H2O thinking

eWater CRC

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A professional team drilling to 100 m to install a groundwater bore. (Rotary percussion rig)
Courtesy of Mick O'Neill, ACE Drilling, Bungendore NSW

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Time for a national accord on water use

Professor Gary Jones
CEO, eWater CRC

Something has to be done about environmental water management.

In spite of the legislation that has been passed, the money that has been allocated, the programs that have been agreed, and the water that has been purchased, river and wetland ecosystems across south-eastern Australia remain under threat.

It is easy, but also simplistic, to blame the drought for this predicament. And, from a scientific perspective, it would be incorrect to do so. In reality, it is neglect by *people* that has caused the long term decline in the health of rivers, floodplains and wetlands — not the drought. Seventy years or more of unsustainable water allocations and land-use decisions have eroded the condition and natural resilience of river ecosystems. This drought is just the straw that has broken the camel's back.

What the drought is doing, however, is forcing us to confront an issue that has been left unresolved for some time. And it is this. Although governments have moved to improve water management through better policy, legislation and investment — a decision for which they should be congratulated — they now need broader industry and community interests to get on board as well.

The 'inconvenient truth' is that in 2009 there appears to be no 'stable' consensus view on water sharing, for the Murray-Darling Basin or almost anywhere else in Australia. We need a collective understanding and agreement, bringing all of us — rural and city, communities, industries and politicians — into accord over water use for human and environmental needs.

the government needs community support for its actions; it needs the mandate of a national accord

Without such a consensus, the consequences for the environment are profound. Federal and state governments are harangued or stymied on almost every move they make to recover water for the environment. And when a government's 'freedom to operate' as the public custodian and manager of the environment is eroded in this way, what is the result? Environmental water being set aside for human uses, wetlands being drained to provide water for irrigation, and governments' role in purchasing water being challenged at every turn !

In 2007-2008, less than 2% of water consumption in the southern Murray-Darling Basin was directed to the environment. For many in the community, this was the right decision. It is madness, they argue, to be allocating water to the environment when irrigation farmers are struggling to survive. Surely the environment can wait until the drought breaks?

But scientific evidence from climate change research and ecological research suggests there are significant ecological risks in this policy. Firstly, in south-eastern Australia, we may be waiting a long time for the rains to come. This record dry period no longer appears to be a drought by any traditional scientific definition based on deviation from 'average' rainfall. The mounting evidence is that we have undergone a step-change to a hotter and drier climate, for a period that will last decades or longer.

Secondly, several recent scientific surveys and reports show that the resilience and condition of many river and wetland ecosystems is so depleted that there may be little left to protect if we wait too much longer before acting.

The heated public debate about water use is also much more than just one of the environment versus human consumption. The citizens of Canberra, Adelaide and now Melbourne are securing their water supplies by drawing on the waters of the Murray-Darling Basin. The Victorian food-bowl modernisation project, and its pipeline from the Goulburn River to supplement Melbourne's water supplies, has shown that public debate about urban versus rural consumption can be just as emotional and partisan, or even more so, as any concerning the environment.

To break this impasse, and to give governments the freedom they need to help solve the water-sharing predicament we are in, I believe we need a *National Accord on Water Use*.

The Accord should be initiated by a Water Summit of industry and community leaders representing all sectors and legitimate interests. The summit should debate and agree on a set of community standards for sharing water between cities, irrigation, industries, and the environment. The standards

Public debate about urban versus rural water consumption can be just as emotional and partisan as any concerning the environment.

should include principles for financial compensation that might underpin any necessary adjustments or transfer of rights and entitlements. I intentionally use the term 'community standards', in the form of a public accord, in contrast with the existing 'political' standards in the form of policy and legislation. The public accord will give governments the 'freedom to operate' in all areas of water management that they so obviously lack right now.

The Accord must include an honest and open conversation on the modernisation and rationalisation of the irrigation industry. As others before me have said, it is technically possible to get twice as much irrigation production with half as much water. There are billions of dollars of Commonwealth money on the table to make this happen, if we can reach a sensible agreement on how to move forward.

