The national newsletter of salinity R&D

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# focus ON SALT

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CRC FOR PLANT ~ BASED MANAGEMENT OF DRYLAND SALINITY

CRCLEME
Cooperative Research Centre for Landscape Environments and Mineral Exploration

# Saltland proving its worth

*By Georgina Wilson*

## Posing to prove a point


Sheep regularly graze this stand of Oldman saltbush near Kimba (SA), which was previously "useless, waterlogged, saline unproductive pasture," according to Eyre Peninsula woolgrower Barb Woolford. This photo, titled 'Smoko' and taken by Barb, won the Productive Saltland Pastures category in the SGSL Pride in Saltland Management photography competition. The traveling exhibition is now touring nationally (visit www.landwaterwool.gov.au)

**Research is now confirming the value of saltland pastures, but plant selection and more efficient establishment along with an improved understanding of livestock physiology would multiply gains, a Western Australia audience heard recently.**

In a keynote address to a *Sustainable Grazing on Saline Lands (SGSL)* forum in Perth during October, Dr David Masters from CSIRO and the CRC Salinity highlighted recent findings.

Dr Masters suggested there were benefits in categorising saltland based on factors such as soil and water salinity, rainfall, waterlogging and site characterisation to allow rational decision making on potential improvements.

"At high salinity categories, improvements in saltland are likely to bring only small increases in animal production, plant growth and water use," he said. "Whereas by selecting areas of moderate to low salinity, a good return on investment is possible and long-term benefits in salinity management will follow."

The example given was of Michael and Margaret Lloyd's property near Lake Grace in WA. While the salinity at the surface is low on this site, the water table at about two metres down is about 1.5 times that of seawater. By strategically planting double rows of shrubs with annual pastures in the inter-row, the Lloyds have managed to maintain a stocking rate at or above the district average (four dry sheep equivalent per hectare) while preventing a rise in the saline water table. With an introduction of rotational grazing, stocking rate has been increased to 7 DSE/ha on some parts of the farm.

In the longer term, new technologies currently in the pipeline will present some exciting new opportunities. These include new forages, both pastures and shrubs, reduced establishment costs and better grazing systems, he predicted.

Dr Masters pointed to recent CRC research led by Dr Mary-Jane Rogers of the DPI in Victoria in screening numerous legumes for salt tolerance. The star performer was the high-yielding *Melilotus messanensis*, which when grown in a solution of sodium chloride at about 35 per cent seawater yielded 89% of that produced by similar plants grown in pure water (see p 5). Selections of *M. messanensis* containing low amounts of the unwanted toxin coumarin are now underway to develop a commercial cultivar suitable for the WA wheatbelt, the South East of South Australia, plus New South Wales and Victoria inland from the Great Dividing Range.

A major factor in successful saltland pastures is the establishment costs and Dr Masters drew on work by Dr Ed Barrett-Lennard (Department of Agriculture WA) and Dr Jason Stevens (Botanic Gardens & Parks Authority).

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# Salinity — what are the prospects

*By Bruce Munday*


**The ultimate test for applied research is that it should be useful. If not, then it has been undertaken just for the exercise. Useful research delivers outputs in which the intended end users willingly invest because it is clearly in their self-interest.**

At some point in an R&D program it is important to take stock of the knowledge and understanding that we have accumulated and declare how this can be used to guide rational investment in salinity management – in other words, **what are the prospects**?

Five years into its research, the CRC Salinity is now well placed to do just that – to synthesise what we know in key areas and make this knowledge accessible to natural resource managers, agriculture professionals and policy advisers, leading farmers and leaders of farming groups and catchment management organisations.

The CRC has identified five key areas of research where we can make confident and comprehensive prospect statements:

- Lucerne in crop and livestock systems
- Sustainable production from saline lands
- New industries from perennials in low rainfall environments (<450 mm annual rainfall)
- Livestock production from perennials in recharge areas
- Forestry in water supply catchments at salinity risk (>450 mm annual rainfall).

The first of these, *Lucerne*, is now well into production and will be available towards the end of February, with others to follow later in 2006.

The CRC's *Prospect statements* are not promotional material, but objective statements identifying investment opportunities whilst acknowledging the risks. Not only do they draw together many of the research findings of the CRC, they also integrate important work from other agencies and industry bodies. In particular each will:

- Review of the state of current knowledge of the focus topic
- Assess the economic and hydrological importance at national, regional, catchment and farm levels
- Explore on and offsite advantages and disadvantages of each innovation, covering the full range of impacts such as productivity, water quantity and quality, and biodiversity
- Provide a prospective view of the particular innovation and how it might be introduced into landscapes, catchments and farms, and at what scale across the nation
- Identify the benefits from investing in future R&D based on analysis of gaps and opportunities
- Use case studies or models to test and support the theory.

There are real benefits too for the CRC in generating these *Prospects statements*. It encourages us to further develop our own integrating processes, develop 'systems level' frameworks for investment, interrogate our own projects for relevant knowledge, and reality-test the draft outputs with key people in research and extension.

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These scientists are looking at germination behaviour of saltbush and have found that simple treatments such as debracting saltbush fruits and priming with plant hormones can increase the germination of buried seed. Recent data from a Meckering field site using *Atriplex amnicola* (river saltbush) buried at eight millimetres showed that debracting and treatment with giberellic acid could improve field emergence from 15% to 70%.

Grazing pastures containing high levels of salt has many consequences, now better understood, Dr Masters commented. High salt can reduce feed intake and produces dramatic changes in rumen populations and their function. High salt during pregnancy may change salt tolerance of lambs and some interesting new research indicates that cattle may be more salt-tolerant than sheep. Saltbush may also have beneficial effects on health and product quality with high levels of vitamin E in the plant decreasing the risk of muscle-wasting diseases and increasing the shelf-life of meat. For wool, recent research has indicated that levels of salt of up to 20% in sheep diets have increased efficiency of wool growth from 10 up to 14 grams per kilogram of organic matter intake.

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# Storing energy in salty water

*By Bruce Munday*

**Large volumes of saline water, so often seen as the collateral damage from drainage or salt interception schemes, might actually be a neglected resource according to Cliff Hignett, an independent agricultural consultant, specialising in soil water problems.**

Mr Hignett, based in Adelaide, contends that saline water in solar ponds has the potential to generate low grade heat energy ideally suited to regional industries such as glasshouse horticulture, fruit drying and aquaculture or even for heating public buildings and swimming pools.

When water is heated, warm water usually rises. However saline water, being more dense than fresh water, suppresses this convective process so that heat can be stored in the lower layer raising the temperature as high as 80 degrees Celsius.

The key to storing the hot water at the bottom of the pond is the salinity gradient – the saltier and denser the water at the bottom and the fresher the water at the top, the more heat that can be stored before normal convective processes take over.

Mr Hignett comments that there are limitations to the application of solar ponds: "While the heat is ideal for drying and warming, it can't be used to boil water or make steam and cannot be transported far – so the enterprise using the heat needs to be next to the pond. Secondly, the pond needs to be well designed. Ideally it needs to be around three metres deep, with free (crystalline) salt on the bottom, and the top needs to be held at the lowest salinity available. An important management consideration is the control of algal growth in nutrient-rich water which can be achieved by growing brine shrimp – a highly saleable product in itself.

