More water management innovations in the Angas Bremer district of South Australia

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Abstract
By 1981, in the Angas Bremer district (Langhorne Creek) the annual use of groundwater for irrigated agriculture had increased to more than four times the annual groundwater recharge. Over the subsequent 20 years a reduction by 80% in groundwater use was achieved. The irrigators in this district have continued to develop and implement pioneering water management policies and tools.

Angas Bremer policies for water management include:
- *Groundwater allocations were reduced by 50% over 10 years.*
- *Incentives convinced irrigators to exchange groundwater allocations for lake-water allocations.*
- *Aquifer Storage and Recovery is used by individual irrigators to store water when it is available from the ephemeral Angas and Bremer rivers and from Lake Alexandrina.*
- *New conditions have been added to water licences. They require every irrigator to invest a minimum of dollars and time into:*
  - *Irrigation Annual Reporting that includes water-volumes and hectares-irrigated*
  - *Water-table height measurement and recording*
  - *Use of FullStop devices to measure and record drainage and the salinity of the water in the root-zone*
  - *Planting and maintenance of at least two hectares of deep-rooted, winter-active vegetation (typically native trees) for every 100 megalitres of water-allocation*

Angas Bremer tools for water management include:
- *Data-logging of aquifer-water-levels at 15 minute intervals*
- *Data-logging of the water-levels in the rivers*
- *New district maps that outline those locations that are at higher risk due to (a) saline soil (b) shallow water-table (c) restricted deep drainage and (d) waterlogging.*
- *A new district Soils Book that provides detailed information and management advice about each of the 25 main soils.*
- *An interactive computer disc that is used to distribute the Soils book, the Risk Maps and the complimentary Geographic Information Systems software. Every irrigator can design and print maps of paddocks and maps of the district by using the GIS software to combine their selections from the 140 district map-layers that are provided on the CD.*
- *The Website www.angasbremerwater.org.au*

Key words
Angas Bremer irrigation water management tools Soils Book Map Layers Computer Disc FullStop

1. INTRODUCTION

The Angas Bremer district is located near Strathalbyn, beside Lake Alexandrina, approximately 30km from the Murray Mouth and 60km south east of Adelaide (Figure 1). In South Australia, the Angas River and the Bremer River collect runoff from the hills east of Adelaide and they carry the water to Lake Alexandrina. The Angas Bremer irrigators water 7,100 hectares (ha) including 5,400 ha of wine-grapes, 470 ha of lucerne and 430 ha of potatoes.

Since 1980, the 160 irrigators have worked closely with their elected Angas Bremer Water Management Committee and with specialists from government agencies (Thomson 2002, 2004). By working together they have developed and implemented the innovative water management policies that are described in this paper.

2. THE WATER MANAGEMENT POLICIES

2.1 The volume of every groundwater allocation was reduced

In 1980 the over-used groundwater resource was brought under the control of legislation (prescribed). A Land Use Survey was used to document the area of each crop type that was being grown by each irrigator. Each irrigator was allocated a volume of water equal to the sum of the theoretical amounts needed to irrigate the area of each of their crops.

The total volume allocated greatly exceeded the volume thought to be sustainably available.

A water meter was fitted to each well. The district total of the metered volumes was measured to be much less than the district total volume allocated.

In 1987 the irrigators reluctantly agreed to the cancellation of any allocation volumes that their water meter records showed that they had not been using, a total of 4,000ML.

After extensive public consultation, the first Water Allocation Plan (WAP) for the Angas Bremer district (1987 to 1992) legislated reductions in the size of every water allocation. The percentage reduction was smaller for smaller allocations and it varied linearly with the size of the allocation. The maximum reduction was by 30% which was implemented as 10% each year over 3 years. (Figure 2)

If a water allocation was sold to a non-family member its size was reduced by 5%.

In the second Water Allocation Plan (1993 to 1998) each allocation was reduced by an additional 15% over 3 years.

2.2 Incentives encouraged the exchange of groundwater allocations for River Murray water allocations

The low farm-gate return from growing lucerne (12t/ha at $200/t) and the high capital cost for designing and constructing a pipeline to carry water inland from the lake limited the use of lakewater for growing irrigated lucerne hay to a distance less than one kilometre from the lake.

Lakewater provided an advantage because the salinity of the water in Lake Alexandrina (500mg/L) was lower than the salinity of the water in most irrigation wells (above 1,500mg/L). A change to lakewater enabled an irrigator to grow higher-value crops that needed water that is less-saline than can be used to irrigate lucerne.

Another incentive was provided by reinstating any volume that had been cut from a groundwater allocation if it was converted to a lakewater allocation.

To provide an incentive for decision making, all conversions from groundwater to lakewater had to be completed before a sunset date of 30 June 1996.

Due to the expansion of the Australian wine industry, by 1997 the farm-gate price being received for one tonne of winegrapes had risen from a break-even price of about $400 per tonne to more than $1,000/t. The return from growing winegrapes (12t/ha) now greatly exceeded the return from lucerne hay. Compared with lucerne hay, needing irrigation of 10ML/ha (1,000mm), winegrapes need 2.5ML/ha. Irrigators could exchange their reduced-groundwater allocation for a larger volume of lower-salinity lakewater. Eventually they were able to sell their excess water allocation (for about $400/ML) and use the money to finance planting a vineyard supplied via a pipeline with water from the lake ($30,000/ha). Between 1986 and 2002 the area of Lucerne in the district fell from 2,000ha to 500ha. Several growers of lucerne hay relocated from the district. Between 1993 and 2002 the area of winegrapes increased from 400ha to 5,400ha (Figure 3). Many large grape-growing-companies bought land and developed vineyards in the district.