Moreover, as many people understand, though no-one will identify publicly, there are parts of Australia that should never have been turned to irrigation. Their soil types and drainage characteristics make them economically marginal even in the best of times. A national accord will have to face the natural reactions of people who love their region and work and do not want it to change. But now is the time to address this matter once and for all, and to do so in a way that seeks to protect the economy and social fabric of rural communities through broad-scale agreement. The alternative looks likely to be slow decline through a thousand cuts and water trades.

Accords have brought peace of a sort between violently opposed parties in apparently intractable resource management problems all over the world, as well as in Australia. In their 2003 book 'Renegotiating the Environment', Jenny Stewart and Grant Jones outline a number of cases — in forestry, water and elsewhere — where it has been possible '*to solve environmental problems by finding and developing common ground between opposed or differing interests'*.

Once agreed, the Accord should be overseen and 'upheld' by a national body of water-industry and community leaders — one perhaps not unlike the old Australian Water Resources Council but with broader membership. It will need members that give it the authority that comes from the will, conviction and influence of the individuals involved, not from government legislation or decree.

By all means let us keep developing the policies and plans we have committed to for the next decade. However, these plans and rules will be far more effective when governments and industry have the broad community backing — the social licence — to implement them. As the work of Stewart & Jones suggests, in matters as big as water, the government needs community support for its actions; it needs the mandate of a national accord.

To support a national water accord we also urgently need to develop the emerging science and practice of environmental water management. eWater CRC and the National Water Commission are running a workshop on this issue in late February, and I will outline its key learnings in the next issue of *H2O.Thinking*.

I was beginning to fear that, as a policy instrument, environmental flows were dead in the water. But, starting with a national accord on water use, I believe we can turn that sombre prediction around. I know we have the technology to use water far more wisely than we do now, for the environment as well as for cities and irrigation. We only need the shared conviction and resolution to do it.

This problem cannot just be left to politicians and government departments and agencies to solve. It is one that all Australians must agree to work out together.

Reference

Stewart J. and Jones G. 2003. Renegotiating the Environment: The Power of Politics. Federation Press.

H_2O news

RIVER MODELS 'ON TRACK' TO MEET NEEDS YOUNG WATER SCIENTIST AWARD 2009 WATER INFORMATION R&D ALLIANCE eWATER INNOVATION TAKES SHAPE SCHOLARSHIP TO HONOUR THE LATE PROFESSOR PETER CULLEN

River models 'on track' to meet needs

Integrated river management modelling, currently underway in eWater CRC, continues to be highly relevant to the future modelling needs of river-management agencies in jurisdictions across Australia.

This is the key finding of a series of visits recently to four states by leaders of the CRC's River Systems Suite, in which they provided an update on development of eWater's River Manager and River Operator tools.

A prototype version of eWater River Manager is expected to go on trial later in 2009. The tool supports planning and management of rural regulated and managed river systems, and will ultimately interface with models of shallow groundwater as well as easing management of changing water-ownership and effects of climate-change. River Operator, which supports river operations at short timeframes, will follow later.

During 2007 and 2008, the federal government (via the National Water Commission and Department of Environment, Water, Heritage & the Arts) granted extra funding to help ensure these tools are ready for use as soon as practicable, with Senator Penny Wong announcing a grant of $6 million alone in October 2008.

During their recent visits, the leaders reported on progress, and outlined the functionality to be expected in future version releases. For more detail, see www.ewatercrc.com.au/reports/rivermanager-1.pdf.

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For more information

Young Water Scientist Award 2009

Entries for the **2009 Riversymposium Young Water Scientist Award** close on 17 April. The award is worth $3000 to the winner, but all the finalists will gain recognition of their outstanding research and innovative thinking through presenting their work at the 12th International River*symposium* in Brisbane.

The award is open to any young scientist currently undertaking postgraduate research in water-related areas through any recognised Australian educational institution.

Kylie Catteral, from Gold Coast Water, who is currently completing her doctorate through Griffith University and the CRC for Water Quality and Treatment, was the 2008 winner. Kylie's presentation on 'Development of a rapid microbial-based toxicity assay for waters & wastewaters' was highly praised by the judges.