"Costs usually split into three parts. Firstly, the cost of shaping the lake, which might be as much as $50,000 per ha on flat land, requiring a lot of earth moving. Then there might be as much as $100k for lining the lake with black plastic to prevent leakage, and laying pipes across the base of the lake to extract heat. Finally add the cost of a pump to circulate water through the pipe system and into the heaters in your facility.

"The economic benefit will depend on the use to which the heat is put, but a 1ha solar pond produces about seven million megajoules of heat per year – an equivalent amount of gas would cost at least $110k."

Mr Hignett points out that this is not new technology. It has been used overseas since the 1950s, Israel being the acknowledged leader. At the moment, the only solar pond in Australia is at Kerang in Victoria, where the Pyramid Hill Salt Company uses it to produce hot air to flash dry their 'Gourmet Table Salt'.

For a further investment the hot water can be used to produce electricity. While the price is more than most mains supplies, it is around 30 per cent of the cost of running a diesel generator, or other solar based methods. Further information is on www.solarponds.com

Photo: C Hignett

Solar ponds at Pyramid Hill

# Turning ideas up there into action on the ground

**The recent South Australian Dryland Salinity Committee's annual salinity forum, partly sponsored by the CRC Salinity, addressed *Lessons learned in managing on-ground change for salinity and related NRM benefits*.**

The forum featured:

- Case studies from six regions on projects to engage landholders in on-ground change
- Integrating salinity and biodiversity outcomes – the USE Biodiversity Offset Scheme
- The development of large-scale commercial plantings of oil mallees to manage dryland salinity in Western Australia
- Potential future commercial options for large-scale revegetation for salinity and other NRM benefits in SA through biomass industries and biosequestration
- Progress with dryland salinity monitoring and evaluation at a State level.

Summing up, SA Dryland Salinity Committee member Anita Crisp noted: "Although communities by and large are all dealing with the same issues, there are so many small differences, and cultural attitudes, that often stem from settlement, that one size and approach doesn't fit all.

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# Timber in your tank sir?

*By Bruce Munday and Matt Crosbie*

**Salinity and shrubs could combine to become the 'petrol' of the future given emerging technologies which allow ethanol to be produced from woody plants, cereal straw and grasses.**

The next generation of renewable ethanol, made by the fermentation of biomass, could come from lignocellulosic or woody materials rather than expensive-to-produce starch and sugar sources such as grains and sugar cane or their processing residues.

CRC researcher, Mr John Bartle, recently told the South Australian Annual Salinity Forum in Adelaide "This new technology, which is still in the process of being proven commercially, has enormous potential in Australia - particularly with our major problem of salinity encroaching on valuable agricultural land.

"Salinity has a major impact on water quality in many of the main tributaries in the Murray-Darling Basin, whilst other tributaries are at risk. In Western Australia up to 5.5 million hectares of agricultural land are at risk of salinity from rising water tables.

"In many cases planting trees and shrubs will still be the best means available of stopping the spread of salinity and its impact on natural resources."

The Biofuels Taskforce Report, recently released by the Prime Minister, notes the large international investment in this technology, its likely cost advantage and the ready supply of low cost woody feedstocks.


Photo: J Bartle

Oil mallees might be an option in the WA wheatbelt

The Taskforce noted the potential for lignocellulosic ethanol technology to impact materially on the economics of the ethanol industry in the coming decade. However, it cautioned that policy interventions based on current industry technologies and feedstocks should be limited in the absence of further assessment of the impact of lignocellulosic technology.

Mr Kevin Goss, CEO of the CRC Salinity, believes Australia is likely to have a strong advantage in cellulose-based ethanol production because of the large scale use of woody crops required for salinity control.

"It is absolutely essential that large scale commercial uses for woody crops be developed if salinity is to be beaten. Ethanol production could consume the residue fraction of woody crops after extraction of higher value products such as essential oils.

"In WA the rapid development of native mallee species as woody crops is just one example of a potential supply of cellulose for ethanol production.

"The CRC Salinity is working hard to increase the diversity, production and adoption of woody crops through a range of research projects including *Florasearch* which is identifying native plant species for salinity control and commercial potential."

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Different regions, different communities within regions and different individuals are at varying stages of understanding, caring and engaging.

"We heard today how important it is to keep connected and grounded to your target audience – the landholders. Time and time again we heard that an approach tailored to and understanding individual needs is imperative.

"We also heard a lot about integration and working with a farming systems approach and about getting multiple benefits and reducing the impact of externalities."

Anita commented on the need to balance regional strategic planning with community engagement: "We need to recognise that regional plans and investment strategies and the work that regional boards do are really geared around investment and accountability purposes. They are not written for landholders. However, the success of this new regional approach most certainly depends upon the level of support in the community. That will hinge on the level and quality of community support available to translate and match regional priorities and new initiatives with local priorities, needs and thinking.

"Exciting initiatives with market-based instruments in the oil mallee project and the work of the CSIRO point to where we are heading. But it is premature to throw away existing, tried and true techniques such as incentive programs – MBI's are most certainly another tool on the belt, but again one approach doesn't suit all situations. The way we do business may be changing, but it is imperative that this is delivered/facilitated through a simple and consistent community interface – again we can't lose sight of who our target audience is."

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# What chance a salt-tolerant legume?

*By Bruce Munday*

**A companion legume for salt-tolerant grasses would be a great boost for saltland grazing. The possibility of finding a plant that fixes nitrogen and also provides high-quality feed out of season is the aim a CRC Salinity project *Developing forage options to stabilise and regenerate saline environments* led by Dr Mary Jane Rogers of DPI Victoria.**

Photos: J. Deretic

*Melilotus* species growing at 240 mM NaCl in hydroponic tanks in the glasshouse at Tatura. INSET: *Melilotus messanensis*.

Dr Rogers and Jo Deretic have screened over 100 forage legumes for salt tolerance in the glasshouse at Tatura using germplasm acquired both locally and internationally by Steve Hughes at the SARDI Genetic Resource Centre (GRC) in Adelaide in collaboration with Richard Snowball at the Department of Agriculture GRC in Perth.

Dr Rogers has measured the dry matter production of individual species growing under hydroponic saline conditions. "Some species have produced a large amount of dry matter under non saline conditions but have low relative salt tolerance levels, whereas other species are extremely low producing but have a high level of relative salt tolerance," she commented.

"Several legume species including *Melilotus messanensis, Medicago polymorpha, Lotus glaber, Trifolium hybridum, T. diffusum* and several subspecies of *Medicago sativa* (ssp. *Sativa, falcata, caerulea*) are looking promising as a suitable species for moderately saline conditions in southern Australia.

"These species stand out by combining good relative salt tolerance with high levels of dry matter and have out-performed the control species, balansa clover (*T. michelanium*), strawberry clover (*T. fragiferum*) and lucerne (*M. sativa*)."

Waterlogging is a familiar feature of discharge sites, so tolerance of waterlogging is a further essential attribute for salt-tolerant forage species. Dr Tim Colmer and Kirsten Frost at the University of Western Australia are currently evaluating the waterlogging tolerance of the same legume species as Dr Rogers by growing plants in sterile agar solution. Their results to date support the salinity tolerance research, the most promising species showing tolerance to both the salinity and waterlogging stress.