2.3 Aquifer Storage and Recovery

The over-use of groundwater caused the water level in some wells to fall by up to 10 metres and well-salinities to rise. To offset these changes, some irrigators began to experiment with Aquifer Storage and Recovery (ASR). They piped low salinity water from the ephemeral Angas and Bremer rivers and used it to recharge their irrigation wells under gravity.

Policies were developed by the Angas Bremer Water Management Committee (ABWMC) to encourage ASR. These policies included (1) the right to extract 50% of the volume stored and (2) a roll-over credit lasting for up to 3 years and allowing the use of 30 to 50% of any volume that had been stored but not used.

2.4 New conditions on water licences.

2.4.1 Irrigation Annual Reporting
Accurate records are a pre-requisite for all successful management. Irrigation Annual Reporting involves every irrigator in improving the management of their local water resource. It is a framework that encourages record-keeping and learning by irrigators. It is NOT a tool for extracting data from irrigators.

Irrigation Annual Reporting began in the Angas Bremer Area in 1996 and it is now a requirement in the Water Allocation Plan for this Prescribed Wells Area (RMCWMB 2001).

For each farm, Irrigation Annual Reporting is a simple, inexpensive process whereby each irrigator measures and records information, that is useful for them, on a locally-developed Irrigation Annual Report form.

At the district-scale, Irrigation Annual Reporting involves the local collection of the Irrigation Annual Report form from every farm then collation of all the collected data to produce the District Summary Irrigation Annual Report (Figures 7 and 8).

A copy of the District Summary Irrigation Annual Report document is provided to every contributor and the Report for each year is also available from the Angas Bremer website. Each year the content of this Report is discussed at a community meeting that is held within 2 months of collecting the data.

This feedback enables each irrigator to compare their own irrigation management with the irrigation management of every other irrigator and with their own irrigation management in previous years (Figures 9 and 10).

Confidentiality
Only when the confidentiality of information provided by individual irrigators is guaranteed and delivered, will irrigators accurately report the sensitive data useful for them to see how their irrigation practices are changing from one year to the next and how their irrigation practices compare with other irrigators. For example the fraction of water that was wasted to drainage can be compared with how much was wasted in previous years and with the fraction wasted by other irrigators.
An irrigator will not provide accurate data if they suspect that their data may in future be used to their disadvantage. To protect themselves, irrigators can choose to provide in-accurate data because they know that comprehensive, independent checking of the accuracy of the data that they report is not affordable. Collection of incomplete or inaccurate data wastes everyone’s resources and can lead to faulty conclusions.

2.4.2 Monitoring wells
If irrigators were to apply too much imported River Murray water, water-tables would rise and cause waterlogging and salinity problems. Each irrigator has put in a 6 metre-deep monitoring-well and each irrigator measures the height of the water-table in that well four times each year (September, December, March, June). The four numbers are recorded and reported as part of each irrigator's Irrigation Annual Report.

The Angas Bremer Water Management Committee decided that every irrigator would own and monitor a well, rather than installing fewer wells at strategic locations and involving only some members of the community. Every irrigator is involved so that if water tables do rise, the irrigators will themselves immediately drive the steps needed to manage the problem. The depth-to-watertable data that is collected by the irrigators is displayed as maps (Figure 11).

2.4.3 FullStop devices
Every irrigator has installed at least two FullStops. Each FullStop is located directly beneath a dripper. One is buried at a depth of 50cm and one is at 100cm. Recently more FullStops have been added at 30cm.

The CSIRO FullStop device does two things:
a. A FullStop detects whether the soil is wetted down to the depth at which the FullStop is installed
The FullStop Wetting Front Detector is a specially shaped funnel, a filter, a float and a flag. The funnel is buried in the soil, at a depth in or below the active root zone of the plants. When rain falls or the soil is irrigated, water moves downwards through the soil. A wetting front is the boundary between the wet and the dry soil. The water moves as thin films around the soil particles. As the wetting front moves down the cone of the buried funnel, because the cross-sectional area of the funnel reduces, the water in the films is contained in a shrinking volume of soil. This causes the soil at the bottom of the funnel to get wetter. The soil becomes so wet that gravity can extract the water and it passes through the filter to be collected in the reservoir. This water floats a light-weight rod which in turn operates a flag above the soil surface that indicates that the soil is "full" so irrigation should "stop", hence the name "FullStop" (Figure 4). The FullStop has no wires, no electronics and no batteries. Water from a wetting front converges in the funnel to fill the reservoir and this raises the float. If the soil is dry before irrigation, the dry soil absorbs more water and the wetting front penetrates the soil only to a shallow depth. However if the soil is wet before an irrigation, it cannot store much more water, so the wetting front penetrates the soil to a deeper level.

b. A FullStop collects a water sample that can be used to measure the amount of salt, or other chemicals, in the rootzone.
A syringe is used to extract the water-sample from the FullStop, via the 6 millimetre tube. The salinity of the water sample can be measured using an electrical conductivity meter and the data charted against the date (Figures 5 and 6).

2.4.4 Maintenance of winter-active vegetation
With the goal to avoid the rising water tables that typically are associated with irrigation, every Angas Bremer irrigator plants and maintains two hectares of deep-rooted winter-active vegetation for every 100 Mega-Litres of water allocation. This strategy was suggested by the local irrigators and demanded by the majority of them. In the Water Allocation Plan it has become a legal requirement that is transforming the appearance and improving the amenity of the district. This re-vegetation demonstrates good environmental management and it is being used in the marketing of local products.

