FullStop salt monitoring at Angas Bremer

2008 Progress Report to the
Angas Bremer Water Management Committee
and to the
South Australian Murray Darling Basin Natural Resources Management Board

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Introduction

The Angas Bremer Water Management Committee obtained 3 prototype FullStop Wetting Front Detectors from CSIRO in 2000. The prototypes were dismantled, copied and modified, and 18 of the Angas Bremer version were evaluated in the district during the 2000-1 irrigation season.

The Committee then decided to include Wetting Front Detectors as another component of the Angas Bremer Irrigators Code of Practice. At soil depths of 50 and 100 cm, two FullStops were installed on every farm with each below a drip emitter. Growers were already reporting the total irrigation water applied and the depth to the water-table. Irrigation Annual Reporting was now extended to include the irrigation schedule, the responses of the FullStops and a salinity measurement from the water sample captured in the deeper (100cm) FullStop.

After three years it was becoming clear that the placement depths of 50 and 100 cm were too deep for the significant proportion of growers whose much-smaller-than-expected individual irrigation applications did not wet the soil down to the 50cm FullStop. By this stage a commercial version of the FullStop had become available. In 2004, forty growers were identified and each was supplied with an additional new FullStop wetting front detector buried at 30 cm depth.

We have provided reports on district salt trends to the Angas Bremer Water Management Committee and to the South Australian Murray Darling Natural Resources Management Board in 2004 and 2006. This 3rd report was commissioned to include the latest two seasons of FullStop data (2006-7 and 2007-8).

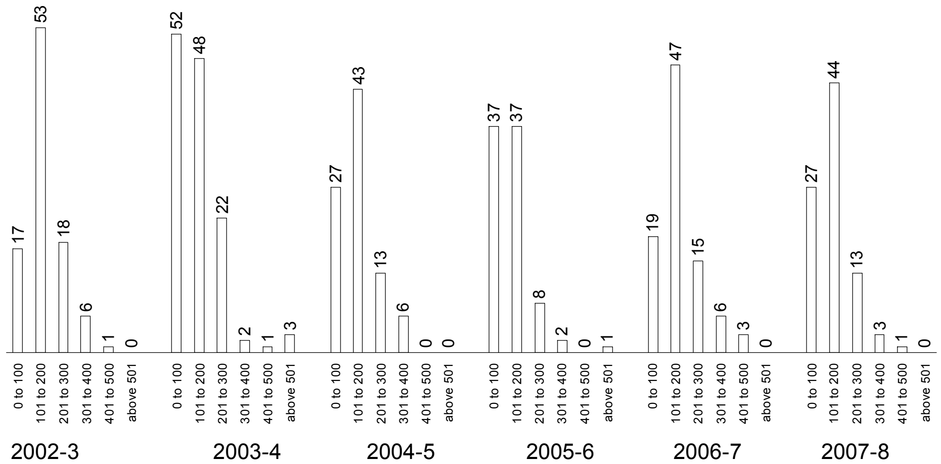
This report is arranged into six sections:

1. Irrigation and rainfall
2. Grower involvement
3. District average salt trends
4. Salt readings measured by individual growers
5. One individual grower's data
6. Hydrus modeling simulations
7. The next steps

1: Irrigation and rainfall

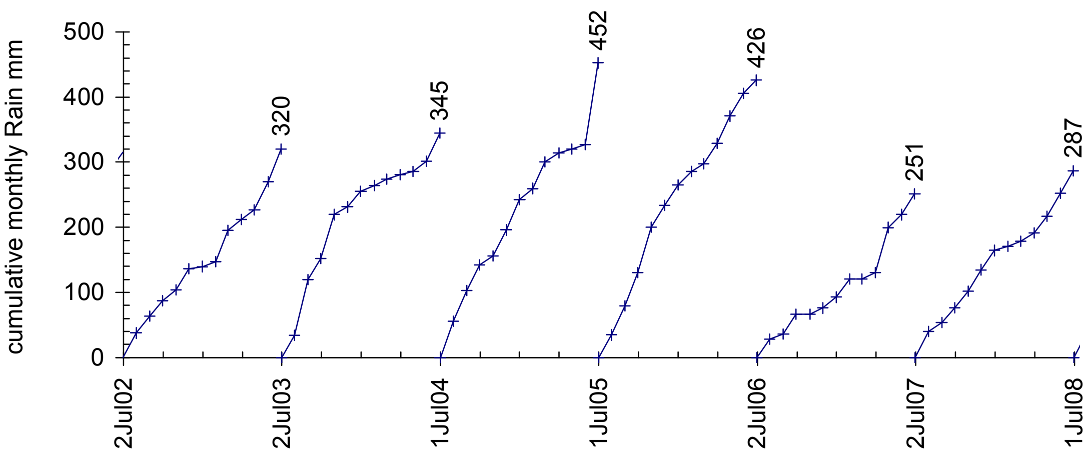
Angas Bremer growers apply small amounts of irrigation water, with the median value between 100 and 200 mm per year. Such small amounts of water mean that less salt is added to the rootzone, but at the same time there is less likelihood that the salt will be leached from the rootzone, particularly in this relatively dry environment with typical rainfall of 400mm/yr. Moreover there were several years of well below average rainfall during the six years that are reported in this study.