The ultimate test of these pasture plants is their nutritive value for animals, particularly when grown under saline conditions. Dr Dave Henry and Elizabeth Hulm (CSIRO) are measuring several nutritive traits including dry matter digestibility levels and metabolisable energy of plant material from the glasshouse salinity assessments. Surprisingly, the nutritive value of these forage species does not appear to be deteriorating under the experimental saline conditions.

Plants (other than halophytes) that are more tolerant of saline conditions are generally better able to exclude sodium and chloride ions from their shoots. Kirsten Frost is analysing the plant tissue ions (Na, Cl and K) and again has found a good correlation with the dry matter values, the more salt-tolerant species such as *M. messanensis* having lower concentrations of $Na^+$ and $Cl^-$ in their shoots.

The next step in this project is to evaluate these priority species in the field. Andrew Craig (SARDI) and Phil Nichols (Department of Agriculture, WA) will establish field sites early in 2006 in South Australia and WA to test the glasshouse results for both salinity and waterlogging tolerance under saline field conditions.

However this work is not without its challenges. Dr Sean Miller and Andy Craig's work with the *National field evaluation and selection of new pasture plants to improve hydrologic stability of farming systems* has already found that *M. messanensis*, one of the most promising salt- and waterlogging-tolerant new legumes, fails to nodulate effectively with commercial inoculants. Nodulation is essential for plant growth and survival and to fix atmospheric nitrogen for subsequent use by the grass component of the pasture. Fortunately, a number of highly effective experimental rhizobial strains have been identified and these will be fully evaluated during 2006 to confirm their field performance.

This project is drawing on the combined expertise and experience of researches in SA, WA, Victoria and the ACT, along with the specialised resources and facilities in these States.

**Shoot dry matter (as a percentage of control)**

| Species | 0 dS/m | 16 dS/m |
|---|---|---|
| *Melilotus messanensis* | 100 | 89 |
| *Lotus glaber* | 100 | 81 |
| *Trifolium hybridum* | 100 | 109 |
| *T. diffusum* | 100 | 91 |
| *T.fragiferum* (C1) | 100 | 82 |
| *T.michelanium* (C2) | 100 | 60 |
| *Medicago sativa* (C3) | 100 | 75 |

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# Geophysics in the WA Rural Towns — Liquid Assets project

*By Paul Wilkes, Curtin University and CRC LEME*

**Rural Towns – Liquid Assets is a three-year project which combines salinity mitigation with production of new water supplies as a resource for water-based industries in sixteen of the most salt-affected towns in Western Australia. This multi-agency, multi-disciplinary project works in partnership with the shires and is aligned with strategies prepared by four catchment councils.**


Figure 1. Borehole geophysics operations in Moora, WA

The research team is from the WA Department of Agriculture, CRC LEME, CSIRO Land and Water, Curtin University, University of WA, and the WA State Chemistry Centre. It is supported financially by the National Action Plan for Salinity and Water Quality, the shires and the research partners.

To understand the geology and hydrogeology of rural towns it is necessary to have information on the third dimension, that is, what is present at depth beneath these towns. In particular it is useful to get a more detailed picture of the top 50 metres as this is where most groundwater flows and salt accumulates. We need to know about the shape of the top of bedrock and structures such as faults and dykes that influence water flow and salt movement. One very useful way to get information on geology at depth is to use geophysical surveys on the surface and in existing boreholes and in new boreholes that have been drilled as part of this project.

Already the project has undertaken geophysical work at the towns of Dowerin, Lake Grace, Merredin, Moora, Nyabing, Wagin, and Woodanilling – with nine more towns to follow over the next year.

Designing geophysical surveys for urban areas is challenging as there are many man-made sources of disturbance such as power lines, vehicles and buildings. This requires careful selection of appropriate geophysical methods and survey layouts. Sometimes it requires data filtering to minimise the signals due to artificial sources

## Measuring the pull

Experimental surveys in rural towns conducted by Curtin University Department of Exploration Geophysics, supported by CRC LEME, have found that one of the most convenient and useful techniques is to measure gravity very accurately – more particularly, variations in gravitational field strength as this helps to give us a picture of the underlying geology.

We are all aware of the force of gravity and might assume that it is constant. However it is affected by the densities of the rocks and sediments beneath us, higher density material increasing the pull of gravity. Very accurate gravity meters are available and have been used for many years in mineral and hydrocarbon exploration. The latest meters enable us to measure variations in gravity very accurately - to about one part in 100 million.

To calibrate the gravity measurements we also measure horizontal positions and height above sea level as these also affect the strength of gravity and we have to correct for these to separate out the local geological information.

The positional surveying is now typically done with global positioning systems (GPS) and provides information to better than five centimetres in all three dimensions. Measurements are typically taken at 25–50 metre spacing along roads and across open areas such as parks, each measurement taking about three minutes to complete. In towns such as Wagin we typically measure the gravity at more than 1000 points within the town and some outside the town to see more of the regional picture of the catchments which affect the towns.

From this network of gravity stations we construct an image or map of the spatial variation of gravity and also a very accurate digital elevation model showing the

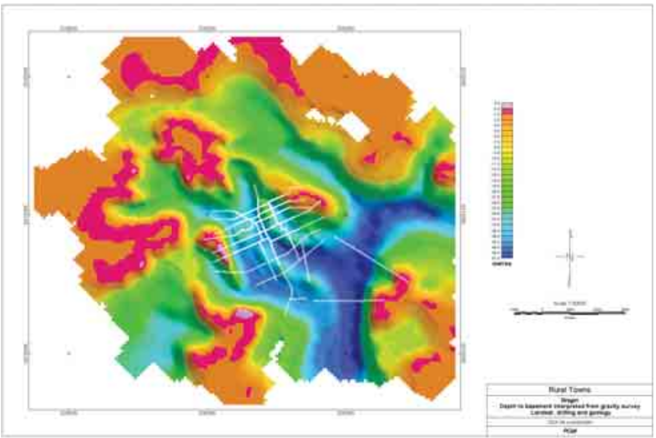


Figure 2. Depth to bedrock map for Wagin, WA

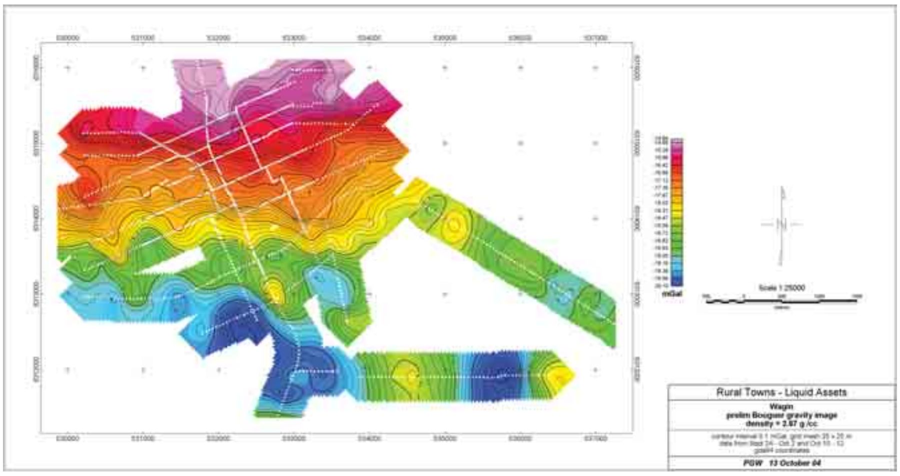


Figure 3. Gravity map of Wagin, WA

variation of height above sea level. Using these images, and from what we already know about the local geology from drilling and surface observations, we can compute the depth to underlying bedrock and some of the horizons within the sediments that lie between ground surface and bedrock. This analysis enables us to locate channels (such as ancient river beds) beneath the towns and some of the other geological structures which affect the flow of water beneath the towns. Figures 2 and 3 show some results of these investigations in Wagin and which are used as input to other parts of the Rural Towns – Liquid Assets project (see *Focus on Salt Issue 32*).