3. THE TOOLS

3.1 Data-logging of district aquifer-water-levels
Since December 2002, data-loggers have been used in each of 12 wells into the confined (deeper) aquifer plus 12 wells into the un-confined (shallow) aquifer. The well water level data is recorded every 15 minutes. This data is being used to develop an improved understanding of how the aquifers respond to rainfall, to river-flows, to flood events, to the drainage of water into wells for aquifer storage and recovery and to pumping from the aquifer for irrigation (Woods 2006). Three dimensional animations are being developed to show the temporal movements of the potentiometric pressure surfaces of the aquifer.

3.2 Data-logging of river-water-levels
Since August 2004 data-loggers have been used at each of 3 locations on the Bremer river plus at 2 locations on the Angas river. The river water levels are recorded and converted into flow rates and flow volumes. This data is being used to quantify the volumes used for winter flooding and for aquifer storage and recovery.

3.3 Angas Bremer District Risk maps
District Risk maps have been developed to show those locations that are at higher risk due to (1) saline soil (Figure 16), (2) shallow water-table, (3) restricted deep drainage or (4) waterlogging. In these areas new plantings can be avoided or special management is needed.

3.4 Angas Bremer District Soils book

A new local Soils Book provides detailed information and management advice for each of the 20 main soils in the district. The irrigator can easily compare the photo of each soil profile with what is visible in his soil-pit and quickly find the management advice in the book that applies for the soil in that soil pit.

For each of 25 typical soils, the book provides a 4-page data-sheet that includes a large coloured photo of the wall of a two-metre deep soil pit. Every soil-layer is described and, for each layer, the laboratory results from 15 chemical analyses are tabled, compared with target values and interpreted.

The “Management” section for each soil describes (1) any potential soil problems (2) pre-planting actions that can be taken to tackle those problems and (3) how best to manage the soil after planting.

3.5 Angas Bremer computer disc

An inexpensive (4 dollars) interactive computer disc (CD) delivers the District Soils Book, the risk and other district map-layers and the complimentary geographic information systems (GIS) software. Each irrigator uses their CD and chooses small sub-sets from the 140 district map-layers to design and print a variety of maps in order to understand and better manage each of their paddocks. Figures 12, 15 and 16 are examples of maps that can be produced using the CD.

For many years valuable data has been collected by individual government officers and documented within hard-copy reports that are stored in filing cabinets located near their widely dispersed work stations. Additional data is held within hard-copy reports written by private consultants. Most people within other government agencies and people in the general public do not know that this data exists. For the Angas Bremer district, much of this data has now been assembled. Much of the data has been displayed as map-layers. The existence of the data has been publicised and the data has now been made easily accessible to everyone who is interested because it has been widely distributed on the CD. Some of the local children are using the data within their school projects.

Discussions between local irrigators and government or private specialists are becoming increasingly productive because the irrigators now have access to the same data that is being used by the specialists. The irrigators can include their local knowledge to inform their own interpretation of the technical data.

3.6 Angas Bremer Website www.angasbremerwater.org.au

Since 1970 a large amount of data has been collected about the Angas Bremer district. The Angas Bremer Water Management Committee is working to ensure that this data is used and that (1) everyone knows that this data has been collected (2) all of the data is easily accessible and (3) time and dollars are not wasted in the future, by duplicating data-collection work that has already been done. The data is being made available from the website.

A project is under-way to enable users of the website to interact with the map layers via the website. It will then not be necessary to make and distribute multiple copies of updated CDs. As new map layers are produced, they will be added to the website.

In the future, irrigators will complete their Irrigation Annual Report forms and submit them via the website.

A new Angas Bremer groundwater model and a new groundwater solute transport model are being developed. It is planned that interaction with these models will become available via the website.

4. FUTURE CHALLENGES

4.1 Reduced Murray allocations

Years of drought and empty dams in the Murray Darling Basin have left irrigators with only 16% of their Murray allocation at the start of the 2007-8 irrigation season. In Lake Alexandrina the water level is falling and the salinity is rising (Figure 13). The outlook for 2008-9 is even more challenging.

4.2 Rising salinity of groundwater

A recent review of the data has shown that, despite the reduction in groundwater extraction from 20,000 to 1,000ML/year, the salinity of the groundwater is continuing to rise at 20mg/L per year and the area of land underlain by low salinity water continues to decrease (Figures 14 and 16) (Zulfic 2007). The recent Aerial Geophysics project has shown that much of this groundwater is more than 4,000 years old (Cresswell 2004).

4.3 Alternative sources of water

Angas Bremer irrigators are investigating innovative ways to access additional water, to use reclaimed water and to desalinate brackish groundwater.

