower salinity floodwaters (on average, once every two years).

2.3 Quantity and time or period of underground water needed by ecosystems

1. Mosquito Creek Wetland

The presence of dense *Chara* stands in the centre of the wetland suggests that the wetland pool is permanent and does not dry out in summer. No similar pools occur elsewhere in the PWA, therefore it is unlikely that rainfall would sustain a permanent pool in this location. Changes to the current head regime should be minimised to ensure that underground water inputs essential to maintaining the pool in summer and the on-going health of the ecosystem are sustained.

2. Redgum Swamps

The swamp red gums are predominantly dependent on seasonal flooding and are therefore likely to obtain most of their water from the saturated soil

profile that is replenished during natural and artificial winter flooding. The swamp red gums may derive up to 50% of their water from the shallow unconfined aquifer during the drier summer months and/or extended periods of low rainfall.

Because they generally occupy local depressions, the red gums will feel the first impacts of rising watertables. Red gums are relatively tolerant of waterlogging, however if the period of inundation is longer than the winter and spring months, then poor tree health and eventually death will result. The creation of permanent underground water fed pools in the low-lying red gum swamp areas will result in tree death in those areas permanently inundated. Experience in other red gum swamps suggests that red gums will persist following 3 years of permanent inundation. Maintaining underground water levels in the red gum swamp areas at more than 3 metres below ground level will minimise the potential for waterlogging and tree health decline.

3. ASSESSMENT OF THE EFFECT ON OTHER WATER RESOURCES

In preparing this draft Water Allocation Plan, the River Murray Catchment Water Management Board has assessed that the taking and use of water from the prescribed resource will not have a detrimental effect on the quantity and quality of water that is available from any other water resources.

4. ASSESSMENT OF THE CAPACITY OF THE RESOURCE TO MEET DEMANDS

4.1 Needs of underground water dependent ecosystems

See discussion above under heading "Assessment of Needs of Underground water Dependent Ecosystems".

4.2 Existing demand

Annual underground water extractions from the confined aquifer of 21 000 ML were common throughout the late 1970s, and reached a peak of 26 600 ML in 1980-81. During the 1980s underground water use steadily declined, falling to 11 500 ML/annum by the end of the decade. The declining trend continued into the early 1990s, with only 3 700 ML used in 1992/93 following the second-highest annual rainfall on record (623 mm in 1992). In the two years that followed underground water use increased once again, rising to 7 300 ML in 1994/95. Since 1995/96, annual extractions have fallen and remained relatively stable at around 2 200 ML/annum.

Variations in recorded underground water use reflect an overall decline in the demand for underground water in the Angas Bremer PWA since the on-set of development in the 1950s. Demand for underground water has declined largely as a result of increased access to lower salinity River Murray water taken from Lake Alexandrina.

Current levels of demand for underground water for various purposes are estimated as follows:

2120 ML/annum for irrigation;
30 ML/annum for town water supply (Langhorne Creek);
20 ML/annum for stock and domestic use;
15 ML/annum for recreation (irrigation of sporting grounds); and
15 ML/annum for industry.

4.3 Future demand

The principal factors which are likely to affect future demand for underground water from the prescribed resource are (1) trends in the type and area of irrigated crops, (2) improvements in water use efficiency, (3) availability and access to River Murray water from Lake Alexandrina, and (4) expansion of future underground water dependent industries.

1. Trends in irrigated crop type and area

The following information is based on irrigation community views regarding likely development over the next ten years. Furthermore, it is assumed that the area under irrigation in 1997/98 (5,733 ha) represents 100% development.

Following a rapid rise during the last decade, vineyard development is likely to plateau in the future, with the area of vines under irrigation increasing by around 20% by 2010. A 10% increase in cereals is

anticipated, with a rise of 50% expected in vegetables other than potatoes. Other crops such as olives and wood lots may be established as these industries and their markets expand.

By contrast, the area given to irrigation of lucerne has fallen dramatically from the highs of past years and is expected to decline to around half the current extent by 2010. Similarly a 50% reduction in pasture is anticipated, while the areas of almonds and irrigated potato crops are likely to fall to 75% of the current levels.

These projections in crop development suggest a small (5%) increase in total irrigated area by 2010. As a consequence irrigation water use could rise by as much as 30%. In recent years a sizeable quantity of allocated River Murray water has remained unused at the end of each irrigation season. These volumes of "slack" water are likely to be more than sufficient to cater for the projected total irrigation need suggested by trends in crop development.

Given the preference of irrigators to use low salinity River Murray water rather than relatively high salinity underground water, it is anticipated that increases in demand for irrigation water in the Angas Bremer PWA will be met by activation of existing River Murray allocations, rather than increased demand for underground water.

2. Improvements in water use efficiency

In meeting the criteria for allocation contained in this plan, ongoing structural readjustment of the irrigation sector toward further improvements in irrigation efficiency are anticipated, which are likely to result in a further decline in the demand for underground water for irrigation.

3. Availability and access to River Murray water

If access to and/or availability of River Murray water for the purpose of irrigation in the PWA was significantly reduced it is likely that demand for underground water would increase. This plan, however, provides a maximum level of allocation for the prescribed resource, and further allocation of the low salinity component of the underground water resource will not be permitted under this plan.

4. Expansion of future underground water dependent industries

The potential for productive use of saline underground water is likely to increase as technological advances are made and markets develop. These might include salt harvesting for chemical industries, saline aquaculture and saline-tolerant primary production systems.

Other minor factors such as changes in population and stocking rates are unlikely to have a significant bearing on demand for underground water in the future. Overall, the capacity of the prescribed resource is considered sufficient to meet current and anticipated demand for underground water.

5. WATER ALLOCATION CRITERIA

The present and future needs for water of the occupiers of land in the Angas Bremer Prescribed Wells Area have been outlined in section 4. Irrigation is expected to be the largest and strongest growing water user in the region. However, dryland farming is expected to remain as a land user in the Angas Bremer Prescribed Wells Area, with its associated requirement for stock and domestic water.

An assessment of irrigated crop potential of the land in the Angas Bremer Prescribed Wells Area indicates that some areas may have limitations for irrigation development. Such areas may remain dryland-farming areas, or may develop some other activity. Irrigation will tend to concentrate in areas, which combine good quality water with suitable soils. The productive capacity of the land will also depend on land management practices, avoiding land degradation issues such as erosion and water logging.

The overall capacity of the water resources in the Angas Bremer Prescribed Wells Area are considered to be sufficient to meet all existing and reasonably foreseeable future demands for water, considering the capacity of the land. Locally, in areas with good water quality and suitable soils, the demand for water may exceed the capacity. However, improvements in irrigation efficiency and more active use of trade of licensed water allocations may accommodate further irrigation development in these areas.

Generally, the effects of the policies in this plan on land values are thought to be minimal. Land suitable for irrigation in an area with good quality underground water will always have a higher value than land that is not suitable for irrigation.

The River Murray Catchment Water Management Board has taken the above aspects into account in setting the policies and criteria within this plan.

Terms used in this plan that are defined in the Act shall have the definitions set out in the Act.

The following objectives and principles apply to the taking and use of water from the Angas Bremer Prescribed Wells Area, including the taking and use of water drained or discharged to a well within the Angas Bremer PWA in accordance with a permit under section 9(3)(c) of the *Water Resources Act 1997* ("recharged water").

5.1 Objectives

1. Sustainable rate of underground water use.

2. Efficient use of water.

3. The impact of water use on the prescribed underground water resource, other water resources, and the environment, is minimised.

5.2 Principles

Basis of water (taking) allocation

1. Subject to principle 2, water (except recharged water) taken and used from the wells in the Angas Bremer PWA will be allocated as a volume that may be taken and used in any water-use year.

2. Subject to principles 3 and 4, any unused portion of up to 30% of a water allocation for any water-use year (excluding recharged water) may be taken and used after the end of that water-use year (at any time over the subsequent three water-use years) with an allocation for a subsequent water-use year

3. The combined amount of an allocation from a subsequent water-use year and any allocation from an earlier water-use year shall not exceed 130% of the allocation of that subsequent water-use year in which the combined allocations are taken and used.

4. For the purposes of this Plan, a "water-use year" means the period between 1 July in any calendar year and 30 June in the following calendar year.

Basis of recharged water (taking) allocations

5. The basis of allocating recharged water will be an entitlement to take, during a water-use year, a percentage (not exceeding 100%) of the volume recharged in the previous water-use year under a permit under section 9(3)(c) of the Act.

6. An allocation of recharged water must be used within a period of five consecutive water-use years following the date of allocation.

Water available for allocation

7. Subject to principle 10, the maximum volume of water (except recharged water) that may be allocated in any water-use year is 6 500ML.

8. The maximum volume of water (except recharged water) with a salinity level less than 5 000 EC (3 000 mg/L) that may be allocated in any one water-use year is 5 000 ML.

9. The maximum volume of recharged water that may be allocated in any one water-use year is 2 500 ML.

Criteria for allocation

General

10. Water shall only be allocated where there is no net increase in the area of land that is salinised and/or waterlogged as a result of the taking and/or use of the water.