Figure 1a. The number of growers who applied annual irrigation volumes of below 100mm, 100-200 mm, 200-300 mm, 300-400 mm, 400-500 mm and of more than 500 mm in each of the six seasons



File: tblIrrigationsQuery.xls Chart 1
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855

Figure 1b. The cumulative annual rainfall (1Jul to 30Jun) for each of the six years



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Data: SILO
Chart: Tony Thomson 08 8463 6855

2: Grower involvement

In 2000, at the start of the project, growers were asked to record the salinity only of water caught by the FullStop buried at 100 cm. We judged 100 cm to be the bottom of the rootzone and that this measurement would indicate the salinity of the water leaving the rootzone.

Angas Bremer was one of the first districts where FullStops were used, and at that time there was little experience about the soil depth at which a wetting front detector should be installed. We have subsequently learned that 100 cm is too deep for this design of detector, because to collect water, the FullStop requires a relatively 'strong' wetting-front. Nevertheless in 2000 about half the growers reported collection of at least one water sample at 100 cm depth.

Not all of the growers who collected a sample at 100cm measured its salinity. Of those who did, some recorded the salinity of every event collected in the FullStop and some only measured the salinity once in the season, usually after harvest. In the first two years, up to 20 samples from 100 cm were reported per month (top graph of Figure 2 on following page). A few growers, who did not get their deeper detector to respond, recorded salinity measurements from 50 cm instead.

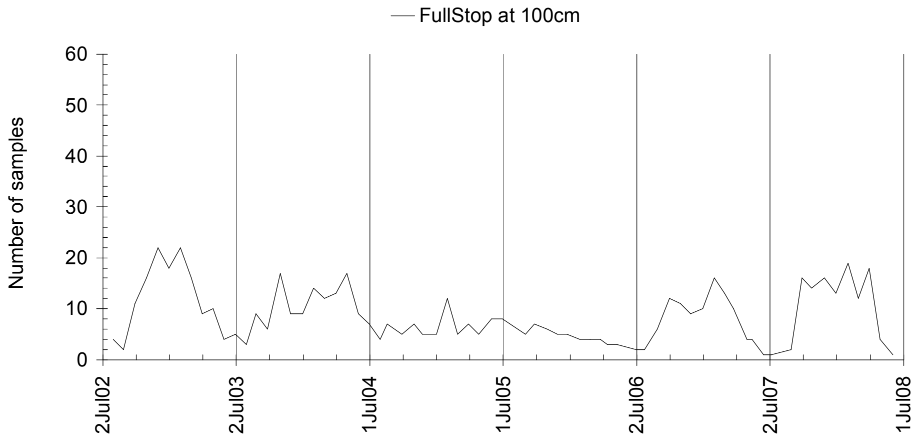
The next two years saw a change in behavior. This period coincided with a minimal interaction between scientists and growers because the project was not officially funded by any agency. Overall, fewer salinity samples were recorded from 100 cm, suggesting a reduction in enthusiasm from some growers. However, more salinity samples were reported from the 50 cm depth, probably because some growers recognised that the high salinity values could adversely affect their vines.

By year 4, we found that there was still a proportion (around 20%) of growers not recording the salinity of at least one sample at 50 cm depth. Part of this was due to loss of interest – some growers had stopped checking their detectors. However there appeared to be a group of growers who applied water 'little and often', and their wetting fronts did not go very deep. According to the theory these growers should be accumulating the highest salt levels in their rootzones.

About 40 of these growers were selected and supplied with new detectors which were installed at 30 cm depth. Years 5 and 6 saw the greatest level of grower involvement with the project. Many who had not previously reported any salt readings became actively involved, with a maximum of 50 salt samples reported per month.

Years 5 and 6 coincided with a peak in the drought, and the increase in the number of salt measurements demonstrates initiatives taken by the growers themselves. After 6 years the participation of the growers has become far greater than it was at the start of the project (Figure 2 - overleaf).

Figure 2: Number of salinity samples in each month as reported by growers from FullStop Detectors located at soil depths of 100 cm (top chart), 50 cm (middle) and 30 cm (bottom)



File: Salinity 2002-08 FS 100.xls Chart 1 (3)
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855