Figure 4. Apparent conductivity about 20–30 metres below ground level at Wagin, WA. Colours represent conductivity (in millisiemens per metre), red being the more conductive and here showing salinities greater than that of seawater.

### ...the current...

Electromagnetic (EM) surveys have also been carried out in some of the towns and more will follow. These provide information on the variation of electrical conductivity with depth, a property related to geology, salinity and water content.

Parks and sports ovals are often suitable locations for these surveys as they minimise the disturbances caused by powerlines and artefacts from other metallic services and infrastructure. For the ground electromagnetic surveys we lay out square loops of wire, up to 50 metres on the side, pass current through these and measure the electromagnetic signal we receive back from the ground during the time intervals between current pulses in the transmitter loop. This signal is processed to provide information on ground conductivity.

Where boreholes already exist in the towns these prove to be useful survey sites. When using boreholes we measure the conductivity of the ground surrounding the borehole, using probes that are typically 38 mm in diameter and conveniently fit down 50 mm PVC cased boreholes.

### ... and the radioactivity

We also measure natural gamma radioactivity in the boreholes as this relates to the local geology through the concentrations of radioactive potassium, uranium and thorium. Combining gamma and EM conductivity logs provides useful information to correlate with the geological information that has already been obtained through studying the material brought to the surface from drilling the boreholes.

This project is using existing geophysical techniques in novel ways to improve the understanding and outcomes for rural towns.

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Photo: P Wilkes

Figure 5. Gravity and GPS survey operations in Wagin, WA

# Students and salt

*By Matt Crosbie*

**The CRC Salinity's postgraduate program spans each of the CRC's core research programs. At the same time it helps to expand the scope of the research that the CRC can undertake according to its Education Officer, Daryll Richardson.**

"Currently we have 55 'active' PhD students with seven graduated so far and up to 22 students expected to graduate over the next 12 months. A reflection of the exceptional standard of CRC Salinity students is that among them, they have been awarded every research fellowship presented by the prestigious AW Howard Memorial Trust Inc. since its inception (Lindsay Bell – 2003, Alison Southwell – 2004, and Natasha Teakle – 2005)."

The CRC's postgraduate professional development program assists students to represent the CRC at both national and international events, where on many occasions they might be the CRC's only representatives. In 2005, 11 international and five national travel awards enabled students to present their work to the world, in several cases taking out Conference awards. Mr Richardson added that the postgraduate research program is highly valued by the CRC, which recognises the exceptional contribution it makes to its organisational goals.

A CRC review of the postgraduate professional development program recommended that students should have access to accredited training opportunities. This has led to a series of workshops that provide students with a range of 'statements of attainment' in various elements of management including communication, conflict resolution and leadership.

The first of these workshops was held recently at Mundaring Weir (Western Australia) in conjunction with the annual postgraduate student meeting. The success of this venture will lead to further workshops at each of the three main campuses of the participating universities.

Photo: J Franklin-McEvoy

Jim hiding under hat whilst administering alkane capsules.

The following two case studies provide snapshots of what some of our students are researching.

### Animal production from saltbush

Jim Franklin-McEvoy, a PhD student at The University of Adelaide, is researching sheep production from saltbush-based pastures planted on salinised land.

The project is a continuation of his Honours experiment dealing with supplementary feeding of sheep to increase wool growth and meat production on saltbush.

"Saltbush (*atriplex* sp.) is a major part of the diet of sheep in pastoral Australia," Jim says. "It has also been planted extensively in WA and South Australia to revegetate salt-affected land.

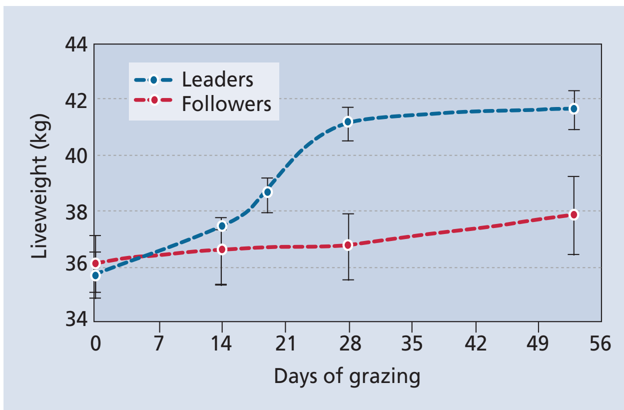
"Something that intrigues people when looking at a paddock of saltbush that has been grazed by sheep is the way sheep heavily graze specific bushes and apparently leave others untouched.

"Are these 'preferred' bushes more nutritious than the bushes that sheep ignore? This was the focus of one of my experiments, in which we rotated two groups of sheep through eight paddocks to determine whether there was any animal production penalty associated with grazing the less preferred plants. The first group of ten-month-old Merino wethers - the 'leaders' - grazed the first 40 per cent of the saltbush, and were then moved to the next paddock. Immediately following was another group, the 'followers', who grazed the remaining plants. This continued through eight paddocks for 53 days. The difference in weight gain was impressive, the leaders gaining 200 grams per day for the first 28 days, while the followers only gained 20 g/day.

"However, for the final 25 days, the leaders gained 20 g/day and the followers gained 45 g/day! (see graph)

"Over the whole grazing period, the sheep given greater dietary selection gained almost 6kg of liveweight, while the other group gained only 1.7 kg. So while the sheep given the opportunity to be 'fussier' grew faster, their poor growth after one month is a mystery. This may be due to gradually declining kidney function, a disorder among both groups.

"This has led me to another experiment, in which we are feeding laboratory rats with pellets containing various inclusion rates of saltbush (20, 40, 60%). We harvested leaves from highly palatable and highly unpalatable saltbushes, and so we have six experimental diets and a control, all




Weight gain of 'leaders' and 'followers' in same paddock

Photo: J Franklin-McEvoy

Apparent differences in palatability of *Atriplex nummularia*

adjusted to contain equal concentrations of energy and protein. This experiment is designed to demonstrate whether there really is a nutritional penalty associated with eating unpalatable saltbush, where feeding it in a pellet prevents selectivity.

"While obviously sheep and rats have somewhat different digestive anatomies, we believe that the results from this experiment will have practical implications for sheep production from saltbush-based pastures, a key component of plant-based management of dryland salinity."