Use of Water for Irrigation

11. Water shall only be allocated for irrigation where a monitoring well constructed in accordance with the criteria set out in principles 1 and 2 under Part 7.2.2 of this Plan, "Permits - Drilling of Monitoring Wells", is situated on the land upon which the water is to be used.

12. Water shall only be allocated for irrigation at a rate that exceeds 500ML to be taken and used in any one water-use year if there is a minimum of two monitoring wells constructed in accordance with principles 1 and 2 in Part 7.2.2 of this Plan, "Permits - Drilling of Monitoring Wells", situated on the land upon which the water is to be used.

13. From 2 January 2003 water shall only be allocated for irrigation where the use of that water shall achieve a field application efficiency of at least 85%.

14. For the purposes of principle 13 the term "field application efficiency" means the proportion (expressed as a %) of the water applied to a particular location that is not lost under the roots of the crop quantified by:

$$\frac{\text{Irrigation water available to crop}}{\text{Water received at the field inlets}}$$

15. For the purposes of principle 14:

a) the particular location shall be sited below the roots of the major crop types in such a manner that it accurately represents the water tight integrity and the distribution uniformity of the irrigation system;

b) the numerator shall be defined by: the sum of [irrigation water applied (mm) less water lost to drainage (mm)] for each irrigation event; and

c) the denominator shall be defined by:
the sum of irrigation water applied (mm) for each irrigation event

16. Prior to 1 January 2003, water shall only be allocated for irrigation at the rate of 100ML for every hectare of non-irrigated vegetation planted and nurtured on Relevant Land in accordance with the Angas Bremer Irrigation Region Revegetation Booklet set out in Appendix B to this Water Allocation Plan with sufficient density to minimise the potential for waterlogging on the land to be irrigated, or any other land.

17. From 2 January 2003 water shall only be allocated for irrigation at the rate of 100ML for every two (2) hectares of non-irrigated vegetation planted and nurtured on Relevant Land in accordance with the Angas Bremer Irrigation Region Revegetation Booklet set out in Appendix B to this Water Allocation Plan with sufficient density to minimise the potential for waterlogging on the land to be irrigated, or any other land.

18. For the purposes of principles 16 and 17, the term "Relevant Land" means land within the AB Irrigation Management Zone.

a) that is owned by the licensee; or

b) in which the licensee has a legal interest; or

c) that is under the care, control and management of the relevant Council under the *Local Government Act 1999*, the River Murray Water Catchment Management Board, or a Minister, instrumentality or agency of the Crown with the written consent of that Council, Board, Minister, instrumentality or agency.

19. For the purposes of principle 18, the AB Irrigation Management Zone is the area defined by light and dark shading on Figure 1.

20. For the purposes of principles 16 and 17, the term "planted and nurtured" means:

a) vegetation that has been planted, or will be planted (in the case of land not owned by the applicant, pursuant to some legally binding agreement or obligation), and will be maintained (in the case of land not owned by the applicant, pursuant to some legally binding agreement or obligation); and

b) vegetation that has not been planted but has been (and will continue to be) maintained or allowed to exist in good condition (in the case of land not owned by the applicant, pursuant to some legally binding agreement or obligation).

21. Water shall only be allocated where the proportion of irrigation water applied that drains past the root zone of the crop does not enter the underground water or the River Murray, except where that proportion of water which enters the underground water is subsequently removed via saline underground water mitigation scheme(s).

Taking and Use of Recharge Water

22. Recharged water shall only be allocated where the proposed point of extraction is the same, or within 500 metres of the well into which the recharged water is directly or indirectly drained or discharged.

6. TRANSFER OF WATER LICENCES AND ALLOCATIONS

The following objectives and principles apply to the transfer of water, including recharged water.

6.1 Objectives

1. Provide for the temporary or permanent transfer of water licences and/or the whole or part of the water allocation of a licence where the transfer does not have an adverse impact on:

    a) the prescribed water resource;

    b) the sustainable rate of use of the prescribed resource;

    c) other users of the prescribed resource; and

    d) ecosystems dependent on the prescribed resource.

2. Minimise salinisation and waterlogging.

6.2 Principles

General

1. Water shall only be transferred where it does not result in:

    a) increased salinity of the prescribed water resource;

    b) waterlogging of soils in the Angas Bremer Prescribed Wells Area;

    c) loss of habitat or biodiversity in the Angas Bremer Prescribed Wells Area;

    d) any adverse impact upon the environment in the Angas Bremer Prescribed Wells Area; and/or

    e) any adverse impact on the quantity and quality of water available from another water resource.

2. Water shall only be transferred where it does not have a detrimental impact upon another licensee's right to take water.

3. Water shall only be transferred where the proposed point of extraction lies within the same aquifer.

4. Water with a salinity level greater than 2 500EC (1 500 mg/L) at the well of origin shall only be transferred where the salinity of the native underground water at the proposed point of extraction is not less than 2 500EC (1 500 mg/L).

5. Water with a salinity level less than 2 500EC (1 500 mg/L) at the well of origin shall only be transferred where the salinity of the native underground water at the proposed point of extraction is less than 2 500EC (1 500 mg/L).

6. For the purpose of principle 5 and 6, the salinity of the water at the well of origin and the proposed point of extraction shall be determined by:

   6.1 testing a sample of the water collected after pumping for at least one hour from an existing bore at, or proximate to, the well of origin and the proposed point of extraction; or

   6.2 by reference to the salinity contour diagrams in Appendix A to this Water Allocation Plan.

Transfer of recharged water

7. Recharged water shall only be transferred where the proposed point of extraction remains the same, and the land upon which the recharged water is used, remains the same.

Transfers for irrigation

8. Water shall only be transferred for irrigation on land within the Angas Bremer PWA where a monitoring well constructed in accordance with the criteria set out in principles 1 and 2 in Part 7.2.2 of this Plan, "Permits - Drilling of Monitoring Wells", is situated on the land upon which the water is to be used.

9. Water shall only be transferred for irrigation on land within the Angas Bremer PWA at a rate that exceeds 500ML to be taken and used in any one water-use year if there is a minimum of two monitoring wells constructed in accordance with principles 1 and 2 in Part 7.2.2 of this Plan, "Permits - Drilling of Monitoring Wells", situated on the land upon which the water is to be used.

10. From 2 January 2003 water shall only be transferred for irrigation on land within the Angas Bremer PWA where the use of that water shall achieve a field application efficiency of at least 85%.

11. For the purposes of principle 10 the term "field application efficiency" means the proportion (expressed as a %) of the water applied to a particular location that is not lost under the roots of the crop quantified by:

$$\frac{\text{Irrigation water available to crop}}{\text{Water received at the field inlets}}$$

12. For the purposes of principle 11:

   a) the particular location shall be sited below the roots of the major crop types in such a manner that it accurately represents the water tight integrity and the distribution uniformity of the irrigation system;

   b) the numerator shall be defined by:
   the sum of [irrigation water applied (mm) less water lost to drainage (mm)] for each irrigation event; and

   c) the denominator shall be defined by:
   the sum of irrigation water applied (mm) for each irrigation event

13. Prior to 1 January 2003, water shall only be transferred for irrigation on land within the Angas Bremer PWA at the rate of 100ML for every hectare of non-irrigated vegetation planted and nurtured on Relevant Land in accordance with the Angas Bremer Irrigation Region Revegetation Booklet

set out in Appendix B to this Water Allocation Plan with sufficient density to minimise the potential for waterlogging.

14. From 2 January 2003 water shall only be transferred for irrigation on land within the Angas Bremer PWA at the rate of 100ML for every two (2) hectares of non-irrigated vegetation planted and nurtured on Relevant Land in accordance with the Angas Bremer Irrigation Region Revegetation Booklet set out in Appendix B to this Water Allocation Plan with sufficient density to minimise the potential for waterlogging.

15. For the purposes of principles 13 and 14, the term "Relevant Land" means land within the AB Irrigation Management Zone:

    a) that is owned by the licensee; or

    b) in which the licensee has a legal interest; or

    c) that is under the care, control and management of the relevant Council under the *Local Government Act 1999*, the River Murray Water Catchment Management Board, or a Minister, instrumentality or agency of the Crown with the written consent of that Council, Board, Minister, instrumentality or agency.

16. For the purposes of principle 15, the AB Irrigation Management Zone is the area defined by light and dark shading on Figure 1.

17. For the purposes of principles 13 and 14, the term "planted and nurtured" means:

    a) vegetation that has been planted, or will be planted (in the case of land not owned by the applicant, pursuant to some legally binding agreement or obligation), and will be maintained (in the case of land not owned by the applicant, pursuant to some legally binding agreement or obligation); and

    b) vegetation that has not been planted but has been (and will continue to be) maintained or allowed to exist in good condition (in the case of land not owned by the applicant, pursuant to some legally binding agreement or obligation).

18. Water shall only be allocated where the proportion of irrigation water applied that drains past the root zone of the crop does not enter the underground water or the River Murray, except where that proportion of water which enters the underground water is subsequently removed via saline underground water mitigation scheme(s).