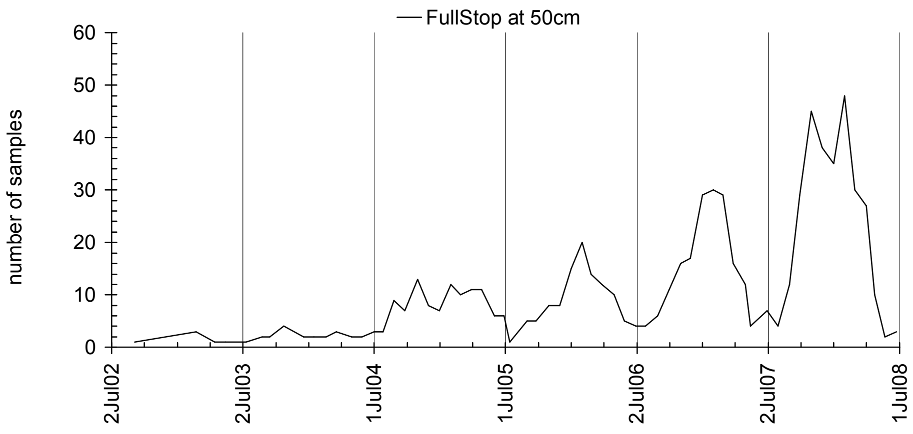


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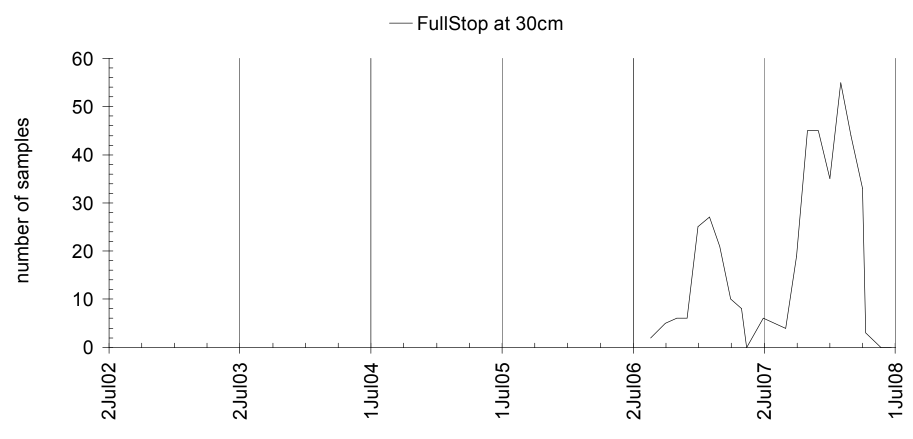
Chart: Tony Thomson 08 8463 6855



File: Salinity 2002-08 FS 30.xls Chart 1 (6)
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855

3: District average salt trends

The district average salt readings show a general trend of increase through each growing season, peaking in June. Salinity then falls to its lowest values at the commencement of the next irrigation season (Figure 3 overleaf).

This is what we would expect if post-season leaching-irrigations and the winter rain do remove salt from the profile.

However, there were two trends we did not expect:

1. At around 2,000mg/L, the lowest average salinity readings at the start of each season are quite high. In general we cannot assume that rainfall and leaching strategies are sufficient.

2. The highest district average readings – reaching 4,000 to 5,000 mg/L - are above the generally accepted threshold for grapes. We expected occasional high readings, but not that the district average would be so high.

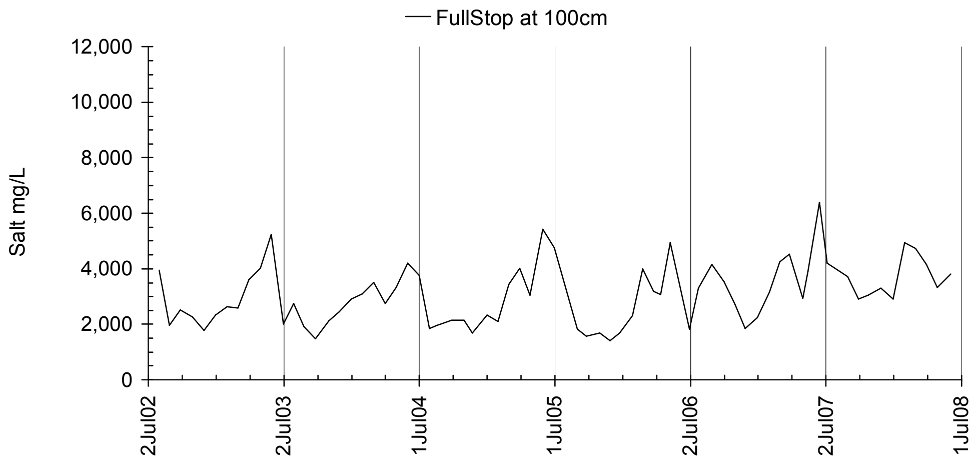
There are two other trends of note:

1. In general we do not see an increase in salt over the six year period, although we did not have shallow salt readings (30 cm) during the first four years.

2. We do not see the salt increasing with depth as we might expect if salt is being leached downwards. This is probably because not all growers report data from all depths. Soil properties and the amount of water applied at one time determine how deep the water will go and hence the maximum depth from which a water sample will be obtained.

In the last 2 years, the data from the new 30 cm detectors does show cause for concern. Many of these readings come from growers who had not reported data before, probably because they had recorded zero or very few events at 50 cm in the past. The data shows some very high salt readings at this shallow depth in year 5 (2006-7) demonstrating that these growers are accumulating salt in the top part of the rootzone. Very high salt readings were reported at 30 cm depth in year 6. This is probably a consequence of the sharp rise in the salinity of lake Alexandrina and of growers using water from salty bores. (Figure 3 - overleaf).