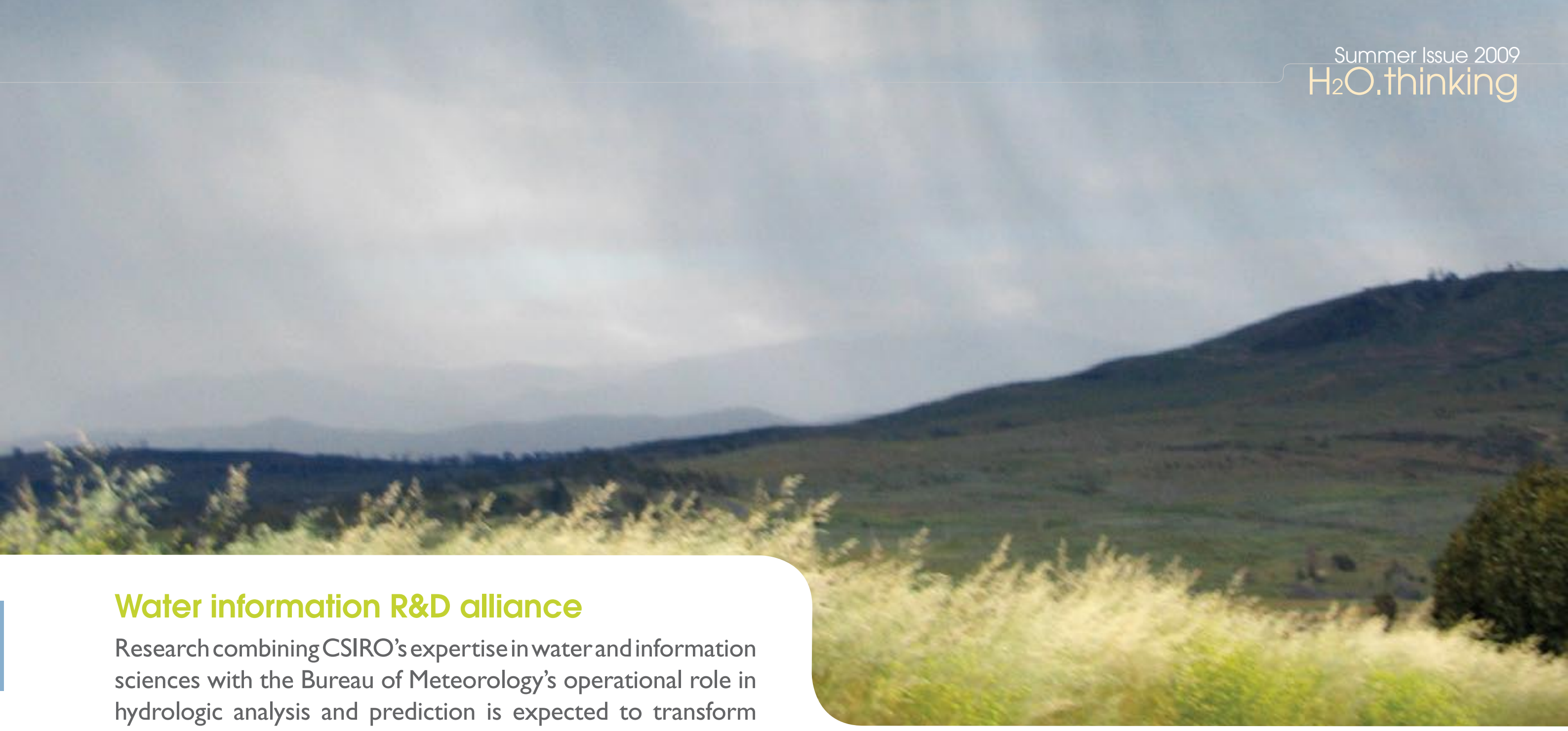
In 2007, Dr Simon Linke (currently at the University of Queensland and eWater CRC) won the first 'River*symposium* Young Water Scientist Award', for developing a new way of prioritising freshwater rivers for restoration and conservation.