**Fungi and salt**

Bree Wilson's PhD studies at Charles Sturt University, Wagga Wagga, are investigating the genetic and functional diversity of mycorrhizal fungi in saline soil.

"Mycorrhizal fungi have a symbiotic relationship with the majority of land plants, both herbaceous and woody," Bree explains.

"Their major function is to increase the uptake of nutrients and water by plants. They achieve this by increasing the surface area of the root through the development of an external mycelium or fungal hyphae system and, in some cases, an internal system of fungi that are involved in nutrient exchange. The fungus in turn receives sugars from plant photosynthesis in exchange for the extra nutrient acquisition.

"Fossil records of spores and hyphae of arbuscular mycorrhizal-like fungi suggest that they evolved with and may have been vital to the establishment of the first land plants over 400 million years ago, so their importance in ecological function cannot be underestimated.

"In general, much is known about the plant response to salinity, such as decreased growth and productivity. However, we know much less of the effect of salinity on soil fungi like mycorrhizal fungi, and we need research to determine if salinity has a negative impact on these important fungal communities.

"Molecular biology, such as DNA fingerprinting techniques, is one way to explore the diversity and ecology of mycorrhizal fungi as the DNA can be extracted directly from the environment and identified using DNA sequencing.

"In this study, I have chosen two field sites, one at Wagga Wagga and the other north of Orange in NSW, to investigate how the diversity (community or populations) of mycorrhizal fungi may change over a salinity gradient.

"In the first part of the research I will use Denaturing Gradient Gel Electrophoresis (DGGE) to analyse the soil communities and to look at the genetic diversity. DGGE is a DNA fingerprinting method which allows for the parallel analysis of multiple samples which can be processed more rapidly and cost-effectively than is possible using other methods.

"From this, the aim is to select a few of the fungi present at the sites and design glasshouse-based experiments to see how they may differ functionally. For example, their ability to accumulate phosphorus or compounds involved in conferring salt tolerance to the plants that they live symbiotically with, or mechanisms of tolerance that enable the fungus to grow in a saline environment.

"This project will help us identify what types of fungus are growing in certain areas, but may also enable us to select for the best fungi for commercial inoculum programs in particular environments.

"This project has only been going for seven months, so it is still in its early days!"

Photo: M Crosbie

Bree Wilson viewing DNA extracted plant root and soil samples

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# Salinity targets finalised for the Murray-Darling Basin

**The recent adoption of the Victorian End-of-Valley Salinity Targets by the Murray-Darling Basin Ministerial Council is a major step forward in the progress towards managing salinity within the Murray-Darling Basin.**

According to Murray-Darling Basin Commission (MDBC) Chief Executive Dr Wendy Craik, this means that salinity targets are now in place for the majority of tributary rivers in each of the Basin States. New South Wales, Queensland and South Australia finalised their targets in 2004, whilst targets remain interim for the Australian Capital Territory and the Kiewa, Ovens and Wimmera Rivers.

Dr Craik said this key milestone for the *Murray-Darling Basin Salinity Management Strategy 2001-2015* (BSMS) was reached at the recent meeting of the Ministerial Council in Brisbane, with Victoria submitting its end-of-valley salinity targets.

"The End-of-Valley Salinity Targets are a key feature of the BSMS and effectively provide a 'Cap' on increasing salt loads from each tributary valley," Dr Craik said.

"Partner Governments developed an interim set of End-of-Valley targets for stream salinity and salt loads, and these were considered by catchment communities during the public comment period for the draft BSMS in 2000/2001.

"The Salinity Targets are an important means to prioritise within-valley catchment actions such as improved farming systems and targeted vegetation management," she said.

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**Basin salinity management strategy — End-of-valley salinity targets**

| Valley | Baseline conditions (1st Jan 2000) | | | End-of-valley targets (as absolute value) | | |
|---|---|---|---|---|---|---|
| | Salinity (EC µS/cm) | | Salt load (t/yr) | Salinity (EC µS/cm) | | Salt load (t/yr) |
| | Median (50%ile) | Peak (80%ile) | Average | Median (50%ile) | Peak (80%ile) | Average |
| **ALL PARTNER GOVERMENTS** | | | | | | |
| Murray-Darling Basin | 570 | 920 | 1,600,000 (95%ile) | 627 | 800 | 1,760,000 (95%ile) |
| **SOUTH AUSTRALIA** | | | | | | |
| SA Border | 380 | 470 | 1,300,000 | - | 412 | - |
| Lock 6 to Berri | 450 | 600 | 1,500,000 | - | 543 | - |
| Below Morgan | 600 | 820 | 1,600,000 | - | 770 | - |
| **NEW SOUTH WALES** | | | | | | |
| Murrumbidgee | 150 | 230 | 160,000 | 162 | 258 | 169,600 |
| Lachlan | 430 | 660 | 250,000 | 460 | 693 | 257,500 |
| Bogan | 440 | 490 | 27,000 | 581 | 456 | 34,830 |
| Macquarie | 480 | 610 | 23,000 | 504 | 744 | 25,760 |
| Castlereagh | 350 | 390 | 9,000 | 368 | | 8,910 |
| Namoi | 440 | 650 | 110,000 | 475 | 715 | 127,600 |
| Gwydir | 400 | 540 | 7,000 | 412 | 545 | 7,000 |
| NSW Border Rivers | 250 | 330 | 50,000 | 250 | 330 | 50,000 |
| Barwon-Darling | 330 | 440 | 440,000 | 389 | 453 | 576,000 |
| NSW Upper Murray | 54 | 59 | 150,000 | - | - | - |
| NSW Riverine Plains | 310 | 390 | 1,100,000 | - | - | - |
| NSW Mallee Zone | 380 | 470 | 1,300,000 | - | - | - |
| **VICTORIA** | | | | | | |
| Wimmera | 1,380 | 1,720 | 31,000 | 1,380 | 1,720 | 31,000 |
| Avoca | 2,060 | 5,290 | 37,000 | 2,096 | - | - |
| Loddon | 750 | 1,090 | 88,000 | 711 | - | - |
| Campaspe | 530 | 670 | 54,000 | 412 | - | - |
| Goulburn | 100 | 150 | 166,000 | 99 | - | - |
| Broken | 100 | 130 | 15,000 | 141 | - | - |
| Ovens | 72 | 100 | 54,000 | 72 | 100 | 54,540 |
| Kiewa | 47 | 55 | 19,000 | 47 | 55 | 19,000 |
| Vic Upper Murray | 54 | 59 | 150,000 | - | - | - |
| Vic Riverine Plains | 270 | 380 | 630,000 | - | - | - |
| Vic Mallee Zone | 380 | 470 | 1,300,000 | - | - | - |
| **QUEENSLAND** | | | | | | |
| Qld Border rivers | 250 | 330 | 50,000 | 250 | 330 | 50,000 |
| Moonie | 140 | 150 | 8,700 | 140 | 150 | 8,700 |
| Condamine-Balonne | 170 | 210 | 4,200 | 170 | 210 | 4,200 |
| Paroo | 90 | 100 | 24,000 | 90 | 100 | 24,000 |
| Warrego | 101 | 110 | 4,800 | 101 | 110 | 4,800 |
| | | 100 | 130 | 5,500 | | |
| **AUSTRALIAN CAPITAL TERRITORY** | | | | | | |
| ACT | 180 | 280 | - | 180 | 280 | - |

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MDBC Salinity Manager, Matt Kendall, said the within-valley actions together with downstream actions, such as salt interception schemes and dilution flows, were also expected to contribute to meeting the Basin target at Morgan in South Australia.