Figure 3: District average monthly salinity of samples from FullStop Wetting Front Detectors buried at 100 cm (top chart), 50 cm (middle) and 30 cm (bottom)



File: Salinity 2002-08 FS 100.xls Chart 1 (6)
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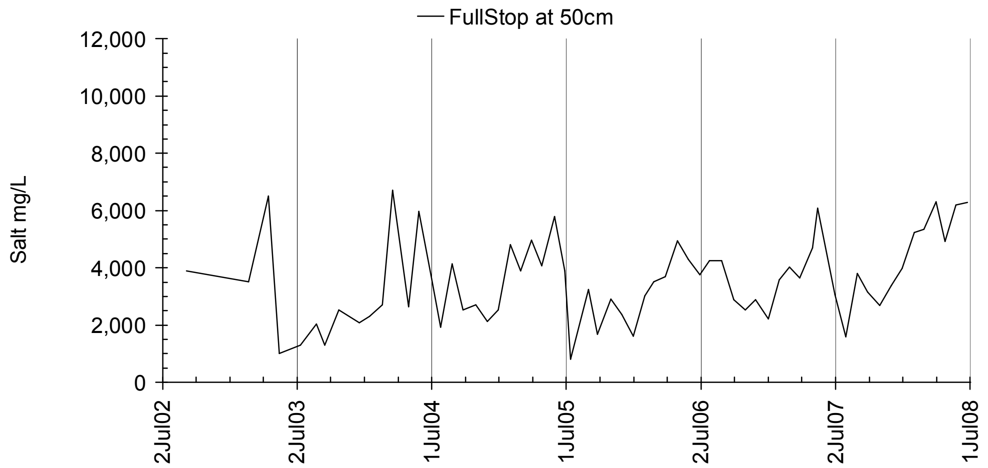
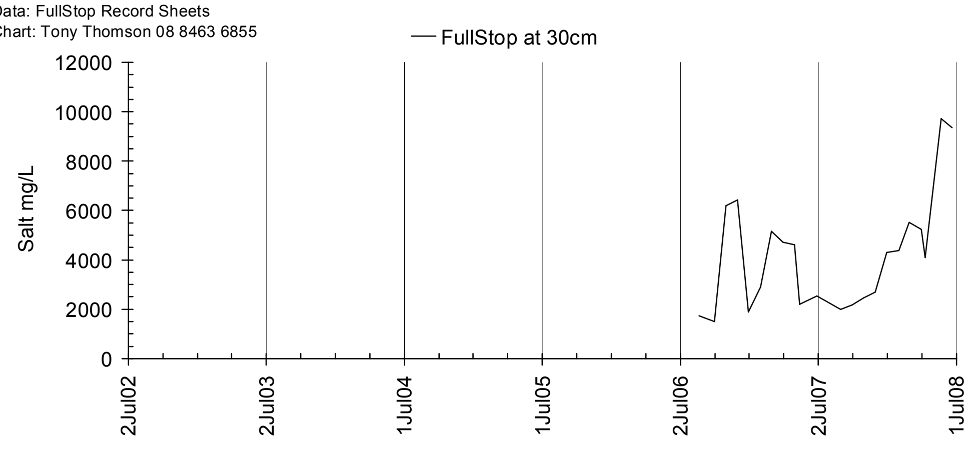


File: Salinity 2002-08 FS 50 Chart 1 (5)
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855



File: Salinity 2002-08 FS 30.xls Chart 1 (5)
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855

4: Salt readings measured by individual growers

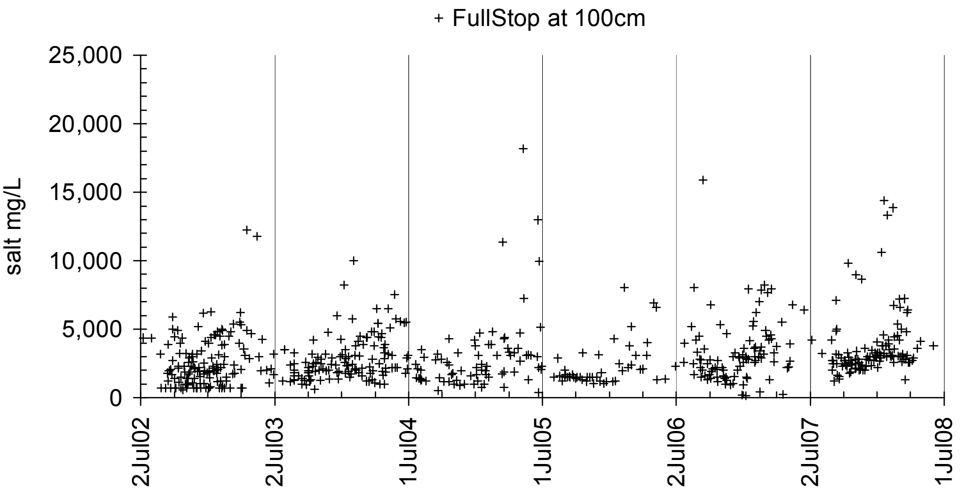
District average data can hide many of the trends happening on individual farms. This is particularly important in the Angas Bremer region because the oldest, established vineyards are located on the flood plains of the River Angas and the River Bremer and newer plantings are sited very differently, further from the rivers or closer to the lake.