7. PERMITS

7.1 Drilling of wells

The following objectives and principles apply to permits for activities relating to wells under section 9(3)(a) & (b) of the Act comprising the drilling, plugging, backfilling or sealing of a well and the repairing, replacing or altering the casing, lining or screen of a well.

7.1.1 Objectives

1. Minimising the effect of well location on water levels.

2. Minimising the impact of drilling, sealing, backfilling or plugging of wells on the water resource.

3. Minimising the impact of repair, replacement or alteration of the casing, lining or screen of wells on the water resource.

7.1.2 Principles

1. The equipment, materials and method used in the drilling, plugging, backfilling or sealing of a well, shall not adversely impact on the quality of the underground water resource.

2. The equipment, materials and method used in the repair, replacement or alteration of the casing, lining or screen of a well, shall not adversely impact on the quality of the underground water resource.

3. Wells for the purpose of aquifer recharge operations shall be constructed so that the headworks allow both recharge and discharge operations to be metered without interference.

7.2 Drilling of monitoring wells

The following objectives and principles apply to permits for the activity of drilling or sealing a monitoring well under section 9(3)(a) of the *Water Resources Act 1997*.

7.2.1 Objectives

1. Provide for the monitoring of the capacity of the resource to meet demands for the underground water resource on an on-going basis.

7.2.2 Principles

1. A permit shall only be granted for the purpose of drilling or sealing a watertable monitoring well where:

    1.1 the proposed well is completed to 2m below the current standing watertable to a maximum depth of six metres;

    1.2 the proposed well is cased with 75 mm ID (internal diameter) Class 12 UPVC with three metres of slots directly above the bottom of the well, and a PVC bottom-cap;

1.3 the casing of the proposed well extends one metre above the natural surface of the land;

1.4 the slotted section of the proposed well is covered with fabric made of terra firma fibre cloth;

1.5 the bottom four (4) metres of the annulus (area outside the casing) of proposed well is backfilled with 1.5 mm of graded gravel;

1.6 the annulus (area outside the casing) of the proposed well is backfilled with cement from the top of the graded gravel (see above) to the surface;

1.7 the casing of the proposed well that extends above the natural surface of the land is protected by an outer sleeve of galvanised pipe 1.5 m in length, with a wall thickness of 4 mm, a screw-on top cap, and set into cement at the ground surface.

2. A permit shall only be granted for the purpose of drilling or sealing a water-table monitoring well where the proposed location of the monitoring well is the lowest practicable point on the land.

7.3 Artificial recharge

The following objectives and principles apply to permits for the activity of draining or discharging water directly or indirectly into a well under section 9(3)(c) of the *Water Resources Act 1997* ("artificial recharge").

7.3.1 Objectives

1. To provide for the drainage or discharge of water to an aquifer for the purposes of:

   a) recharging the pressure of the aquifer;

   b) improving the quality of underground water; or

   c) storage of water for subsequent recovery.

7.3.2 Principles

1. A permit shall only be granted for the activity of draining or discharging water directly or indirectly into a well where the salinity of the water to be drained or discharged is:

   a) less than 2 500EC (1 500mg/L); and

   b) less than the salinity of a sample of the native underground water taken from the proposed point of drainage or discharge.

2. For the purposes of principle 1(b), the salinity of native underground water shall be determined by:

   2.1 testing a sample of underground water collected after pumping for at least one hour from an existing bore at, or proximate to, the proposed point of extraction; or

   2.2 by reference to the salinity contour diagrams in Appendix A to this Water Allocation Plan.

3. Permit shall only be granted for the activity of draining or discharging water directly or indirectly into a well where the headworks of the proposed point of discharge or drainage provide for the effective metering of the recharge water.

4. Permit shall not be granted for the activity of draining or discharging water directly or indirectly into a well where the draining or discharging of the recharged water is to occur simultaneously with the taking and use of the recharge water.

5. A permit shall not be granted for the activity of draining or discharging water directly or indirectly into a well where it would cause, or would be likely to cause, waterlogging and/or salinisation.

6. A permit shall not be granted for the activity of draining or discharging water directly or indirectly into a well where it would have, or would be likely to have, adverse impacts on:

   a) water quality;

   b) the integrity of the aquifer; and/or

   c) a neighbouring well(s).

7.4 Use of effluent

The following objectives and principles apply to permits pursuant to section 9(4)(j) of the *Water Resources Act 1997* for the activity of using effluent in the course of carrying on a business in the catchment area of the River Murray Catchment Water Management Board.

7.4.1 Relevant authority

1. The relevant authority for determining a permit application for the use of effluent in the course of carrying on a business in the Angas Bremer PWA is the Minister responsible for the administration of the *Water Resources Act 1997*.

7.4.2 Objectives

1. Manage the use of effluent to avoid adverse impacts on the prescribed water resource, other natural resources, and ecosystems that depend on the prescribed water resource.

7.4.3 Principles

1. A permit shall not be granted for the use of effluent in the course of carrying on a business if that use would cause, or would be likely to cause, a rise in underground water levels resulting in adverse impacts upon soil, rock, structures, and/or ecosystems.

2. A permit shall not be granted for the use of effluent in the course of carrying on a business if that use would cause, or would be likely to cause, waterlogging and/or salinisation.

3. A permit shall not be granted for the use of effluent in the course of carrying on a business if that use is likely to adversely impact upon the natural drainage of surface water on the subject land.

4. A permit shall not be granted for the use of effluent in the course of carrying on a business if that use is likely to result, directly or indirectly, in adverse impacts on the quality of the prescribed water resource.

5. A permit shall not be granted for the use of effluent in the course of carrying on a business where it is proposed that the effluent will be stored in an existing dam, wall or other structure, and that storage would result, or would be likely to result, in:

   a) the downward leakage of the effluent through the soil into the prescribed water resource;

   b) the overflow of the effluent over the surface of land; and/or

   c) the overflow of the effluent into a watercourse.

8. TAKING AND USE OF OTHER WATER RESOURCES

8.1 Taking and/or taking and use of water resources from the Angas and Bremer river catchment areas

The taking and use of water resources within the Angas and Bremer river catchment areas upstream of the Angas Bremer Prescribed Wells Area has the potential to impact upon the quality and quantity of the prescribed water resource by reducing the volume of stream flow and increasing salinity.

8.2 Use of River Murray prescribed water on land within the Angas Bremer PWA

An increasing volume of River Murray water is being used for irrigation in the Angas Bremer PWA. In 1998-99, approximately 26 500 ML of licensed River Murray water allocations were held by irrigators in the Angas Bremer.

The salinity of the prescribed underground water in the confined aquifer of the Angas Bremer PWA is mostly rising. It appears that the gradual salinisation of the confined aquifer is strongly influenced by downward leakage of saline underground water from the unconfined aquifer, in response to irrigation including irrigation using River Murray water.

To minimise the potential for waterlogging and salinisation resulting from the use of River Murray water within the Angas Bremer PWA, policies have been included in the River Murray Prescribed Watercourse Water Allocation Plan which regulate the taking and use, and transfer of licences and/or water allocations where River Murray water is used on land situated within the Angas Bremer PWA.

9. MONITORING

Under section 101(4)(e) of the *Water Resources Act 1997*, regular monitoring of the underground water resource's capacity to meet the demands for water must be provided for under the WAP. To meet this requirement, stream-flow data will continue to be recorded at gauging stations on the Angas River and Bremer River to ascertain water levels and electrical conductivity. Water level and salinity level data will also be recorded through a network of existing observation wells drilled into the Quaternary and Tertiary aquifers. In order for the capacity of the prescribed resource to be monitored effectively, observation bore water levels and salinity should be measured on a monthly and annual basis, respectively.

Additionally an Irrigation Annual Report is to be prepared at the end of each water-use year by each licensee using the prescribed water resource for irrigation and is to be submitted to the Minister through the Angas Bremer Water Management Committee Inc. (or directly to the Minister if the Committee expires) on the 31 July of each water-use year. The Irrigation Annual Report will include the following data:

a) the volume of water allocated on the licence;

b) the volume of water actually used by the licensee and recorded on each meter during the water-use year;

c) the volume of water actually used by the licensee and recorded on each meter during the water-use year for the purpose of shallow saline water table management;

d) the total amount of water recharged for each meter in the twelve months prior to the 31 October of the water-use year;

e) salinity of equipped production bores measured in December and June;

f) the area of each crop type irrigated;

g) percentage of the total volume of water actually used on each crop type;

h) drainage past the root zone (including the volume of water, the salinity and the concentration of nutrients);

i) the level of the watertable below the natural surface level of the land upon which the water endorsed on the licence is used measured in September, December, March and June of every water-use year;

j) area and duration of any flooding (whether natural or artificial); and

k) the nature of any soil moisture monitoring devices used on the relevant land.

Each water-use year the Angas Bremer Water Management Committee Inc. will prepare an aggregate district annual report and forward it to the River Murray Catchment Water Management Board.