4.4 Increased use of Aquifer Storage and Recovery

Large, plastic-lined dams are expensive and dams lose water to evaporation. If the technical and environmental challenges can be met, and if sensible monitoring, trigger points and legislation are developed and put in place, the aquifer can probably be used to store large volumes of water. (Thomson 2007)

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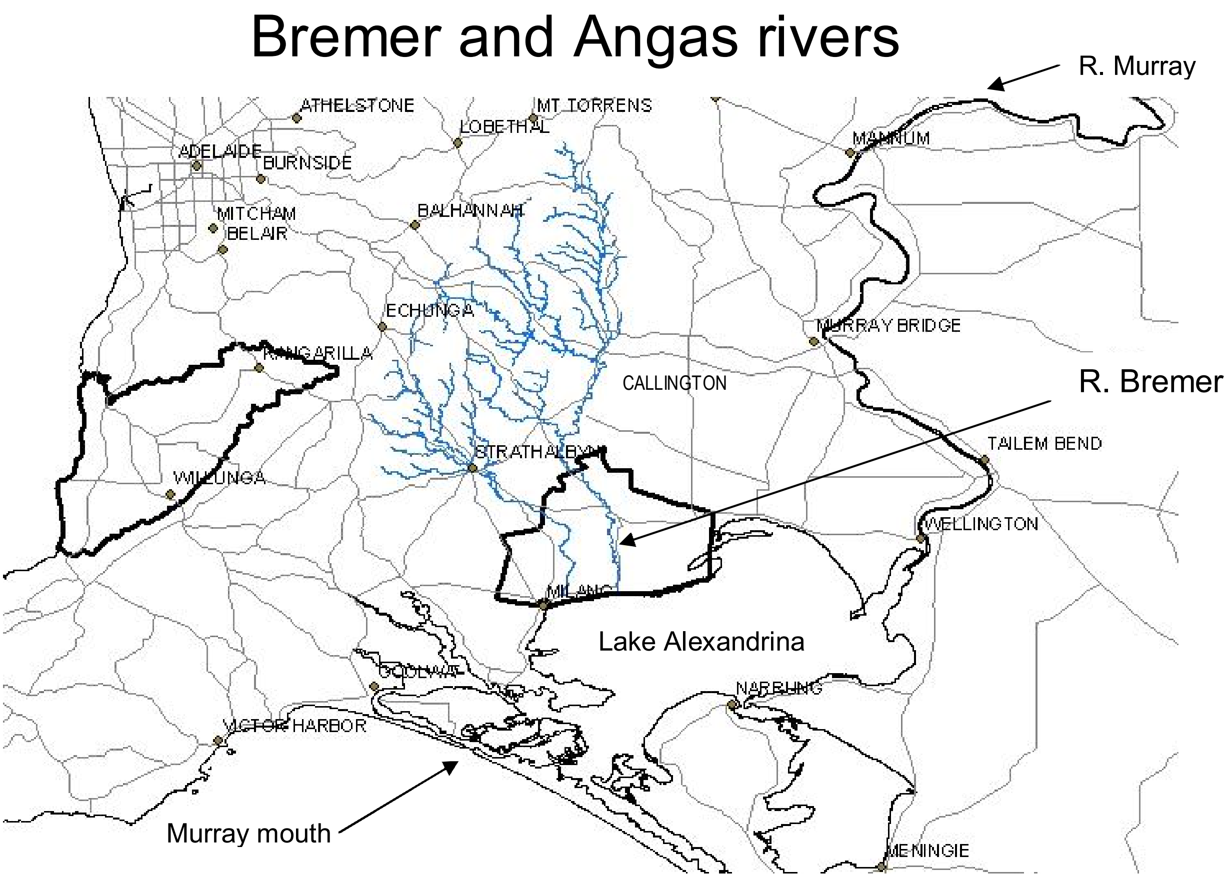

Figure 1
The River Angas, the River Bremer and the Angas Bremer Prescribed Wells Area

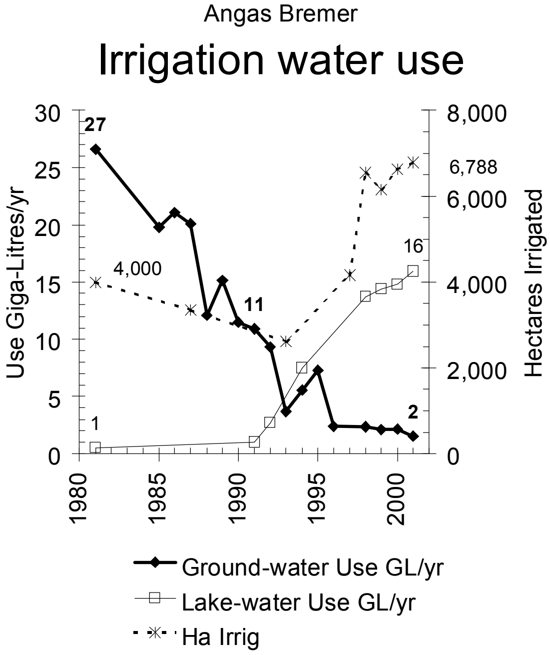

Figure 2 Decreasing groundwater use and increasing use of Murray water from Lake Alexandrina

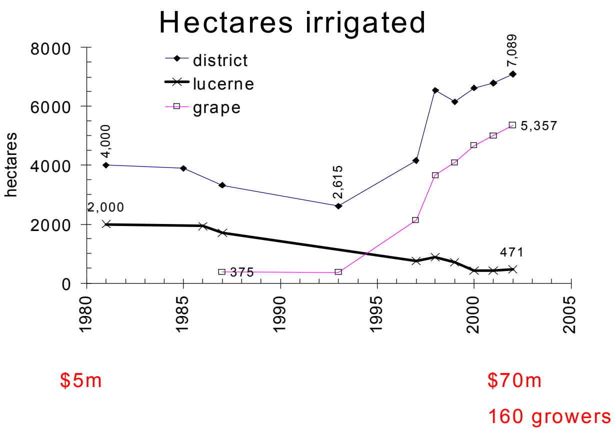

Figure 3 After conversion from Lucerne to Grapes the district area irrigated increased