Floods do not occur every year, and the area that is flooded in any particular vineyard varies in different flood years. The very low individual salt readings in Figure 4 (overleaf) usually come from samples collected soon after a flood.

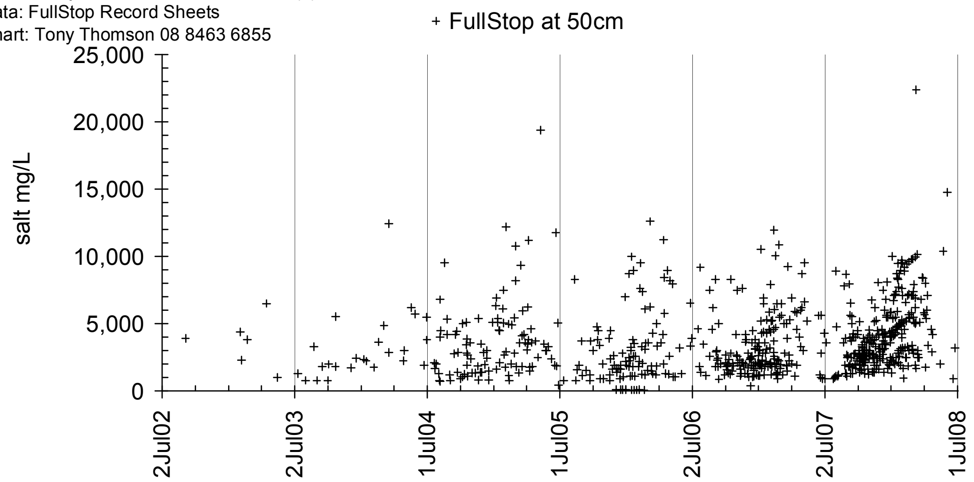
Figure 4 shows a clear rising trend in salt throughout each season, as described for Figure 3. Yet Figure 4 also shows that some vineyards record high salt near the beginning of the season. This shows that some vineyards are not leached sufficiently between seasons.

Conversely, a few sites show fairly low salt in the second half of the season. This is unusual and needs further investigation.

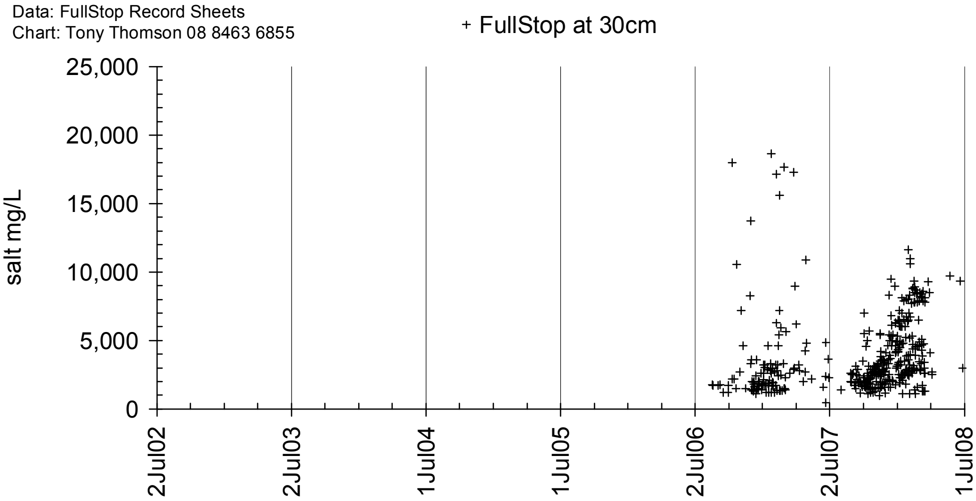
Figure 4: Salt readings reported by individual growers from FullStop Wetting Front Detectors buried at 100 cm (top chart), 50 cm (middle) and 30 cm (bottom)



File: Salinity 2002-08 FS 100.xls Chart (3)
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855



File: Salinity 2002-08 FS 50.xls Chart (2)
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855



File: Salinity 2002-08 FS 30.xls Chart (3)
Data: FullStop Record Sheets
Chart: Tony Thomson 08 8463 6855

5. One individual grower's data

Across the district there is a large variability in the salt concentrations recorded by individual growers. Salt management will of course vary with the soil type and with the farm location relative to the flood plain. However the pattern of salt accumulation also varies widely between the growers and it varies from year to year on the same farm. This suggests that there may be best practice ways to manage salt in the rootzone.

As salt levels can be manipulated by varying the amount and the timing of irrigation and of leaching applications, there is probably an opportunity for growers with very high levels of salt to improve their situation.

We examine this hypothesis with reference to a single grower in Figure 5 (overleaf).