10. MISCELLANEOUS

In preparing this Plan, the River Murray Catchment Water Management Board has had regard to the following:

- the matters referred to in section 6(2) of the *Water Resources Act 1997*; and
- the benefits of consistency with:
  a) relevant Development Plans under the *Development Act 1993*;
  b) relevant environment protection policies under the *Environment Protection Act 1993*;
  c) relevant district plans under the *Soil Conservation and Land Care Act 1989*;
  d) guidelines relating to the management of native vegetation adopted by the Native Vegetation Council under the *Native Vegetation Act 1991*.

APPENDIX A – Glossary

'The Act' The *Water Resources Act 1997*

Biota living organisms such as plants, animals and micro-organisms.

Biodiversity The variety of life forms: the different plants, animals and micro-organisms, the genes they contain, and the ecosystems they form. Biodiversity is usually considered at three levels — genetic, species and ecosystem diversity.

Commercial water use Taking water for any purposes associated with industrial or commercial activity. This includes processing, manufacturing, construction, mining, quarrying, bulk handling, slaughtering, commercial business, aquaculture, or any intensive animal keeping activity defined as intensive farming in the Act.

Domestic water use Taking water for ordinary household purposes. Includes watering land that contains a dwelling and is equal to, or less than, 0.4 hectares.

Ecologically sustainable development Ecologically sustainable development is about integrating the social, economic and environmental implications of resource use and development so that the needs of current and future generations can be met.

Ecosystem A community of organisms that may include humans, interacting with one another. Incorporating the physical, chemical and biological processes inherent in their interaction and the environment in which they live.

Effluent Industrial and sewage wastewater that is used for the purpose of irrigation

Environmental water provisions The environmental water requirements that can currently be met. This is what can be provided, with consideration to existing users' rights, and the social and economic impacts.

Environmental water requirements Descriptions of the water regimes (eg. timing, seasonality, duration) needed to sustain the ecological values of aquatic ecosystems including their processes and biological diversity, at a low level of risk.

Environmental water use The non-profit use of water for purposes that include the maintenance or rehabilitation of aquatic or riparian ecosystems.

Field application efficiency The proportion (expressed as a %) of the water applied to a particular location that is not lost under the roots of the crop quantified by:

$$\frac{\text{Irrigation water available to crop}}{\text{Water received at the field inlets}}$$

Irrigation water use Watering land by any means for the purpose of growing any kind of plant(s) for commercial use.

Licensee A person who holds a water licence.

Minister The Minister for Water Resources who is responsible for administering the *Water Resources Act 1997*.

Point of discharge The location where underground water is pumped or drained into a well for the purpose of aquifer storage and recovery.

Prescribed wells area The area of the Angas Bremer Prescribed Wells Area.

Prescribed water resource A water resource declared by the Minister to be prescribed under the Act. Prescription of a water resource requires that future management of the resource be regulated by a licensing system.

Recharged water Water pumped or drained into a well for purposes of aquifer storage and recovery

Salinisation The build up of salts in the soil as a result of the capillary flow of saline water toward the surface.

Stock water use Taking drinking water for stock not subject to intensive farming (as defined by the Act).

Surface water Water flowing over land, except in a watercourse, after having fallen as rain or hail or having precipitated in any other manner, or after rising to the surface naturally from underground. This term also refers to surface water stored in a dam or reservoir.

To take water To pump or siphon the water; to stop or impede the flow of water over land for the purpose of collecting the water; to divert the flow of water in a watercourse away from the watercourse; to release water from a lake; to permit water to flow under natural pressure from a well; or to permit stock to drink from a watercourse, a natural or artificial lake, a dam or reservoir.

Transfer The transfer of a licence (including its water allocation) to another person, or the water allocation of a licence (in whole or part) to another licensee or to the Minister under Part 5 of the *Water Resources Act 1997*. The transfer may be permanent or temporary.

Underground water Water that naturally occurs below ground level, or water that is pumped, diverted or released into a well for storage underground.

Volumetric allocation An allocation of water expressed on a water licence as a number of kilolitres or megalitres (volume) for a specified period of time, usually per water-use year (as distinct from an area-based allocation).

Water allocation The quantity of water that the licensee is entitled to take and use according to the licence. In respect of water taken pursuant to an authorisation under section 11 of the Act, means the maximum quantity of water that can be taken and used pursuant to the authorisation.

Water Allocation Plan (WAP) A plan prepared and adopted under Part 7 Division 3 of the *Water Resources Act 1997*.

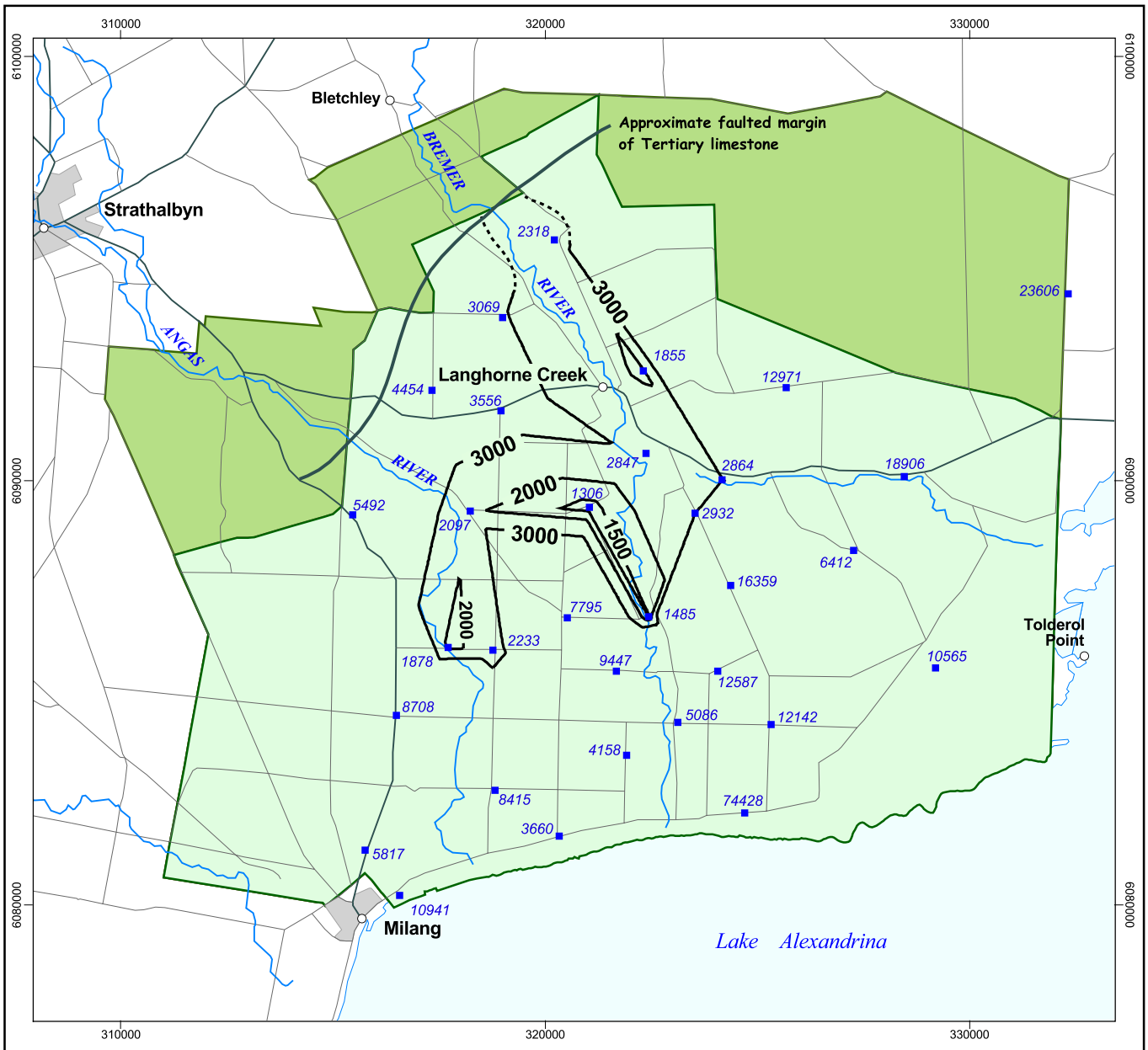
Water logging The permanent or temporary saturation of the soil profile so as to impede plant growth.

Water licence A licence granted under the Act entitling the holder to take water from a prescribed watercourse, lake or well, or to take surface water from a surface water prescribed area. This grants the licensee a right to a specified allocation of water, and may include conditions of the use of that water. A water licence confers a property right on the holder that is separate from land title or land ownership.

Water-use year The period between 1 July in any given calendar year and 30 June the following calendar year. This is also called a Licensing Year.

Well of origin Well at which underground water allocation is licensed prior to transfer.