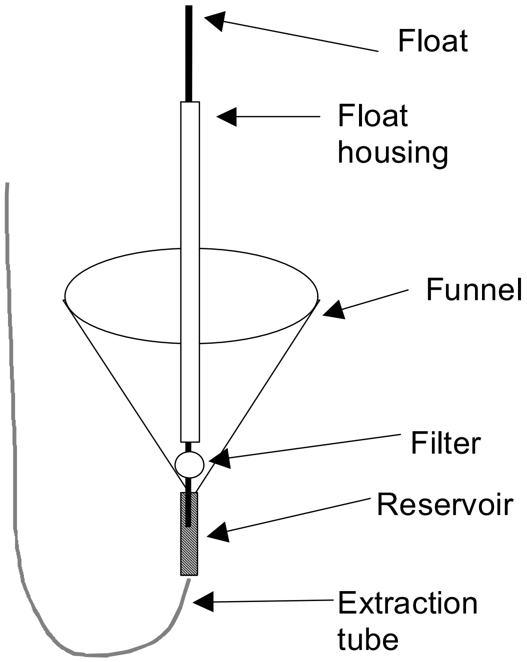

Figure 4 Components of a FullStop wetting front detector

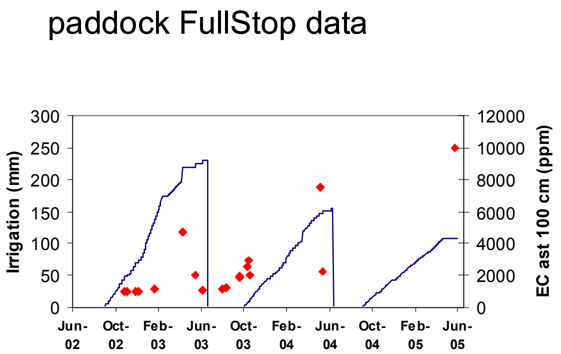

Figure 5 The date and the size of each irrigation (line) and the salinity of each 100cm FullStop-sample of soil water (diamond)