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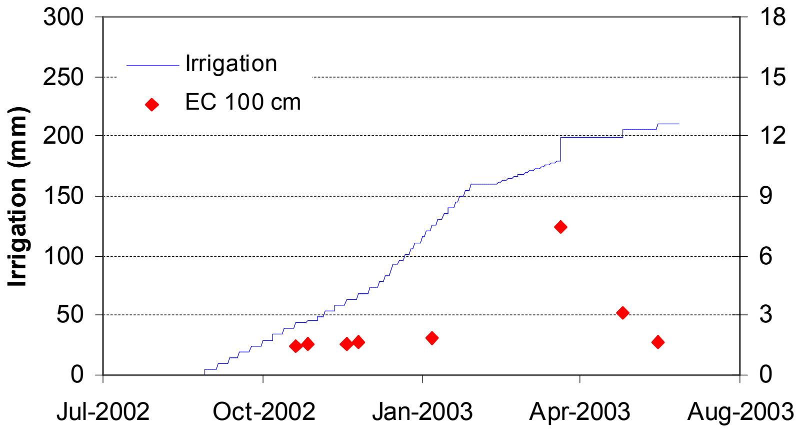
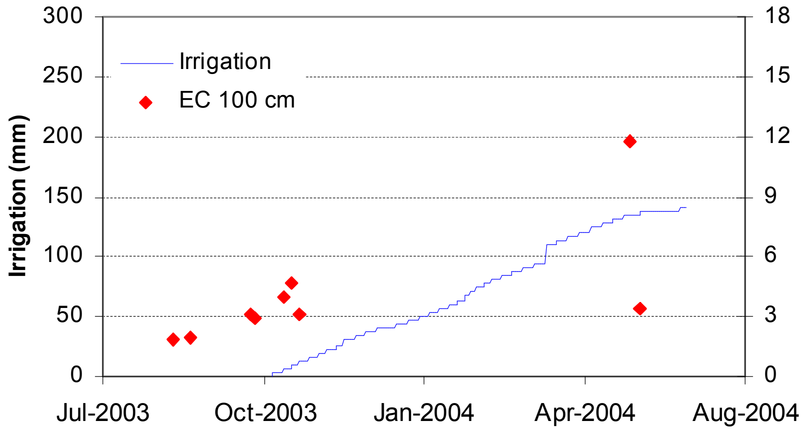
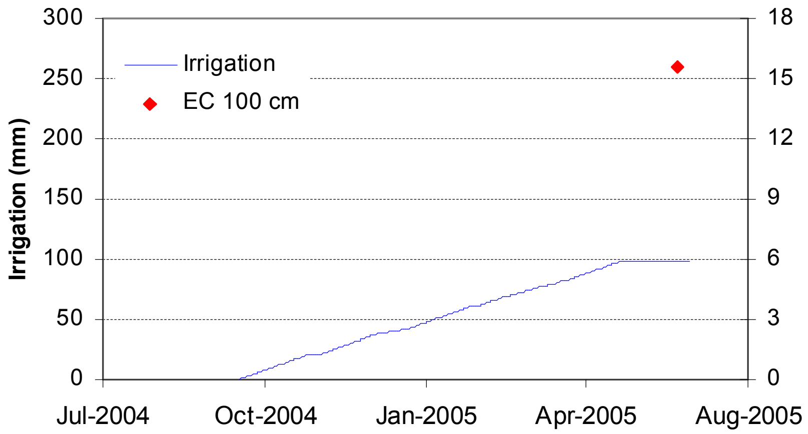
Figure 5: Measured salt readings at 100 cm depth and cumulative irrigation applications as reported by one selected grower for each of the six years



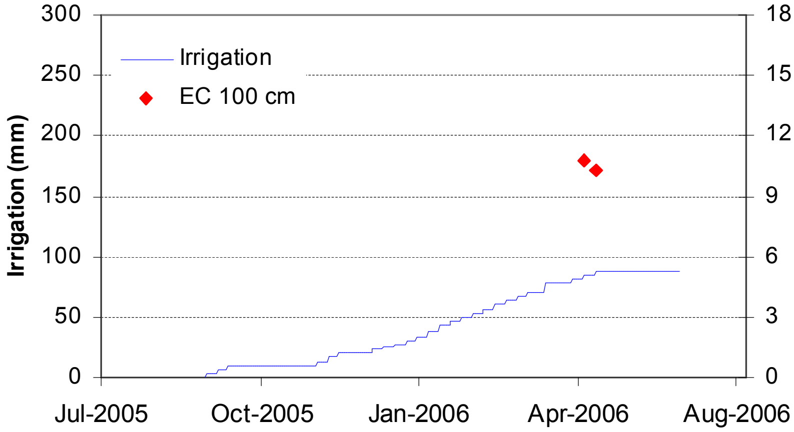
Year 1: Annual irrigation was 211 mm.
Salt at 100 cm starts low (1.5 dS/m) and rises to a maximum of 7.4 dS/m before falling to 1.7 dS/m at the end of the season