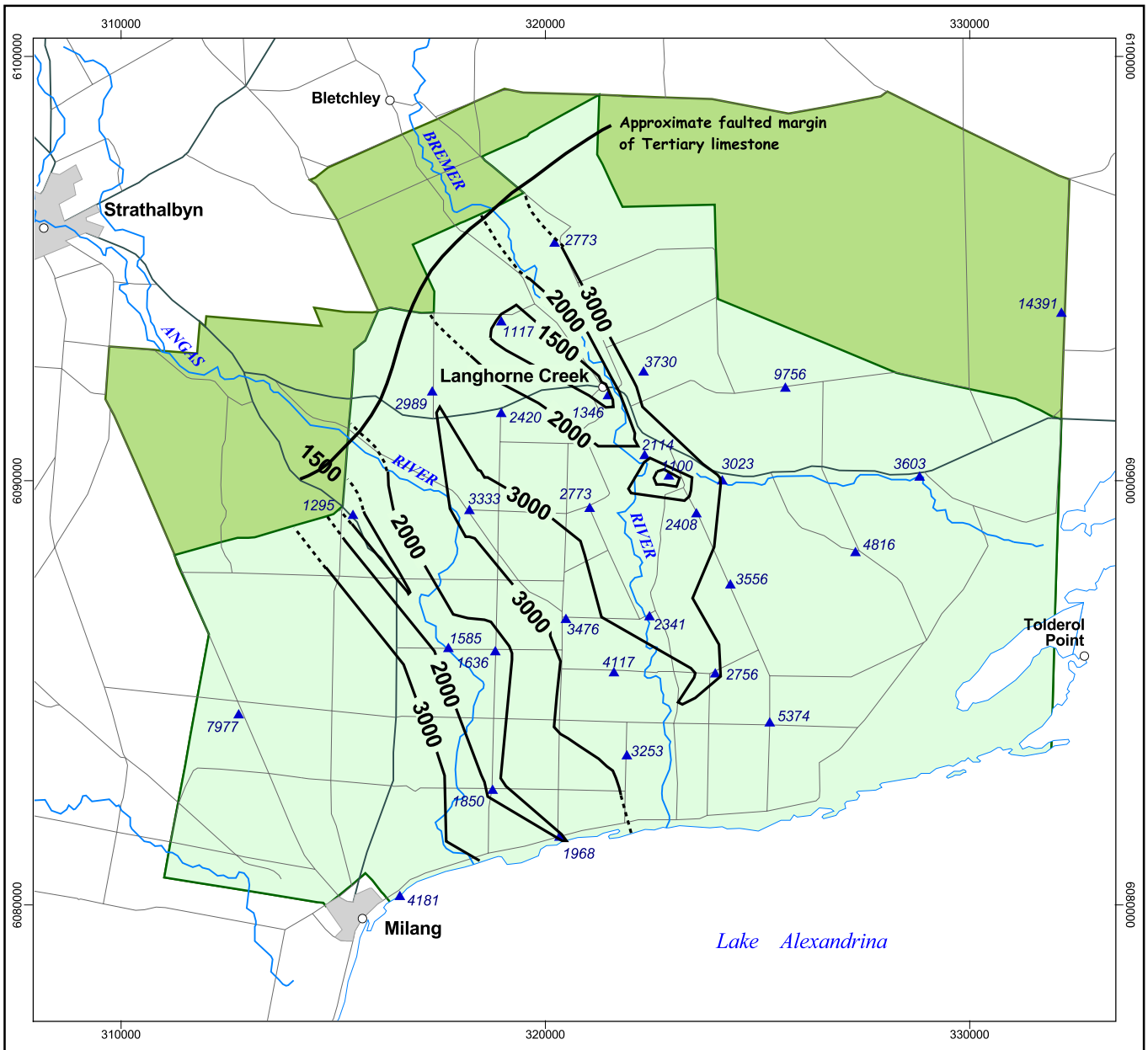
APPENDIX B – Maps



Angas Bremer Prescribed Wells Area and AB Irrigated Management Zone

UNCONFINED (Q) AQUIFER SALINITY CONTOURS - April 1996

Figure B.1



— 2000 — Confined (T1) aquifer - salinity contours 1996 (mg/L)

Contoured by triangulation with grid spacing of 50 metres

▲1977 Confined (T1) aquifer bores and 1996 TDS (mg/L)

Angas Bremer Prescribed Wells Area

AB Irrigation Management Zone

River / creek

Locations

Main road

Minor road

0 1 2 3 4 5

Kilometres

MAP PROJECTION - AMG ZONE 54

N

Angas Bremer Prescribed Wells Area and AB Irrigation Management Zone

CONFINED (T1) AQUIFER SALINITY CONTOURS - April 1996

Figure B.2

APPENDIX C – Angas Bremer Irrigation Region revegetation booklet

Angas - Bremer Irrigation Region

Revegetation Booklet

Commissioned by
The Angas-Bremer Water Management Committee
August 2000

Produced by Environmental Regeneration Australia

Natural Heritage Trust
Helping Communities Helping Australia

Angas-Bremer
Water Management Committee

River Murray Catchment
Water Management Board

TABLE OF CONTENTS

HOW TO USE THIS GUIDE

Re-establishing vegetation requires a reasonable understanding of what the land is capable of supporting. In order to assess this and to give an indication of what may formerly have been present on the land throughout the Angas-Bremer Irrigation region, this guide has been put together.

Because of the range of vegetation associations and soil types it has been necessary to tackle this in a number of stages. This revegetation guide has divided the Angas-Bremer Irrigation area into five common soil types. A brief description of each of these is given in the main body of the text.

In each of the soil types a description of the site is given, a list of weeds and plants likely to be around on such a site and photos to help identify the site type.

If the site description matches the sort of revegetation project you wish to undertake, it is worthwhile checking the former vegetation list and even visiting some remnant vegetation areas or revegetation sites to provide a realistic insight into what you are trying to achieve.

The former vegetation lists are by no means exhaustive and merely try to pick out some indicator species that help show the differences between sites and include species likely to be useful in revegetation projects.

General revegetation information is gathered together at the front of the booklet because most of this information is common to any revegetation project in this area. This is probably the most important information because it really is dealing with the basic requirements of good revegetation planning.

Obviously, all sites are different and historical management practices have had impacts on all sites. A couple of the significant factors likely to make it difficult to re-establish vegetation are also dealt with in the front section of the booklet.

Good luck with your planting!

EASY STEPS TO REVEGETATION

WOODY WEED CONTROL

Woody weed control needs to be done as far in advance of revegetation as possible. For example, 2-5 years of follow up control may be required on species such as Bridal Creeper and Boxthorn, however this will become more difficult in among newly planted trees. Swamp areas will have significant ongoing weed control issues with a broad range of woody weeds including Olives, Caster Oil Plant etc.

FENCING

Fencing should be carried out well in advance of planting time. Under no circumstances should planting go ahead without fencing in place. All likely grazing animals need to be excluded from the revegetation area. If machine planting and weed control is likely, fencing will need to allow for access. For example,

- Wide end of rows to allow for machinery to turn around.
- Fencing far enough back from steep banks to allow for machinery access.
- Openable panels or drop fences if fences are too close to allow for turning.

OTHER GRAZING CONTROL

Grazing by pest and other species may need to be considered:

- RABBITS need to be controlled prior to planting – contact Animal and Plant Control Board
- Ideally, HARE numbers need to be low for successful revegetation.
- RED LEGGED EARTH MITE can be a significant problem but are usually only a nuisance. If huge numbers are present and spraying is an acceptable option this is possible but will need to extend into adjacent paddocks and be repeated regularly.
- KANGAROOS grazing can be a problem. Exclusion fencing or individual tree guards may be possible in some cases. Otherwise plant species selection and planting methods and layout may be adjusted to accommodate the extra grazing pressure. These measures will only be necessary if kangaroos occur in large numbers.

WEED CONTROL

Woody and perennial weeds will need to be dealt with in the year prior to planting as a minimum.
Some weeds, eg Couch, Kikuyu, Horehound etc. need to be controlled during active growth in the spring and early summer in the season prior to planting.

Annual weeds can be controlled with a 2-litre/ha glyphosate spray before planting. In wetter seasons with an early season break and in later sowing areas 2 weed control sprays will be necessary – one soon after initial germination and one in the fortnight before planting. (This strategy will need to be adjusted for individual sites, eg if erosion is a concern 2 sprays may be inadvisable).

It is very important to only use Glyphosate for weed control if direct seeding, unless your contractor advises otherwise. Particularly avoid residuals as these can affect germination in direct seeding.

TIMING

This will be dealt with under the individual soil types. As all the Angas Bremer Water Management Committee area is under 500mm rainfall, unirrigated planting will generally take place between May and August.

If possible, get advice from someone who has seen your site and has experience with tree planting in your area. Irrigated planting needs more planning but planting can be carried out into spring and summer.

SPECIES SELECTION

Species to be planted need to be determined well in advance of planting. The species mix under each soil type will assist in compiling a list. Sourcing seed from local areas is important. There will be sites that have been seriously altered eg increased salinity or waterlogging. These site changes will mean that the planting lists will also need to be changed. Again seek advice on any tricky sites.

SEED AND SEEDLINGS

A complete order for seed and seedlings required for the job needs to be organised by October the previous year at the latest. This allows for local seed collection and growing of tubestock.
If any harder to grow species are to be included in the tubestock order, an extra 12 months time may be required to supply because some of these plants need to germinate over winter. Similarly some plants only set seed biannually, or even less, so some species will be unavailable unless collectors have a couple of season's notice.