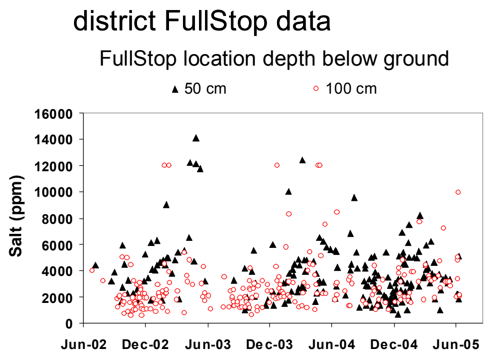

Figure 6 The date and the salinity of every FullStop-sample of soil water

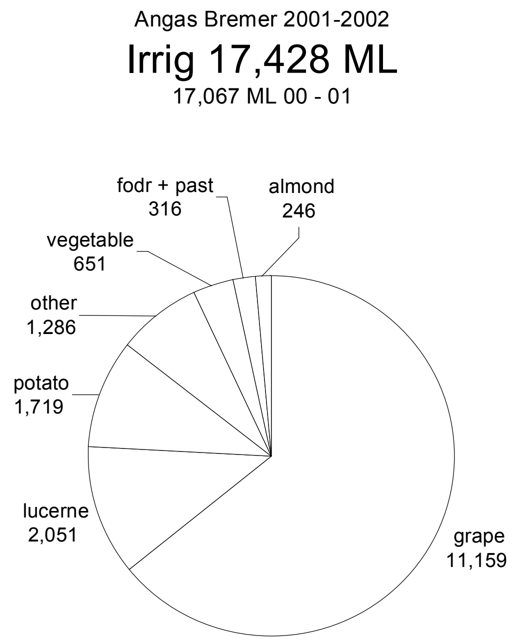

Figure 7
The district volume of irrigation water applied to each crop type

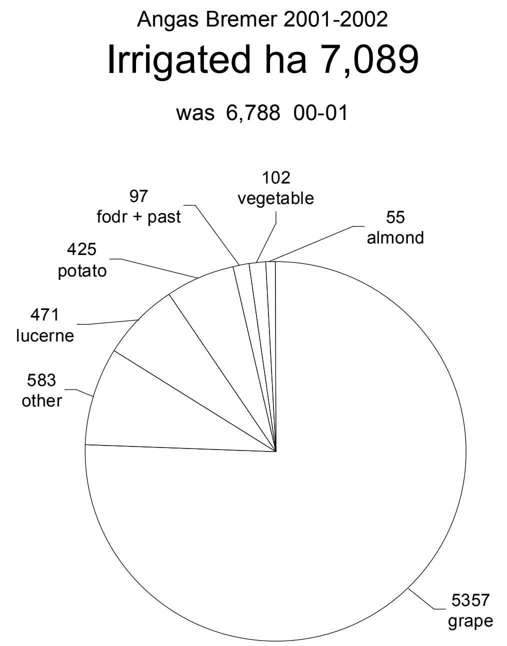

Figure 8
The hectares irrigated of each crop type

Irrig Ann Rep - benchmarking

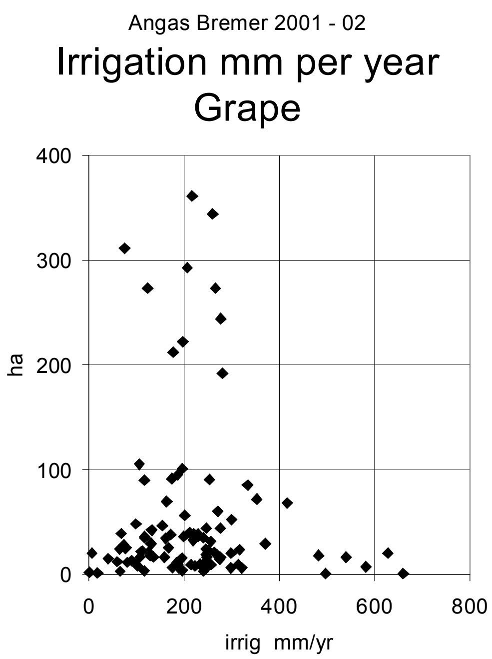

Figure 9 The wide variation in irrigation mm/yr applied by each irrigator

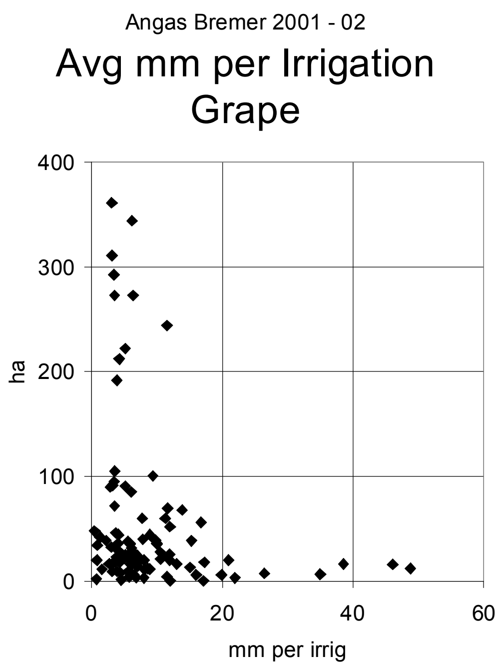

Figure 10 The wide variation in mm per irrigation applied by each irrigator

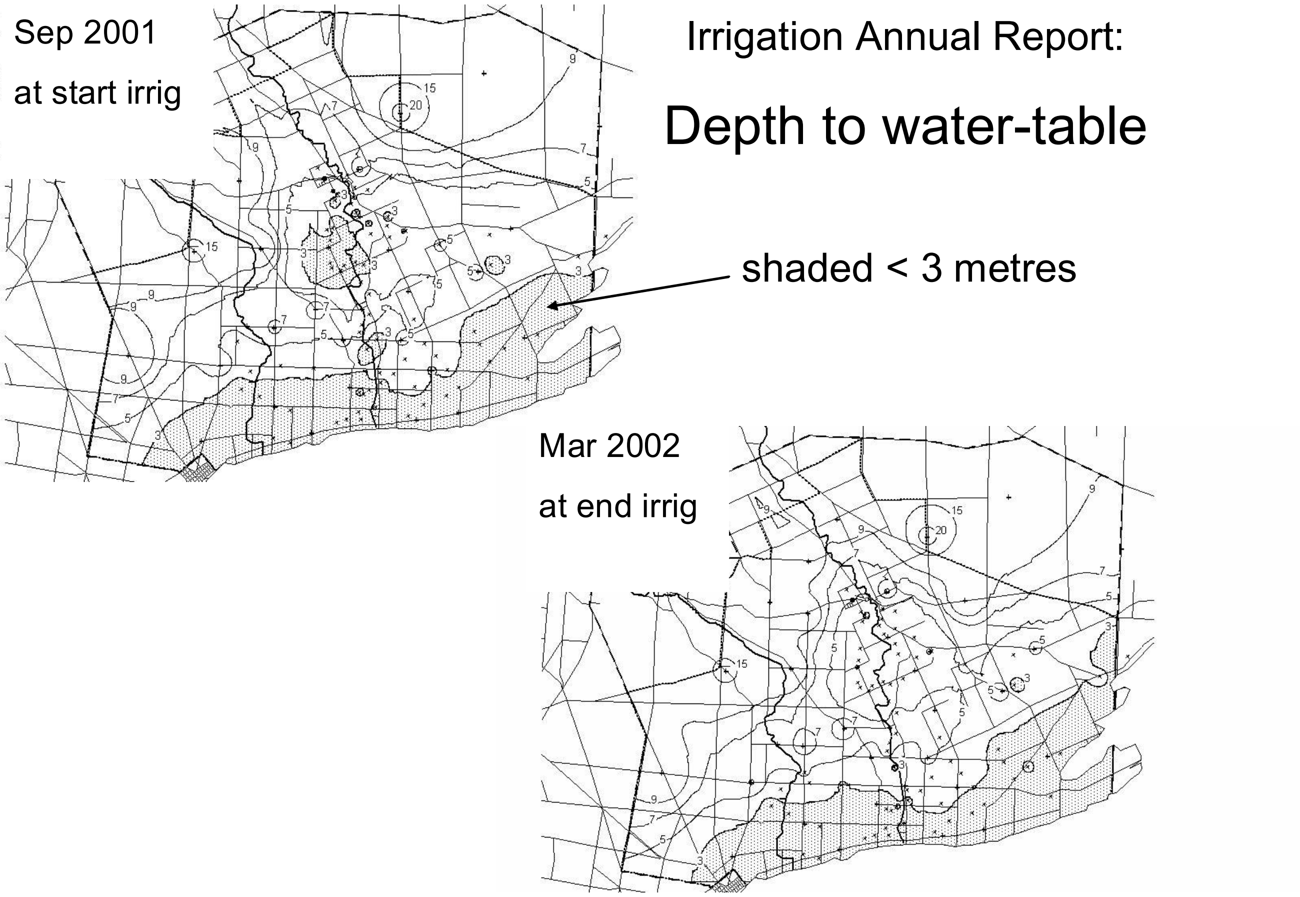

Figure 11 Drainage from irrigation is small because, at the end of the summer irrigation season (March), the depth from the ground-surface to the watertable is larger than at the end of the winter rainfall season (September)