GHD Pty Ltd is sponsoring the award for 2009 (and was sole or joint sponsor in 2008 and 2007 also), aiming to encourage young researchers in their chosen endeavours. Previously, 1998-2006, the award was entirely presented and managed by the water-focused Cooperative Research Centres including eWater CRC and its forerunners.

www.riversymposium.com

For more information

Kylie Catteral received her award from Ross Fryar, Manager for Water and Environment, GHD. Photo courtesy of River*symposium*.



Water information R&D alliance

Research combining CSIRO's expertise in water and information sciences with the Bureau of Meteorology's operational role in hydrologic analysis and prediction is expected to transform the way Australia manages its water resources. For this purpose, a $50 million Research & Development alliance was launched in September 2008, and it has already made significant achievements.

In December 2008, CSIRO delivered a digital surface model as phase I in the building of a new one-second digital elevation model (DEM). Using Shuttle Radar Topography Mission data, the one-second (approx 30 m) DEM will model Australia's ground-surface topography at nearly ten times finer resolution than previous models. This will give the Bureau of Meteorology a reliable definition of stream networks and catchment boundaries needed to calculate water movement through the landscape.

The data will be made available to government agencies under licence through Geoscience Australia and will be instrumental in the Bureau's water information activities.

http://www.bom.gov.au/water/wirada
http://www.csiro.au/partnerships/WIRADA.html

For more information

eWater Innovation (eWI) takes shape

eWater Innovation Pty Ltd, the new commercialisation arm of eWater Ltd, is now out and about.

At present eWI has three staff: CEO Tim Blackman, Office Manager Tamara Posch, and MUSIC/Urban Product Manager Luke McPhail (seconded from eWater CRC). The company office is within the eWater Ltd head office at the Innovation Centre, University of Canberra, ACT, for the moment.

eWI is focused on launching the new version of MUSIC (www.ewatercrc.com.au/toolkit/music) into the marketplace, mid-year. This latest version will have two-years'-worth of water sensitive urban design (WSUD) research packed into it, and its launch is eagerly awaited. The company expects to then launch new versions of MUSIC/Urban products every year that reflect the latest WSUD research and also provide market-leading usability.

The company's vision is for these to remain the 'standard' in urban water-quality management tools in Australia, and to take them to international markets as soon as possible.

Tim Blackman, Chief Executive
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For more information

Scholarship to honour the late Professor Peter Cullen

The successful applicant for the **2009 Peter Cullen Postgraduate Scholarship** is expected to be announced at the end of February.

The NSW Government has established this new annual scholarship with the several aims of: improving understanding of how rivers, groundwater, wetlands and estuaries function and respond to enhanced management; improving the linkages between water science and water management in NSW; and providing research opportunities for water specialists in NSW.

The three-year scholarships, worth up to $20,000 p.a., can be used to pay for equipment, field expenses, sample processing, etc. Eligible candidates are first-year Australian PhD students with interests in water science or water management, whether via biophysical or social or information sciences, or modelling, or resource economics or analysis.

http://www.dwe.nsw.gov.au/about/scholarship.shtml
simon.williams@dnr.nsw.gov.au

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Photo: Fiona Dyer.

WATERING ECOSYSTEMS BY TAPPING INTO SCIENCE

Unknown to the fauna and flora of our Australia streams, lakes, wetlands and estuaries, natural resource managers and planners spend much time and effort debating and agonising over the ecological merits of alternative options for waterway management.

Allocating scarce water resources and investment to allow native fish and riverside vegetation to grow, alongside agricultural crops, livestock and humans, is not an easy task. It involves very complex trade-offs, and considerable understanding of ecology, biology and physical processes.

Knowledge is rapidly improving in these areas — both in the science of predicting ecosystem responses to management activities, and in understanding of the uncertainties involved in predicting those responses.

To enable the water-industry to tap into this growing knowledge and understanding, a new comprehensive software tool, **eWater Ecological Modeller***, is being built by eWater CRC.

"While physical models of hydrology, sediment and nutrient-transport, have been used to help in management decisions for many years, natural-resource managers are increasingly required to base their decisions on predicted or desirable ecological outcomes as well," says Nick Marsh, leader of the 'eWater Ecological Modeller' team.