PLANTING

This is the simplest part of the job if all preparation has been done effectively. Organise plants to be on site well in advance of planting. Organise a demonstration of appropriate planting technique on site if possible.

If direct seeding, the direct seeding contractor should be contacted regularly to ensure they understand the status of the job and preparations. Ensure all preparations are complete and if possible be on site on the day of sowing.

POST PLANTING

Watch out for unexpected grazing and deal with it. Watch out for serious weed competition and discuss with the contractor if concerned. Relax about germination if it is direct seeded. It may take 6 – 10 weeks before you see anything and you will need to put your nose in the trench to see anything at all.

Tubestock will need similar vigilance. Weed competition is the greatest threat to survival so wet spring or summer conditions will probably mean follow up weed control around each plant will be necessary.

PLANTS FOR MODIFIED SITE CONDITIONS

Some sites will have experienced changes since clearing that will make it impossible to replace the former vegetation. The two commonest problems in this regard are salinity and waterlogging. These problems are often linked and due to the wide range of ways they affect a site it is impossible to give specific treatments for all cases. Below are some general statements on the way these problems impact on plants. Before investing time and effort in planting such sites get advice from experienced people who have seen your situation.

SALINITY

High salinity levels significantly impact on plants. Re-establishing deep-rooted perennial vegetation may be very difficult on seriously saline sites.

Also, salinity may not be the only issue on some sites that are very salt affected. In order to establish what may be possible; identify what is currently surviving on site.

1) Bare soil, salt crusting on surface, no vegetation cover.
   Action: Fence well beyond bared area. Trees will not grow in these conditions. Mounding of bared site and allowing two winters prior to planting may establish some highly tolerant species. Focus efforts on areas that have grass cover around the perimeter of the bared areas. Also, revegetation anywhere in the catchment zone for these areas will be beneficial.

2) Samphire, occasional mounds with taller vegetation or grasses.
   Samphire is you best bet on these sites. Exclude stock and plant perimeter areas with highly tolerant species.

3) Saltwater Barley Grass, Saltwater Couch etc
   Exclude stock, mound if possible, plant with salt tolerant species.

It is important to note that most of the species native to this area have reasonable salt tolerance due to their exposure to saline soils and the historical coastal influence. However, changes in water tables and other changes mean some areas are too salty even for these species. Incredibly salt hardy plants such as the samphires, melaleuca halmaturorum and melaleuca brevifolia mean most areas can support some sort of plant life.

Areas that are currently supporting salt tolerant grasses will grow trees and as the range of plants increases so will the possible revegetation species. It is important to realise that part of the cost of salt tolerance is growth rate. Melaleuca halmaturorum is one of the most salt tolerant trees around but it will not grow fast and it will not grow large. In seriously salty situations it will grow even slower!

WATER USE

Ironically in low rainfall areas such as the Angas Bremer irrigation area there are occasions where high water use plants are desirable. Such plants are used to reduce recharge, planting in wet areas or to utilise wastewater.

1. Reducing recharge
Local vegetation is probably the most effective plant association at surviving on local rainfall and yet being able to reduce recharge flow through the root zone. It manages this by relying on a wide species range all competing for water and each responding to different situations. For instance, native grasses will grow when there is plenty of water and the big mallees have deep roots that grab any moisture that gets past all the other plants' root zones.

2. Wet Areas
If planting into a recognised wet spot or an area with a water table that the plants can access it may be necessary to incorporate some higher water using species. If local species are appropriate for this use the former swamp vegetation list found in the 'Black Cracking Soils' section. However, if some sort of woodlot plantation is considered, seek advice. Information that will assist in these decisions should still be gathered. Soil type, existing vegetation, water table depths (summer and winter) salinity level, irrigation potential during establishment will all be helpful.

3 Waste Water Use
Again this is a specialised area and needs to tailor made to your project. It is however safe to generalise by saying that usually bigger plants use more water than smaller plants and faster growers use more water than slower growers do! Water quality and volume available as well as the specific pollutant information will also be necessary for planning. Do not overlook local species as we do have some species that do very well in irrigated situations.

REVEGETATING HEAVY RED SOILS

1. SITE TYPE. Heavy Red Soils

2. SITE DESCRIPTION {including indicator species likely to be on site}

These sites are characteristically flat to gently sloping areas with deep clay to sandy clay soil overlying calcareous subsoil. Currently they are rapidly being planted to vines. They are obviously very fertile sites capable of supporting large Peppermint Box trees and associated vegetation. Few areas of this vegetation are left in the district because of the ability of these sites to produce good cereal crops, etc and a long history of clearing.

Characteristic weed species on these sites are:

Soursob
Salvation jane

Native species that persist on these sites:

Eucalyptus odorata	Peppermint Box
Acacia microcarpa	Manna Wattle
Acacia brachybotra	Grey Wattle

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia acainacea	Round Leaved Wattle
Acacia brachybotra	Grey Mulga
Acacia microcarpa	Manna Wattle
Acacia paradoxa	Kangaroo Thorn
Acacia pycnantha	Golden Wattle
Carpobrotus sp	Pigface
Callitris preissii	Native Pine
Danthonia sp	Wallaby Grasses
Dianella revoluta	Flax Lillee
Dodonaea viscosa	Hop Bush
Einadia nutans	Creeping Salt Bush
Enchylaena tomeentosa	Ruby Salt Bush
Eucalyptus odorata	Peppermint Box
Eutaxia microphylla	Mallee Bush Pea
Maireana sp	Bluebush
Melaleuca lanceolata	Dryland Tea Tree
Myoporum platycarpum	Sugarwood
Pittosporum phylliraeoides	Native Apricot
Vittadinia sp	

4. CONSIDERATIONS FOR REVEGETATION

These red soils have been the prime agricultural production areas in the region. Consequently they have nearly always been cultivated extensively causing significant changes in fertility and soil structure. Where cropping has been carried out in recent seasons there is also the complication of herbicide effects. As much information on the chemical history as possible should be gathered to help in planning. If regular pre-emergent herbicide applications have been made it is probably going to impact on direct seeding results.

Excellent results have been achieved on these sites, particularly in wetter years, but weed competition is always a major issue. A strategy for controlling weeds along seeding rows and immediately around seedlings to ease the competition if necessary should be considered in the planning stages.

Plate 1: Langhorne Ck Cemetery, showing former heavy red soil vegetation type

Plate 2: Successful revegetation site on land adjoining the Langhorne Creek Cemetery, planted in 1991

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection

A good number of the species listed lend themselves to revegetation projects because they grow well as either seedlings or direct seeding. Seed collection from mallee vegetation is usually easy because all except the tallest mallees are usually reachable and the mallee vegetation tends to seed prolifically in their efforts to reproduce. So collect a lot of seed and do so opportunistically because not all species will seed each year.

Wattles need to be a strong component in these revegetation areas because they will tend to alter the site in favour of tree cover again. Their rapid growth matches it with many weedy competitors and their nitrogen fixing roots redistribute the nutrients in the soil to a deeper level favouring deeper-rooted perennial vegetation.

Seeding rates
A typical direct seeding mix would consist of:

Species	Percentage of mix
Peppermint box and other mallees	25
Melaleuca species	15
Wattles (acacias), &others	40
Native pine	10
Dodonea, Enchylaena, etc	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing
Direct seeding can be carried out as late as mid August. Earlier sowing is often desirable but if a wet spring is experienced extra weed control will be required.

Tubestock will need to be planted by August unless watering is intended.

Site preparation
Ideally couch can be controlled in the seasons prior to revegetation. Again, stock exclusion for a season or more is desirable to allow things to stabilise after a long history of cultivation. Glyphosate at 2 litres a hectare is suggested as a knockdown spray to control annual weeds – once as soon as possible after the season breaks.

Sowing techniques
Direct seeding is generally effective on these sites.
Tubestock enable a broader range of species to be established but will be more expensive. Seedling plantings are often used in narrow strip plantings or small areas or where irrigation is being used. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Planting of tubestock can be carried out during the winter months as long as effective weed control has been done. Early winter plantings will probably require follow up weed control as will irrigated plantings.

Barerooted plants and seedlings are options for fodder plantings.

Post sowing management
Red-legged earthmite may need controlling in the weeks after sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies
Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS

Agroforestry
There are really no options for commercial forestry on these sites on natural rainfall. Irrigated woodlots may be a good option where wastewater etc is available. Also high water tables may offer adequate water supply within the reach of plant roots in a few locations. In both these cases high water use, rapid growth species are required.

Private use woodlots are obviously a potential use of such sites. In other states (and Kangaroo Island) mallee areas are used to grow Eucalyptus oil successfully.

Fodder shrub
These heavier soils will suit saltbush growing very well. However, current returns from other crops probably make this potential unattractive unless salinity is an issue.

REVEGETATING RED SANDY SOILS

1. SITE TYPE. Red Sandy Soils

2. SITE DESCRIPTION {including indicator species likely to be on site}

These sites are closely associated with the heavier red soil sites. There are many species that grow on both sites and the main differences are the needs of the plants growing on these sites to be able to cope with drier conditions. Often lighter sandy ridges cross a plain of heavier soil meaning that revegetation sites often cover both of these soil types.