"The Basin target is to maintain the salinity at Morgan at less than 800 EC for 95 per cent of the time. Morgan is located upstream of the major pipeline off-takes for Adelaide's water supply and 800 EC is the Australian limit for good quality drinking water," Mr Kendall said.

"The targets in themselves do not represent the full range of outcomes sought, but are a way of measuring progress towards achieving the Strategy's objectives. While the targets need to be adaptive and flexible, they will only be changed where there is adequate justification, and with the agreement of the Ministerial Council.

"This will provide certainty and integrity for the strategy and will ensure that efforts are directed to finding creative and innovative ways to meet the targets. Data collected to agreed standards from a network of continuous flow and salinity monitoring sites will be regularly reviewed, to assist in the complex process of assessing progress towards meeting the End-of-Valley targets".


Mr Kendall said that the design and delivery of outcomes from individual catchment plans will be essential to achieve these targets. This will require predictive tools that can assess the effects of various catchment actions such as land use on river flow and salinity and to work through the possible trade-offs. These tools will include flow and salinity models (such as *IQQM* and *REALM*) for the tributaries to the Murray and Darling rivers, and local to regional scale catchment salt and water models (such as *2CSalt* and *CAT*) that can link with geophysical and other spatial information.

State government agencies, the Australian Government, catchment management authorities and regional communities all play critical roles in managing salinity.

"The Murray-Darling Basin Ministerial Council has approved these targets as an important base for measuring progress towards achieving salinity control in the Basin," he explained.

The table and map show the end-of-valley target sites across the Basin, including the Basin target site at Morgan.

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# The saltbush, microbes, methane connection — innovation rewarded

**A project to examine why saltbush causes sheep to lose weight and condition has won CRC Salinity PhD student Dianne Mayberry the Western Australian prize in the 2005 Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry.**

Di, who is studying at the University of WA, will receive up to $10,000 to complete a project of long-term benefit to Australia's agriculture.

Presenting the award, The Minister for Agriculture, Fisheries and Forestry, the Hon. Peter McGauran commented "Ms Mayberry's project will help tackle one of the most serious problems facing Australian agriculture - salinity.

"Researchers in Western Australia are trying to find practical ways farmers can get more out of their saline land. In many areas of the State, farmers are sowing saltbush pastures, which are highly salt-tolerant and also provide feed for livestock.

"However, sheep eating it tend to lose weight and condition. Dianne's project will examine whether this is because saltbush adversely affects the diversity and activity

Photo: D Evans

Di Mayberry with some of her subjects

• *Continued next page >*

# $C_4$ native grasses giving edge in high country

*By Georgina Wilson*

**New CRC Salinity research is indicating that some perennial native grasses that use the $C_4$ biochemical pathway for photosynthesis, appear to have a significant advantage in water use in high rainfall areas compared with some common $C_3$ species.**

PhD student Alison Southwell at Wagga Wagga trial site

Photo:M Crosbie

Alison Southwell at Charles Sturt University, Wagga Wagga, has been comparing water use of different native pastures types in the Murrumbidgee catchment near Yass. Since European settlement, the original summer-active or $C_4$ perennial pastures have been gradually degraded by grazing, fertilisers and other human impacts, allowing more competitive winter-active $C_3$ and then exotic annual species to invade.

"These high rainfall areas, often fairly inaccessible, with rocky, shallow and sometimes acidic or sodic soils contribute heavily to salt loads in the Murrumbidgee and Murray," Alison noted. "The native perennial grasses evolved to survive environmental constraints but struggle to compete with introduced annuals such as vulpia, brome grasses and ryegrass. It is neither economical or practical to sow these areas with improved pastures so we need to work with what is there already."

Among the $C_4$ native grasses, some of those still common include kangaroo grass (*Themeda australis*) and red grass (*Bothriochloa macra*). $C_3$ perennials that are still found in many areas and more active in winter months include weeping grass (*Microlaena stipoides*) and several wallaby grasses (*Austrodanthonia* spp.).

From September 2003 to April 2005 Alison monitored three natural pasture sites near Yass comparing a $C_4$ kangaroo grass-dominant site, a mixed $C_3$–$C_4$ site and $C_3$-dominant site with plots sown to annual ryegrass. Plans for a longer study had to be abandoned following drought during 2002.

Neutron probe measurements have shown that the site dominated by the $C_4$ grasses has been dried out to a much greater extent and more deeply than the annual pasture. The $C_3$-dominated sites, including the mixture, showed only a small increase in water use over the annuals.

In a parallel study of transplanted mature plants at Wagga, Alison found that the roots of the $C_4$ red grass were much more extensive than the $C_3$ wallaby grass and penetrated to 1.5 metres, compared with less than 1m.

"The aim for salinity and recharge management is to create the greatest water deficit possible in the soil before the winter rains," she said. "This appears to be happening more with the summer-active native grasses.

"Getting more of these native grasses back into these areas may not be easy, but other advantages would include more even pasture production for graziers, less likelihood of erosion and reduced acidification."

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of microbes that live within the animals' rumen."

During her honours research, Di found that rumen microbes from sheep fed on saltbush produced more than four times as much methane as those from sheep fed on a standard diet.

She intends to quantify the amount of methane produced by sheep grazing in saltbush pastures, enabling her to determine if it is a major contributing factor.

The award is one of seven State winners, and nine others sponsored by Australia's rural R&D corporations (RDCs). They give talented and enthusiastic young people in rural and regional Australia the opportunity and funding to help turn their ideas into reality.

The awards are supported by the Australian Government and Australian Wool Innovation, Land & Water Australia, Meat & Livestock Australia, and by the Fisheries, Forest & Wood Products, Grains, Grape & Wine, Rural Industries and Sugar RDCs. They are coordinated by the Bureau of Rural Sciences.

For a full list of this year's winners, and details of their projects, visit: www.daff.gov.au/scienceawards

# BC2C coming your way

*By Bruce Munday*

**B**iophysical Capacity to Change (BC2C) is a tool for highlighting the magnitude of land-use change impacts on catchment-scale water and salt export, and in particular the variation in response across the catchment. It uses simple but robust approaches to predict the changes in water balance, as well as delays caused by groundwater response times.**

This enables estimates of the long-term average salt and water yield from whole unregulated catchments – that is, catchments in which stream flow is not greatly influenced by man-made structures or flow manipulation. The model also requires that all rain falling within the boundary is discharged to the surface or stream within the same boundaries, which is sensible for upland areas consisting of local scale groundwater flow systems. The results from BC2C are lumped up to a catchment level and do not provide farm level information.

The model is a rapid assessment tool designed to help state extension officers, catchment management groups and planners, policy staff and managers in consultancies and State, regional and local government agencies. Whilst it is relatively simple to use, it requires knowledge of the processes affecting the flow of water through catchments, including hydrogeological information.