"Decisions about water allocation are a good example," says Dr Marsh. "With the environment now recognised as a valid water user in its own right, it's important that managers can link flow management models to ecological response. That way, they can assess crucial environmental water needs and decide between alternative water management scenarios.

"The current mechanism for doing this is a piecemeal, project-by-project affair," he says. "But the new eWater Ecological Modeller tool brings extra strength and reliability to management decisions."

Key features

The tool has several key features. It:

- Comprises an accessible and growing library of ecological knowledge, along with information about the sources of that knowledge,
- Applies that knowledge-base along with data the user puts in (such as time-series of flow, temperature, etc.) to produce predictions of ecological conditions that would result from a given management activity,

and

- Records the inputs and outputs so that decisions can be discussed constructively before being implemented, and also staff can later revisit old decisions and decide whether to reuse them or to upgrade them as ecological predictive capacity improves.

eWater Ecological Modeller is a tool that can potentially support any natural resource management activity, not just changes in flow or environmental water allocations.

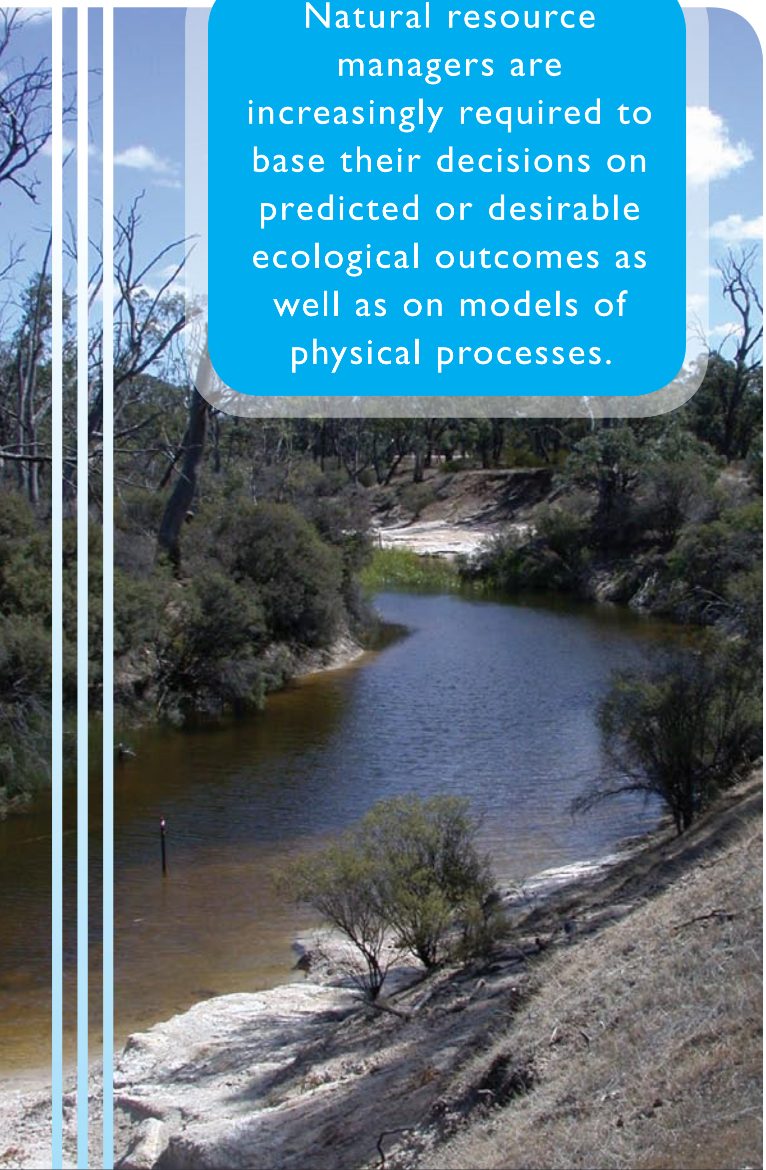
An eco-library

The eWater Ecological Modeller tool comprises a collection, or store, of quantitative ecological prediction models, from a range of sources and authors.