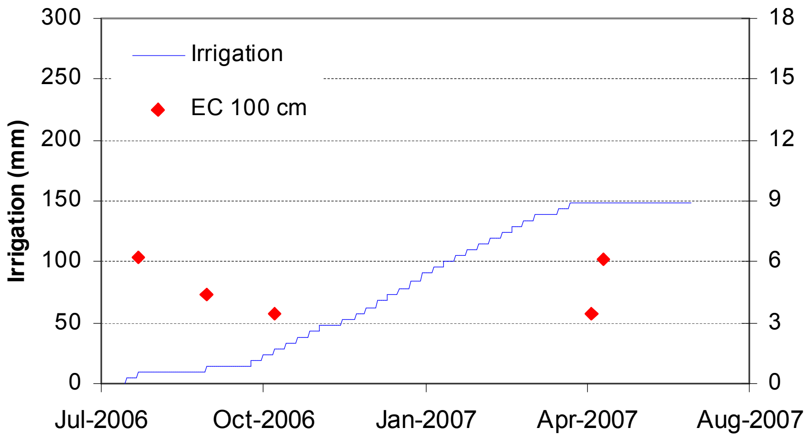
Year 2: Irrigation 141 mm
Salt starts low after reasonable rains (320 mm for 2002-3). 70 mm less irrigation water is applied than in the previous year and the maximum salt reaches 11.8 dS/m at the end of the season



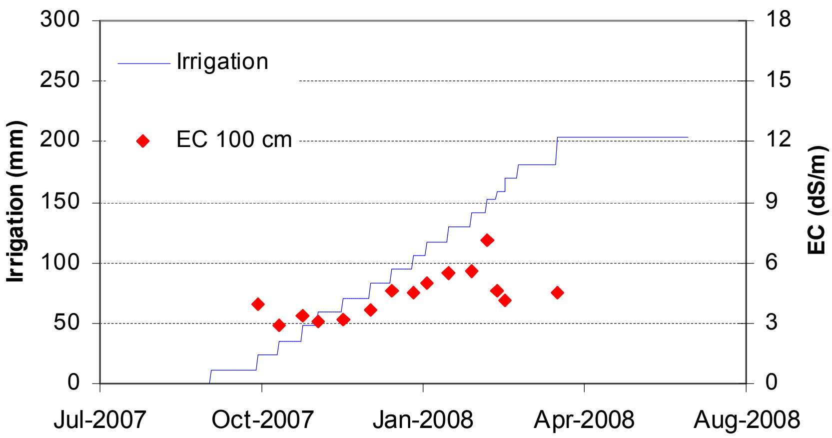
Year 3: Irrigation of 99 mm is 42 mm less irrigation than year 2. Only one salinity reading was reported - at the end of the season at 15.6 dS/m (less irrigation means fewer samples are captured). The irrigation schedule has changed from applying 3.5 hours every 4 or 5 days to applying 0.5 h per day.



Year 4: Irrigation 88 mm. Even less irrigation water was applied than in year 3, but it was applied in larger less frequent amounts. Salt peaks at 10.8 dS/m. This is lower than in the previous year, but there was higher than average rainfall (426 mm for 2005-6).



Year 5: Irrigation 148 mm. Salt starts the season high after a dry winter (251 mm of rain for 2006-7). 60 mm more irrigation water is applied than year 4, and the maximum salt reaches 6.1 dS/m at the end of the season



Year 6: Irrigation 204 mm. 56 mm more irrigation water applied compared to year 5. Although the irrigation water was now much saltier, the maximum EC in the FullStop was only 7.1 dS/m, suggesting root zone conditions were better than in years 1 to 4. Irrigation events were larger, usually 12 hours and 14 days apart.

6. Hydrus modeling simulations

To explore whether the grower strategy in year 6 of larger irrigations events applied less often matches with the theory, we used the computer simulations program Hydrus 3D. The program allows us to simulate the water content and salt concentrations around an individual dripper.

The simulations on the following page were set up as follows:

Application rate of the emitter:	2 L/hr
Soil type	Sandy loam
Irrigation water quality	0.8 dS/m (approx 500 ppm)
Simulation duration	30 days

The following four irrigation schedules were examined:

1.	Daily – 3 hrs/day	6 L per day
2.	2-daily – 6 hrs every second day	12 L per two day
3.	Weekly – 21 hrs once a week	42 L per week
4.	Fortnightly – 42 hrs once a fortnight	84 L per fortnight

In each case the same total amount of water was applied to a soil profile that started without any salt. The vines were able to use all the water applied down to the limit set by the sum of matric (soil water) and osmotic (salt) stress.

The drip emitter is located at the top left hand corner of each diagram
The soil depth shown is 1.5 m
The soil width shown is 0.75 m

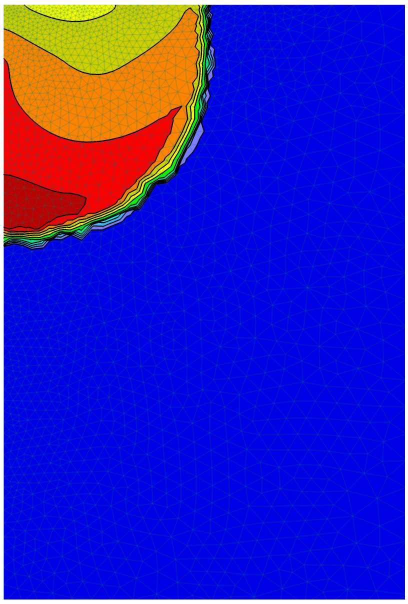
The scale shows the soil salt concentration from 0 dS/m (blue) to a maximum of 16 dS/m (deep red)

Since the same amount of water was applied in each figure (Figure 6 overleaf), the same total amount of salt was added. In simulation 1 the salt is concentrated into a fairly small area, because only 6 litres was applied at one time. With such small applications the profile had dried before the next irrigation on the following day. Simulation 4 shows the other extreme, with the salt distributed into a much larger volume of soil and therefore at a lower average concentration.