BC2C can be run with a user-friendly interface that allows changes to surface vegetation to be reflected in water and salt yield over time.

To date BC2C has been used mainly within the Murray-Darling Basin, for example:

- Prioritising catchments for salinity benefits in the Goulburn-Broken catchment, Victoria
- Searching for areas in the ACT with a potential downstream salinity benefit if converted to commercial tree plantations
- Determining the impact of tree planting in the Little River catchment, NSW
- Assessing the salinity impact at Morgan of tree planting across the uplands of the Murray-Darling Basin.

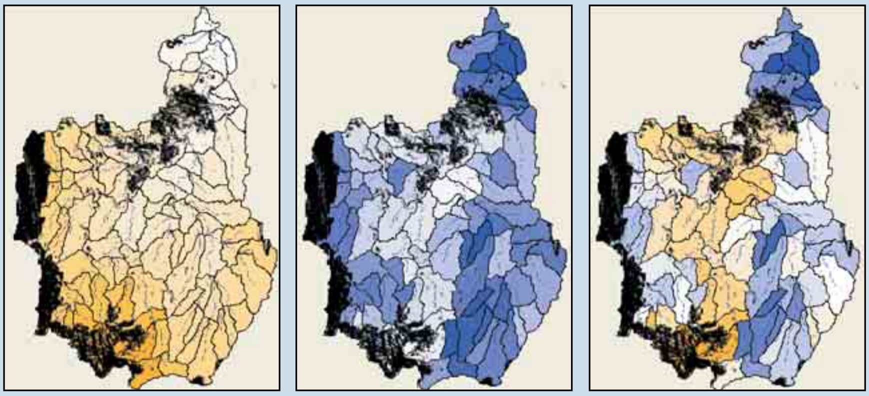

Figure 1. a) water b) salt c) EC contribution to outlet
Typical output from BC2C showing estimated relative impact of afforestation after 20 years on: a) stream flow (darker orange is greater reduction), b) stream salt load (darker blue is greater reduction), and c) stream salinity changes at the outlet (darker blue is greater reduction, darker orange is greater increase).
Black are areas of current forest cover

BC2C could be widely applied to other catchments across Australia.

Being a rapid assessment tool it inevitably has certain features that impose limitations. However, it readily allows a user to get a feel for the current situation in terms of water and salt yield, and the relative differences that can be made by changing the percentage of tree cover within individual parts of the catchment. Far from being an end point, this quickly allows the user to decide where further investigation is warranted, and those areas for which vegetation manipulation will not produce the desired results.

Version 1.0.0b of BC2C is now available for download from the Catchment Modelling Toolkit website http://www.toolkit.net.au/bc2c

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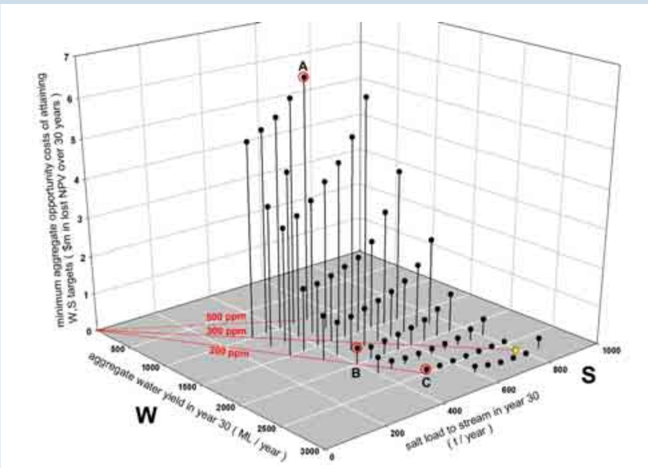
In *Issue 34 of Focus on Salt* the article *Balancing water yields and salt loads with farm profit* featured a graph describing the opportunity costs associated with land use change. Unfortunately labels were not printed for three scenarios. This is corrected in the accompanying diagram.



# Getting to the HARRT of groundwater

*By Georgina Wilson*

**Keeping track of groundwater levels is a crucial part of salinity management, but it can be difficult to interpret changes over time. In particular, groundwater changes may reflect long-term trends due to drainage of excess water below the root zone, fluctuations in rainfall, or land use change.**

The HARTT method (Hydrograph Analysis of Rainfall and Time Trends) has been developed to untangle these various influences. Using HARTT, one can easily identify the long-term trend of groundwater rise or fall at a site, how much of the observed changes are due to unusually high or low rainfall, and the impact of changes in land use.

Since its development by Albany-based Department of Agriculture hydrologist, Ruhi Ferdowsian in 1999, HARTT has become widely used in Western Australia and other States.

HARTT is superior to recharge calculators in two ways: it is based on real data at the site, rather than assumptions and extrapolations; and it accounts for all parts of the water balance, not just recharge. The main disadvantage is that it requires monitoring and collection of data over a period, preferably at least two or three years.

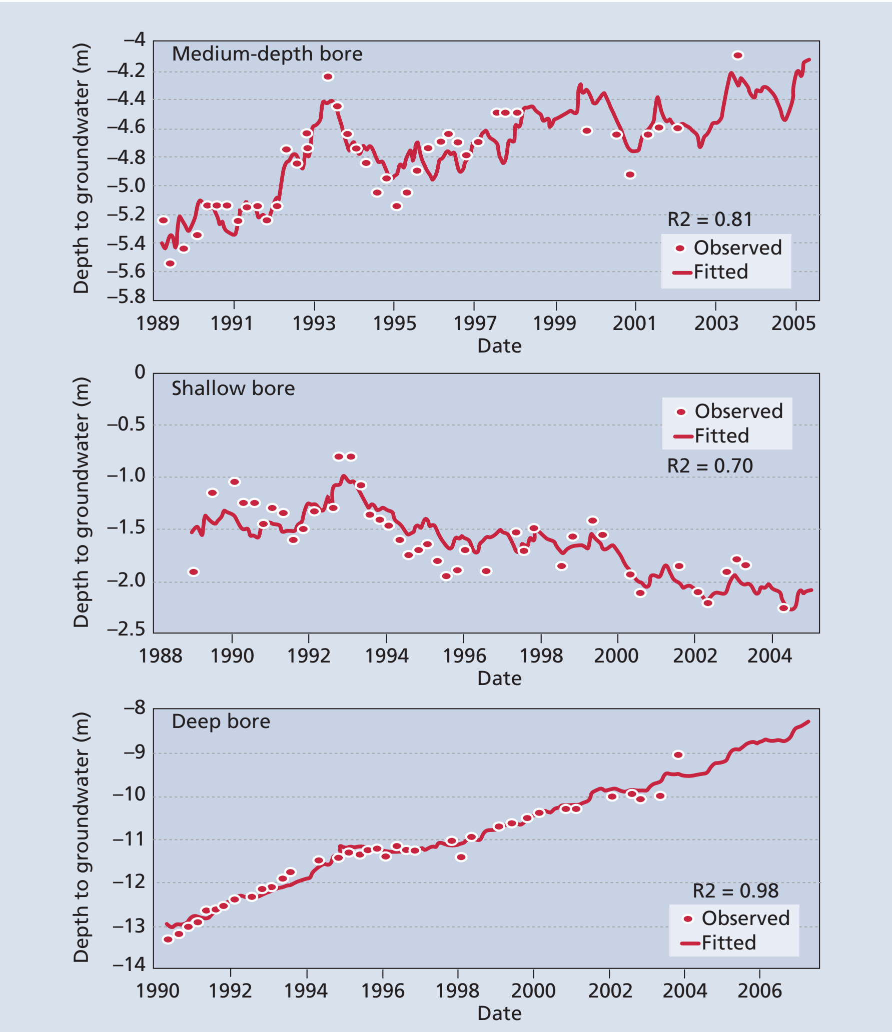
The method provides high quality fits to observed data in all but shallow bores (for which trend estimation is of less interest in any case). And even in these cases, statistical tests show that it is superior to the traditional time-trend-only approach.