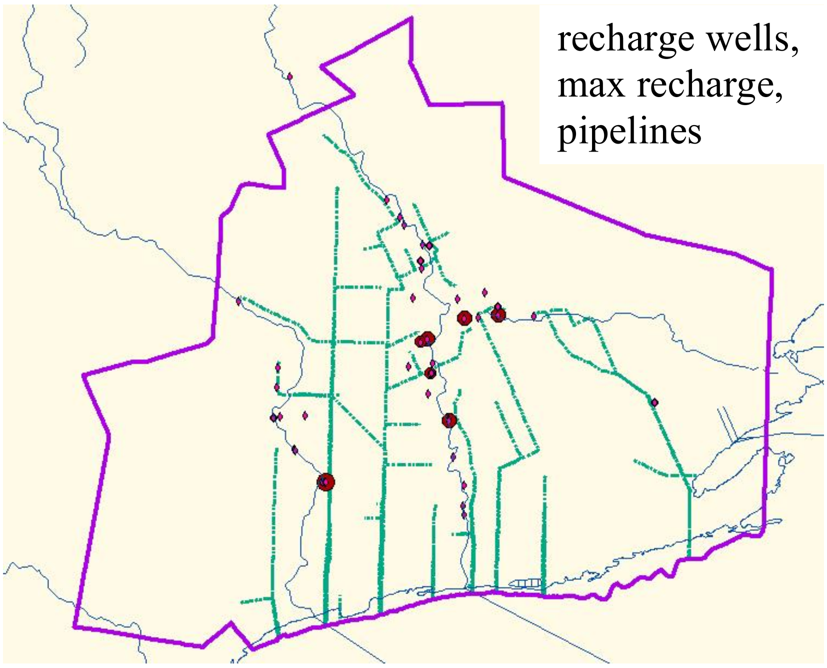

Figure 12 Example of a map produced from the CD. The map shows all the grower's pipelines, their recharge wells and the locations at which large recharge rates (Litres per second) have been achieved

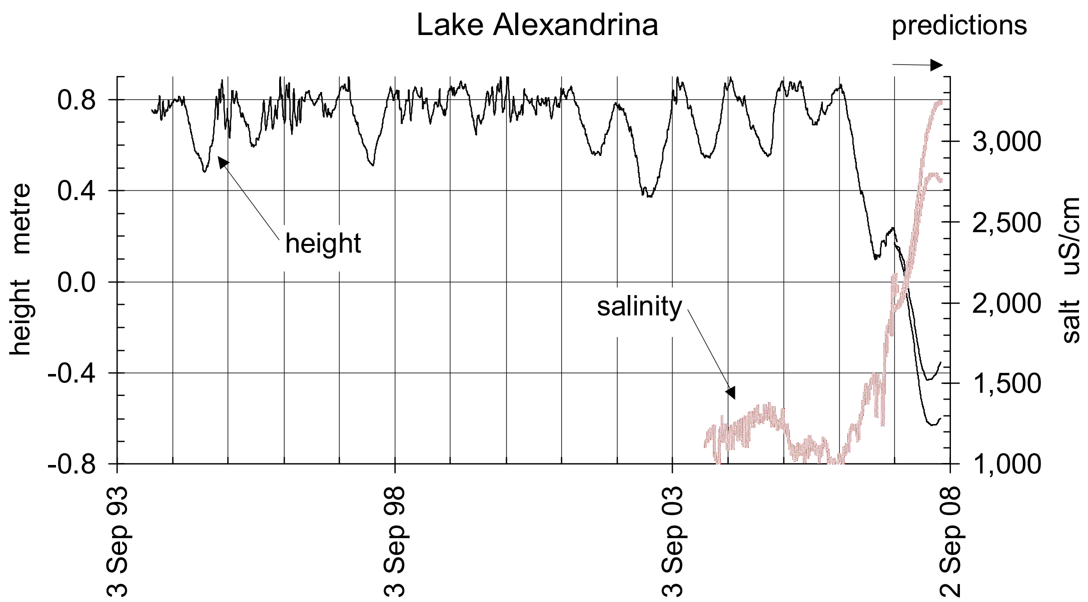

Figure 13 From December 2006 the drought and the negligible flow from the River Murray is causing the height of the water in Lake Alexandrina to fall below any previously recorded levels and the salinity to increase above recorded levels.