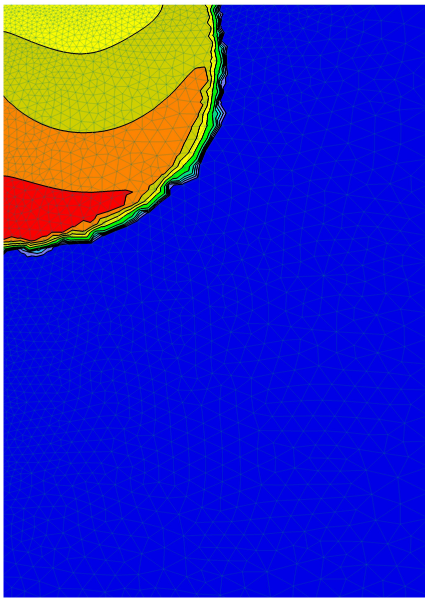
This suggests that the grower in Figure 5 has found a viable strategy for better managing salt during the growing season. This strategy would need to be complemented with an appropriate winter/spring leaching strategy.

Figure 6: Simulated salt readings

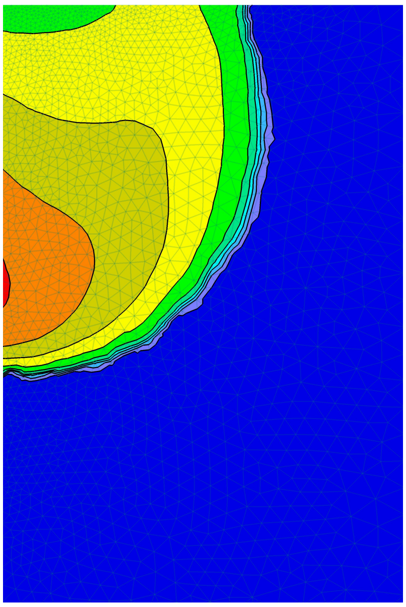
1. 6 litres every day



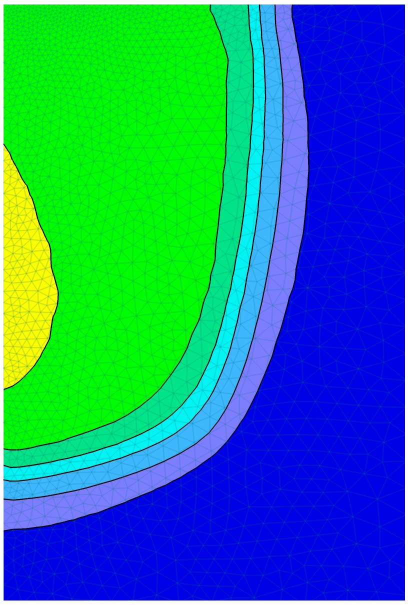
2. 12 litres every second day

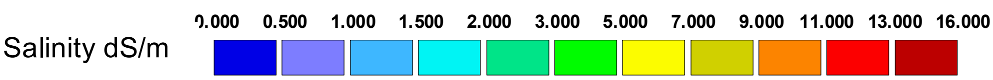


3. 42 litres per week



4. 84 litres per fortnight





7. The next steps

The Angas Bremer experience is remarkable in Australia. These growers were the first to develop their own irrigator code of practice, the first to decide what data needs to be collected and the first to use this information to better manage the water resources of their region.

At the same time they are amongst the most vulnerable irrigators in Australia because they are located at the end of the Murray River system with no control over what happens upstream. The amount of water available, and its quality, have now reached critical levels. The Angas Bremer growers are accumulating a valuable data-set that describes a region on the brink.

Perhaps the most remarkable aspect of this project is that it has been built from the grass roots, by the growers. It is not driven by funding dollars, by agencies or by regulation. It started with the growers' determination to know more and their commitment keeps it going.

Two of the next steps are:

1. To document the Angas Bremer experience as a complex adaptive socio-ecological-system (SES). There is much talk about SES, but there are very few examples from which to learn i.e. how does the hydrology 'work' (ground water, flood plains, water quantity and water quality) and how is the community responding to the changing system and to their changing understanding of the system. Why did this community get it together – what kind of support or facilitation was provided – what have they learnt – can it be reproduced – how can this community best be supported through its next, most difficult challenge?

2. To assist the Angas Bremer growers to move to the next level of monitoring. Here we envisage introducing an automatic system for recording irrigation water quality and root zone salinity. Such a system is being developed through the CRC for Irrigation Futures.

Acknowledgements

We wish to thank the irrigators at Angas Bremer who have invested their time to collect and report the information that is presented here.

We also thank Dr Mike Webb who carried out the Hydrus modeling simulations.