Characteristic weed species on these sites are:

Veldt Grass is the main weed species present on nearly all of these sites

Native species that persist on these sites:

Callitris preissii	Native Pine
Allocasuarina verticillata	Drooping sheoak
Mallee Eucalypts	

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia calamifolia	Sandhill Wattle
Acacia pycnantha	Golden Wattle
Acacia paradoxa	Kangaroo Thorn
Acacia brachybotra	Grey Mulga
Acacia acinacea	Round Leaf Wattle
Allocasuarina verticillata	Drooping Sheoak
Bursaria spinosa	Christmas Bush
Callitris preissii	Native Pine
Dianella revoluta	Flax Lillee
Eucalyptus fasciculosa	Pink Gum
Eucalyptus spp.	Mallee species
Lomandra spp	Iron Grass, Tussocks
Melaleuca uncinata	Broom Bush

4. CONSIDERATIONS FOR REVEGETATION

These sandy sites are generally located adjacent to heavier soil types, and in planning revegetation it is necessary to allow for these variations.

Throughout the district there is evidence of historical movement of this sand in the deposits that have been left along roadsides and in other less disturbed areas. Roadsides and fencelines are often targeted for revegetation areas, so it is likely many trees will be planted into these windblown deposits. It is worth remembering that if they blew around once they could easily be eroded again.

All sandy sites need to be treated with care during any change of land use. Potential for erosion needs to be assessed before on site work commences, and steps to reduce the risk taken. These would include using cover crops, delaying planting to allow site consolidation, spraying narrow bands rather than blanket areas, mulching or spot spraying and planting tubestock.

These sites vary greatly in what grows on them so locate the nearest remnant to your planting area to give some clues. Also seek advice from locals who may remember some of the former Sheoak or Native Pine patches that are common on these sandy sites.

Plate 3: Native vegetation on red sandy soils along Sheoak Road

Plate 4: Successful revegetation on roadside

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection

On sandy areas it is important to get plants established rapidly to reduce the risk of erosion. The initial planting needs to focus on pioneering species with the capability of establishing strongly. If seed is available other plants can be utilised but generally it is better to look at broadening the species range in later seasons once the site is more stable.

Seeding rates

A typical direct seeding mix would consist of:

Species	Percentage of mix
Eucalypts	15
Melaleuca species	10
Wattles (acacias), &others	35
Native pine	15
Allocasuarina (sheoak)	15
Grasses or other (eg. enchylaena)	10

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Seedling planting
Seedling planting is very easy on these soils. Species mixes can closely resemble those recommended for direct seeding although seedlings allow for trickier to grow plants to be included. Propagating cuttings can also be used to grow plants not germinated by seed.

Weed competition needs to be controlled for about 1 metre from each plant.

Planting can commence at the same time as seeding or even up to a couple of months earlier if follow up weed control can be carried out if necessary.

Timing
Seeding times on these sites is determined more by site preparation than some other low rainfall sites. Late July to early August is reasonable because they allow for later weed control in the season of sowing. Cover crop establishment is also necessary on some sites and this also may require an early August sowing time.

Site preparation
Veldt grass is usually the major weed problem on these sites. Weed control should commence as soon as practical after there is enough cover on the site to hold it together. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing. Other annual weeds should be controlled in the same operation. Perennial weeds such as Bridal Creeper will need to be controlled in the year prior to planting and followed up as required.

It is occasionally necessary to secure a site with a cover crop to prevent blowing and this is another operation that will impact on both timing and planting layout so needs to be considered in the early planning stages.

Sowing techniques
Direct seeding is quite effective on red sandy sites but is variable depending on seasonal conditions.

Tubestock enable a broader range of species to be established but will be more expensive. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management
Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies
Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS

Agroforestry
There are really no options for Forestry on these sites on natural rainfall.

Fodder shrub

Other
With irrigation a broad range of species can be grown on these sites. Horticultural possibilities with native flowers may be an option in these areas.

REVEGETATING BLACK CRACKING SOILS

1. **SITE TYPE. Black Cracking Soils**

2. SITE DESCRIPTION {including indicator species likely to be on site}

These are the former swamp sites along the watercourses and lakefront. There is a number of standing swamps still to be found in the area, particularly south of Langhorne Creek, along the lower stretch of the Angas and the flood out areas adjacent to these areas. The swamps are very different to any other landscape in the district and immediately identified by the huge redgum overstorey. Former locations of these sites can also be readily identified by the blackish coloured; deeply cracking soils that that become sloppy grey mud when wet. The original swamps also experienced regular inundation that may no longer occur due to changed drainage patterns.

Lakefront revegetation has had mixed results. Revegetation efforts are complicated by the serious changes these areas have suffered over the last 60-70 years. Total clearing, long term grazing, rising lake levels after the building of the barrages (and resulting groundwater changes) and increased salinity mean these are highly altered sites with a reduced range of appropriate species for revegetation. The highly exposed lakefront means only highly salt tolerant, coastal type species are likely to withstand the elements and weed competition is aggressive. Good results have been achieved only slightly inland from the lake's edge where weed competition is still a major issue.

Characteristic weed species on these sites are:

Boxthorn
Salvation jane
Olives
Castor oil plant
Fennell
Dock
Marshmallow
Briar rose
Nightshade
Myrsiphyllum

Native species that persist on these sites:

Eucalyptus camaldulensis	Redgum
Muehlenbeckia cunninghamii	Lignum

3. FORMER VEGETATION TYPES ON THESE SITES

Former Swamp Areas

Acacia retinodes	Swamp Wattle
Acacia melanoxylon	Blackwood
Muehlenbaekia cunninghamii	Lignum
Eucalyptus camaldulensis	Redgum
Eucalyptus largiflorens	River box
Phragmites australis	Common reed
Cyperus spp	Sedges
Isolepis spp	Sedges
Juncus spp	Sedges

Lake Front Areas

Acacia brachybotra	Grey Mulga
Acacia cupularis	Coastal Umbrella Bush
Acacia microcarpa	Manna Wattle
Acacia pycnantha	Golden Wattle
Allocasuarina verticillata	Drooping Sheoak
Disphyma sp	Small Pigface
Enchhylaena tomentosa	Ruby salt bush

Eucalyptus fasciculosa	Pink Gum
Eucalyptus leucoxylon	SA Blue Gume
Melaleuca halmaturorum	Salt Water Paper Bark
Nitraria billardierei	Nitre Bush
Acacia retinodes	Swamp Wattle
Muehlenbaekia cunninghamii	Lignum
Eucalyptus camaldulensis	Redgum
Eucalyptus largiflorens	River box
Phragmites australis	Common reed
Cyperus spp	Sedges
Isolepis spp	Sedges
Juncus spp	Sedges

4. CONSIDERATIONS FOR REVEGETATION

Black cracking soils are very difficult revegetation targets. Access difficulties, occasional flooding, weed competition, soil cracking and exposed sites all contribute to make plant establishment difficult. If high salinity levels are present it becomes even more complex.

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection
There is only a narrow range of plants suited to revegetation on these sites. Lignum for instance is not usually grown from seed so is only available in smaller numbers from cuttings.

The revegetation of these areas is really hard due to weed competition and so tubestock are often a good option making both species range broader and weed control easier.

If direct seeding is being used Redgum and Wattles will dominate the mix.

Seeding rates
A typical direct seeding mix would consist of:

Species	Percentage of mix
Eucalypts	30
Acacia (wattles)	60
Melaleuca (if appropriate)	
Sedges	5 (seedlings ?)
Lignum	5 (seedlings)

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing
Seeding times on these sites is determined by access as much as anything is. Given that they often go underwater in winter and spring it is a bit of guesswork to try to time planting before the sites dry out. Late July in drier seasons to early spring are the likely planting times.

If it is a site not likely to get inundated access can still be difficult. This is less of an issue for tubestock planting but even this can be difficult in sticky wet conditions. Planting times on these sites should be much earlier, eg June to August.

Site preparation
Woody weeds are a significant problem on the swamp sites. They need to be controlled well in advance of planting. Weed control can start in the season prior to sowing to reduce seed set on annual weeds as well. Two sprays prior to sowing are a good idea if possible. Exclude stock.

Plate 5: Redgum swamp on Bremer River (black cracking soils)

Plate 6: Direct seeding on lakefront black soil site

Plate 7: Successful revegetation on a site not far from Plate 6.

Sowing techniques
In larger plantings direct seeding is still worth using but may require extra follow up. Progress is often slow for the first few seasons after planting.

Tubestock enable a broader range of species to be established but will be more expensive. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management
Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies
Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS

Agroforestry
These are the best big tree growing areas around. If ground water is good quality good growth can be expected.

Redgums are ideal as can be seen in any of the surviving swamps. Other forest species could be used in specific situations. Seek advice.

Fodder shrub
Salt bush would do very well on these sites.