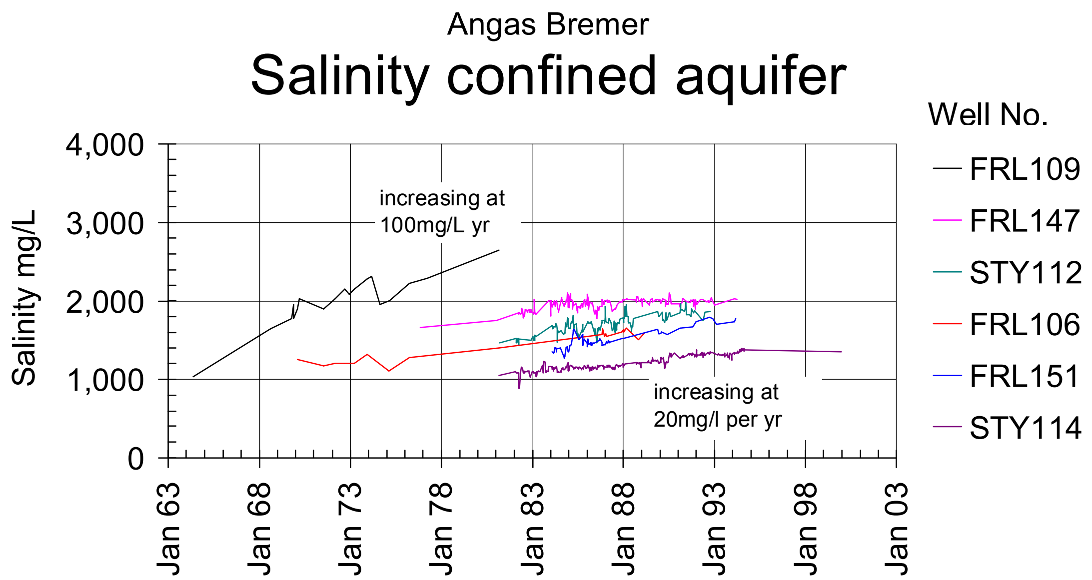

Figure 14 Un-plotted additional data up to 2007 shows that the salinity in most wells is now above 1500mg/L and it is continuing to increase at about 20mg/L per year

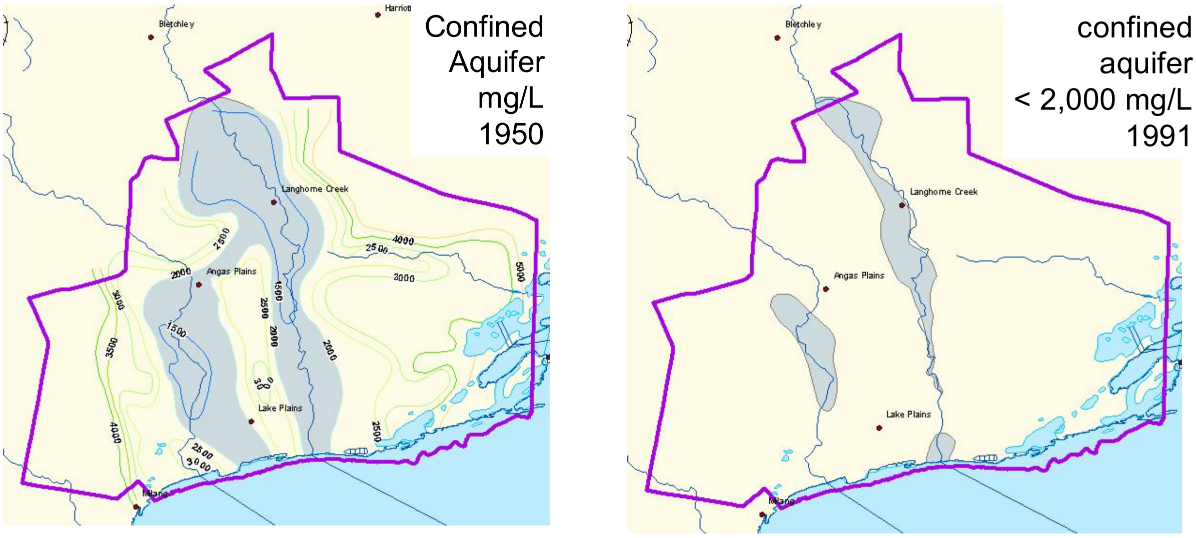

Figure 15 Additional data up to 2007 now shows that the area underlain by groundwater with salinity less than 2000mg/L continues to decrease

Angas Bremer Map layers CD:

Risk due to saline soil

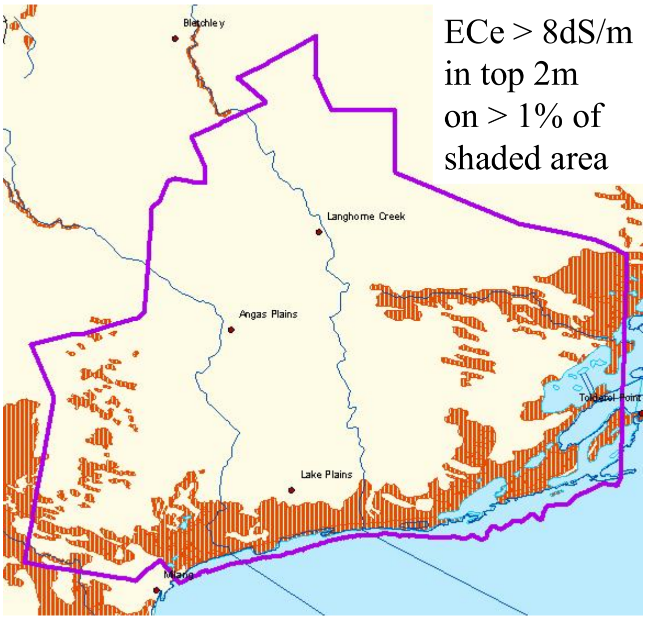

Figure 16 Example of a Risk map printed from the CD. It shows where there is a higher risk that salt will accumulate because some of the soil is already saline