When a manager wants the tool to help predict the ecological consequences of different watering scenarios, the tool calls on an appropriate subset of these models to produce a summary of ecological responses (say, population change for an aquatic species) or habitat responses (such as reduced pool habitat) that can be expected based on existing knowledge.

* Formerly known as the Ecological Response Modelling framework (ERM)

Natural resource managers are increasingly required to base their decisions on predicted or desirable ecological outcomes as well as on models of physical processes.



The tool's model library is built from knowledge gained from ecological responses to trial environmental flows, such as at this sampling site in the Wimmera River, 2005. Photo: Fiona Dyer.

For example, the tool could be used to predict changes in availability of pool habitat in a river under different flow regimes. This might be helpful to groups interested in devising environmental water flows for maintaining populations of fish in a drought-stressed river.

"eWater Ecological Modeller can also be updated with new scientific knowledge — facts, and processes for applying them, perhaps via input from an expert panel — to augment the library of ecological models" says Marsh. "Ecological models are quantitative relationships between stream-flow metrics and the responses of ecosystem components."

Ecological models would typically focus on aspects of the environment which are of ecological, conservation and/or economic importance — anything from a Growling Grass Frog to a Southern Pygmy Perch; from a fast flowing riffle to a microscopic phytoplankton.

Inputs, rules and outputs

"Essentially our ecological understanding is represented as quantitative models to allow management scenarios to be compared," says Marsh, "and with the models being part of a growing knowledge-base, staff can revisit scenarios as the capability improves."

The software contains a number of numeric functions and it can generate ecological response models from any time-series data — that is, data recorded at successive points in time — such as temperature, nutrient concentrations or toxicant concentrations.

"This means that the models can combine environmental flow requirements with water-quality or other habitat information, providing more comprehensive modelling of habitat requirements for a native fish or other ecosystem component, say, than models based solely on water discharge," says Marsh.

When you run the model you obtain two key outputs. The first is a summary of expected organism response or habitat change under the given scenario. The second is a measure of how good that summary or 'prediction' is. The developers call this second output 'confidence' (see box).

At the core of the eWater Ecological Modeller framework is an ecological response model (depicted as the grey box in the diagram). This is a rule or set of rules that describe the life-history requirements or desired ecosystem properties that the user wants to know about. They could be conditions for spawning of a fish species, or for flushing of fine sediments, for example.

To run the model for the particular species or situation of interest, you enter a scenario or a time-series of relevant data (for example, daily flow or temperature). The appropriate numeric function and rules from eWater Ecological Modeller's library then transform the inputs into a new time-series as an output. The output time-series indicates when the conditions for a rule are met — it usually represents habitat availability in response to the input time-series. An example might be: identifying if fish passage is possible on any given day.

The 'daily time-step output time-series' is then summarised into an 'annual time-step time-series' (and a challenging tongue twister!). In our example, this could be the number of days in spring and summer when fish passage is possible. This annual time-series can be further averaged or summarised across years to produce a single summary metric, or score, for the scenario (see diagram).

By running various scenarios and comparing the outcomes, an expert panel or natural resource manager can see a range of choices of environmental water allocations or other aspects of river or resource management to achieve the desired ecosystem condition.

Can the model predictions be trusted? The second output of each model is a measure of scientific rigour which underpins the model development.

Information (meta-data) built into eWater Ecological Modeller's library (see diagram) produces a score for each prediction, based on particular criteria, and the output also includes other information and words of warning to ensure that the model is used appropriately (see box).

Users' confidence in a model's predictions is based on the pedigree of the model (its history, or how it was derived), the limitations of the model (such as the geographic areas it relates to and the types of data it can use), as well as general information about model ownership (who produced it) and why it was produced.

Application trials

eWater Ecological Modeller is a work in progress, currently being refined after trials of a previous version on the Werribee River in Victoria, and the Onkaparinga River in South Australia.

During 2009 the model is being applied in focus catchments in Victoria and ACT to help eWater partner organisations with real-world challenges in flow delivery. While a version is expected to be released during 2009, the team will continue to develop eWater Ecological Modeller over the next three to five years, based on its performance in application trials. The aims include linking the tool with other eWater products, expanding the model types that can be run, continually improving the interface, and networking ecological models across entire catchments or basins. An eWater Ecological Modeller users group will also be established.