REVEGETATING WHITE SANDY SITES

1. SITE TYPE. Sandy Sites – White non-wetting sand dune systems

2. SITE DESCRIPTION {including indicator species likely to be on site}

These sites are common on the western edge of the Angas floodplain area as well as other isolated pockets scattered through the irrigation area. Historically they have posed serious management problems as they are prone to rabbit infestation and wind erosion. Consequently they have often been neglected and may have been left with some remnant mallee for shelter or just allowed to become barren stock campsites.

Characteristically non-wetting dunes bared off over summer. Plants that are likely to occur on these sites are:

Couch Grass
Silver Grass
Evening Primrose
Nut Grass
Veldt Grass

Native species that often persist on these sites:

Danthonia species	Wallaby Grass
Stipa species	Spear Grass
Eucalyptus incrassata	Ridge Fruited Mallee
Melaleuca uncinata	Broombush

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia calamifolia	Sandhill Wattle
Acacia pycnantha	Golden Wattle
Acacia spinescens	Spiney Wattle
Baekea behrii	Silver Baekea
Banksia marginata	Silver Banksia
Banksia ornata	Desert Banksia
Billardia cymosa	Sweet Appleberry
Callitris preissii	Southern Cypress Pine
Callitris verrucosa	Mallee Cypress Pine
Calytrix tetragona	Fringe Myrtle
Clematis microphylla	Old Mans Beard
Danthonia species	Wallaby Grass
Dianella revoluta	Flax Lily
Dodonea viscosa	Sticky Hop Bush
Enchylaena tomentosa	Ruby Salt Bush
Eucalyptus fasciculosa	Pink Gum
Eucalyptus incrassata	Ridge Fruited Mallee
Eutaxia microphylla	Mallee Bush Pea
Grevillea ilicifolia	Holly Leaved Grevillea
Hakea muelleriana	Desert Hakea
Kennedia prostrata	Running Postman
Kunzea pomifera	Muntries
Lasiopetalum behrii	Pink Velvet Bush
Leptospermum coriacium	Mallee Tea Tree
Lomandra species	Iron Grass
Maireana species	Blue Bush
Melaleuca acuminata	Mallee Honey Myrtle
Melaleuca uncinata	Broom Bush
Pultenea tenuifolia	Sand Dune Bush Pea
Rhagodia candolleana	Seaberry Saltbush
Stipa species	Spear Grass

4. CONSIDERATIONS FOR REVEGETATION

All sandy sites pose definite difficulties for management. This is highlighted in areas of rainfall below about 450mm. This is because of the instability of these sites and the difficulty of controlling this during a major land use change. Revegetation relies on removing competition to allow desirable vegetation cover to establish.

These white sands also suffer the effects of historical management practices which have broken down any soil structure that existed and seriously increased soil acidity. Major weed infestations are often tolerated purely because this prevents the risk of erosion.

One interesting feature of these dunes is their ability to hold significant moisture below the surface. This probably indicates that they contribute to ground water recharge. Deep-rooted perennial plants are greatly advantaged by this moisture reserve and will often display rapid growth. This is also the reason why large pink gums often fringe the edges of these dunal systems.

The linear pattern of these dunes in some areas makes farm planning around them quite difficult and a range of options will be used to deal with them. Revegetation with native and fodder species remains important options for management.

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection
These sites have suffered significant alterations over time. Therefore it is not likely that all species that formerly occurred will be successful if planted {in the short term at least}. Initial planting mixes should contain higher rates of pioneering species. If direct seeding is the chosen establishment method, seed availability will also determine the species mix. It is essential that species to be planted should be sourced from as close as possible to the planting location.

Seeding rates
A typical direct seeding mix would consist of:

Species	Percentage of mix
Mallee eucalypts	25
Melaleuca species	15
Wattles (acacias), &others	40
Native pine	10
Allocasuarina (sheoak)	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing
Seeding times on these sites is determined more by site preparation than some other low rainfall sites. Late July to early August is reasonable because they allow for later weed control in the season of sowing. Cover crop establishment is also necessary on some sites and this also may require an early August sowing time.

Site preparation
Ideally couch can be controlled in the seasons prior to revegetation. Otherwise weed control should commence as soon as practical after there is enough cover on the site to hold it together. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing.

It is occasionally necessary to secure a site with a cover crop to prevent blowing and this is another operation that will impact on both timing and planting layout so needs to be considered in the early planning stages.

Sowing techniques
Direct seeding is quite effective on white acid sand but is highly reliant on seasonal conditions. Note that the non-wetting nature of these sites can be a problem. Wetting agents may be required.

Tubestock enable a broader range of species to be established but will be more expensive. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management
Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies
Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

Plate 8: Typical presentation of the white non-wetting sand dunes in the Angas-Bremer region.

Plate 9: Good growth rates can be achieved with the right vegetation mix on these formerly infertile sites.

6. OTHER MANAGEMENT OPTIONS

Agroforestry
There are really no options for Forestry on these sites on natural rainfall.

Fodder shrub
The most common fodder shrub used on these sites is Tagasaste (Tree Lucerne). It does extremely well on these acid sands. It can provide good fodder reserves in autumn and good shelter paddocks. Tagasaste requires tight management to get the best results. Grazing control is critical. Establishment is by direct seeding or seedlings with a number of growers or contractors available. Advice on layout and management should be sought from both suppliers and other farmers with experience.

Management for this plant includes not permitting any seed escape, as it is a potentially serious weed in scrub areas.

Pasture
In some areas of SA acid sands such as this are extensively modified by clay spreading enabling a wider range of cropping and pasture options. This would possibly also extend the options for fodder shrubs and revegetation. Specific advice should be sought.

Other
With irrigation, a broad range of acid loving species is able to be grown on these sites. Horticultural possibilities with native flowers may be an option in these areas.

REVEGETATING GRADATIONAL SOILS

1. **SITE TYPE. Gradational soils**

Plate 10: Roadside showing typical low mallee found on these soils

2. SITE DESCRIPTION {including indicator species likely to be on site}

These are the typical hard mallee soils. Usually grey to brown in colour with textures ranging from loamy clay to sandy. These sites often overly limestone and may have significant limestone scattered on the surface. The plants associated with them are also varied but can be described as typical mallee. On some of the drier parts of the Angas-Bremer area, to the north and east, where these soils are common, the mallee is relatively short and stunted. One of the typical features of these associations is the very large range of mallee eucalypts present (usually 3 or 4). If grazing has been allowed in these associations only larger shrubs will be left in the understorey. This often leaves these patches looking dry and uninviting. Mallee with an intact understorey is less common but worth a visit during the wetter months.

Characteristic weed species on these sites are:

Horehound
Scabious
Wild Turnip
Wild Radish
Capeweed
Wire Weed
Ryegrass
Barley grass

Native species that persist on these sites:

A range of Mallee Eucalypts
Melaleuca lanceolata

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia pycnantha	Golden Wattle
Acacia brachybotra	Grey Mulga
Allocasuarina verticillata	Drooping Sheoak
Dianella revoluta	Flax Lillee
Enchylaena tomentosa	Ruby Salt Bush
Eucalyptus calycagona	Square Fruited Mallee
Eucalyptus gracilis	Yorrell
Eucalyptus incrassata	Ridge Fruited Mallee
Eucalyptus leptophylla	Slender Leaved Red Mallee
Eucalyptus socialis	Red Mallee
Eucalyptus spp	Other Mallees
Hakea muelleriana	Desert Hakea
Lomandra spp	Tussocks, Irongrass
Melaleuca acuminata	
Melaleuca lanceolata	Dryland Tea Tree
Melaleuca uncinata	Broom Bush
Pittosporum phyllyraeoides	Native Apricot
Santalum acuminatum	Quandong

4. CONSIDERATIONS FOR REVEGETATION

A lot of the sites that are being considered for revegetation on this soil type will be quite degraded. If there has been significant wind erosion, a long history of cultivation, significant weed infestation or serious limestone, growth rates may be slow. This is even more likely on sites that originally only supported low vegetation anyway.

Well prepared sites can get excellent results in good seasons because these sites are less hospitable to weeds, and once the site is clean most resources are available for the newly established plants.

Extra site preparation in the form of ripping and rolling may be required in rocky areas. There are good examples of these mallee areas persisting along roadsides.

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection
Use a good range of species from the list. Look at local stands to identify more accurately the species you want for your project. Collect seed from as local as possible.

Seeding rates
A typical direct seeding mix would consist of:

Species	Percentage of mix
Mallee eucalypts	25
Melaleuca species	15
Wattles (acacias), &others	40
Native pine	10
Allocasuarina (sheoak)	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing
Direct seeding and tubes need to be planted as early as practical in most of these sites. Weed control needs to be carried out early and sowing carried out by July.

Site preparation
Ideally couch can be controlled in the seasons prior to revegetation. Otherwise weed control should commence as soon as practical. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing.

If ripping is required it should be done by May.

Sowing techniques
Direct seeding is quite effective on these sites. Seasonal variation can be an issue but given the fact some of these sites are large and results are often as good or better than tubestock planting direct seeding is an obvious choice.

Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job or they lend themselves to smaller jobs on these sites.

Barerooted and seedlings are options for fodder plantings.

Post sowing management
Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition can be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies
Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS

Agroforestry
There are really no options for Forestry on these sites on natural rainfall.