Ruhi Ferdowsian

Results are highly consistent with hydrological expectations and can cope with irregularly spaced data and missing values.

HARTT is based on standard statistical regression techniques, and is available as an Excel template. The HARTT-XLS template uses Microsoft Visual Basic to extract rainfall and groundwater data from a variety of sources including Microsoft Excel workbooks, Access databases and ASCII text files. The final results of the statistical analysis are presented in Microsoft Excel workbooks for viewing and further analysis.

The graph (at left) shows HARTT analysis over 15 years for three very different bores at Jerramungup.




HARRT analysis over 15 years for three different bores at Jerramungup, WA

The latest version of HARTT-XLS for Windows XP and related papers can be downloaded at: www.agric.wa.gov.au/ and search for HARRT. A $50 registration fee applies plus a further fee if support is required.

Minimum data series required to apply the method are reasonably regular observations of groundwater levels (say four to 12 times per year for two to three years), daily or monthly rainfall records, and dates of any management changes. To this can be added daily or monthly evaporation for further accuracy of the analysis, especially for shallow bores.

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# Mapping salt in the Murray-Darling Basin

**In 2004 the Australian Government committed to investing $20 million for identifying and managing underground salt deposits in the Murray-Darling Basin.**

A two-pronged approach, managed by the Bureau of Rural Sciences (BRS), involves:

1. A network of community-based stream sampling projects, spread across the Murray-Darling Basin to produce a uniform dataset of stream salinity monitoring nodes.
2. A detailed salt mapping program using airborne geophysics in two study areas, one in NSW and one in Victoria.

## Community Stream Sampling

The BRS wrote to all Catchment Management Authorities (CMAs) in National Action Plan Priority Regions in the Basin seeking expressions of interest in the stream sampling component of the project.

The BRS has conducted previous stream sampling projects with partners from State Governments and CMAs. In the Cudgegong Catchment in NSW, products such as the catchment rankings for salinity impacts were developed from the stream sampling data.

These are valuable not just as catchment management tools but also for identifying locations where more detailed salt mapping programs may be warranted.

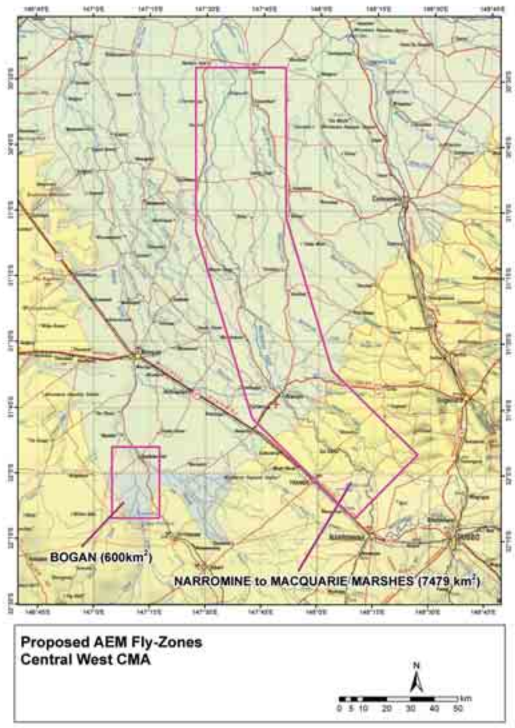
Involving community groups in data collection encourages ownership of the salinity issues in their area. The water testing procedures that will be used are designed to be managed by community groups, with quality control checks to ensure that the data is fit for the purpose intended.

Training of community groups for this type of survey is quick and cost effective, and many Landcare and Waterwatch members are already well trained in water sampling and quality checking methodologies.

The training includes a series of workshops to demonstrate how to calibrate and read the meters and record the data.

## Salinity mapping

In NSW the priority area chosen for salinity mapping is the Central West CMA, approximately 7500 km$^2$ running along the Macquarie River from Narromine to the RAMSAR listed Macquarie Marshes. The intention is to create a three-dimensional model of subsurface salt over the flight area, with the information underpinning long-term strategies to protect one of Australia's major ecological assets.




New AEM salt mapping areas in NSW

A further 600km$^2$ will be mapped near Tottenham in NSW to better understand the potential for salt mobilisation following land clearing.

The Victorian priority area for salt mapping has not yet been chosen, and this will be the focus of a forthcoming workshop of local, State and Federal representatives.

Different salt mapping techniques and their applicability are reviewed in Salinity Mapping Methods in the Australian Context, by Spies and Woodgate (See *Focus on Salt, Issue 34*). This report can be downloaded from http://www.nrm.gov.au /publications/salinity-mapping/.

Airborne Electromagnetics (AEM) has been favoured by the Australian Government for this project because it directly maps the location of salt deposits buried deep in the landscape.

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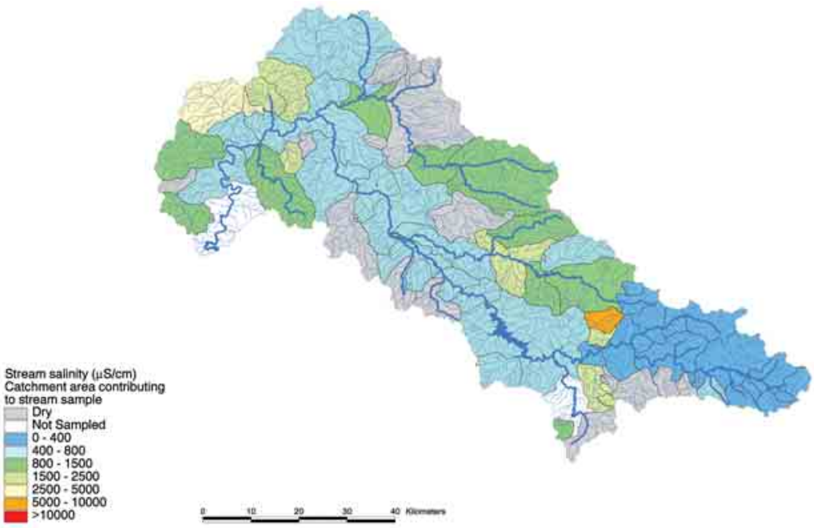


Relative stream salinity levels for sub-catchments in the Cudgegong Catchment, NSW

# About Focus on Salt

*Focus on Salt* is published by the CRC for Plant-based Management of Dryland Salinity (CRC Salinity) in collaboration with the CRC for Landscape Environments and Mineral Exploration (CRC LEME).

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