For more information

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Judiciously applied water allocations can save redgums that become stressed by lack of watering during low flows. Photo: Andrew Tatnell.

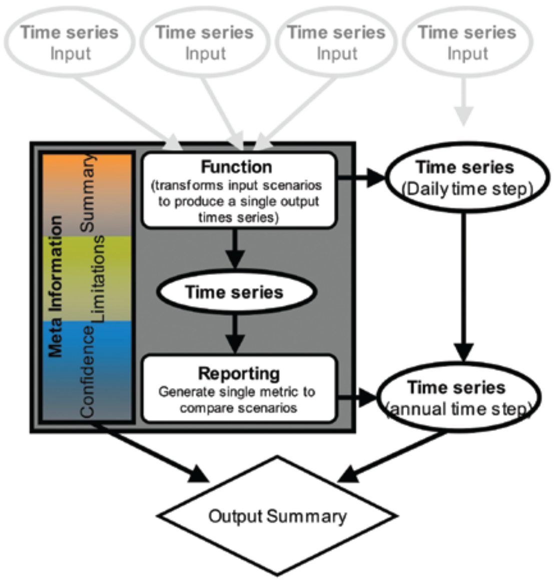
A question of confidence

The people who will use eWater Ecological Modeller (EM), and the teams who research and build the models within it, are often concerned about different aspects of modelling uncertainty or 'confidence'.

Model users, who are likely to be state-agency planners and scientists, water-authority staff, and natural resource management groups such as catchment management authorities, are expected to want to know how much confidence they can have in the possible outcomes. For this group, the model's reliability measure for each scenario is likely to influence them in choosing between competing management interventions.

As a simplified example, take the allocation of water for a wetland. If the model gives a moderately strong guarantee for a positive ecosystem response to the minimum water needed to wet the swamp, but its predictions of the ecological advantages of a major flood carry less assurance, then decision-makers will feel much more comfortable opting for the former water allocation.

But *model makers*, the researchers who quantify relationships between environmental variables and biological components, tend to lose more sleep over the 'dangerous' use of their models. Their worst nightmare is a user group that applies a model in an inappropriate way, perhaps in an unsuitable context, or to an unanticipated policy question, and thereby damages the researcher's hard-earned reputation. Fear of such inappropriate usage could discourage researchers from providing their models to the eWater Ecological Modeller library.



The central functions of eWater Ecological Modeller in diagram form: dark grey = rules or model chosen from the library, which is applied to the relevant time-series data to produce the desired output. Meta information guides choice of rules or model, based on their history.

The EM developers are conscious of these concerns and are developing a framework or confidence schema to support appropriate building, use and interpretation of the models in eWater Ecological Modeller (see main story). They aim to satisfy both model makers and users.

"To suit the needs of model users," says Dr Marsh, "our guiding principle in developing the confidence schema is to adequately communicate the scientific rigour that underpins each model.

"On the other hand, for model makers, the confidence schema must increase the researchers' confidence in providing ecological models to support policy decisions. For example, scientific content should not be diminished and caveats should be in place to ensure appropriate application of models."

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Making Water Work

A Stronger Role for rainwater tanks?

In some new housing developments all houses must have rainwater tanks.

Medium density housing offers a large roof area for catching rainfall.

Could it be that the growing number of home-owners who have installed rainwater tanks may be doing more good than they realise?

Rainwater tanks in urban backyards are sometimes dismissed as a waste of money, a largely feel-good, token effort by home-owners wanting some independence from local water supplies. However, a series of studies suggests they can be much more important than that.

Analysis and modelling by Dr Peter Coombes (of the University of Newcastle, Bonacci Water and the University of Melbourne) and Professor George Kuczera (of the University of Newcastle), both of whom are members of eWater CRC, has pointed out that using rainwater from tanks filled from roofs can potentially improve city water supplies and, at the same time, benefit the environment.

"Our studies show that sourcing water from both centralised supplies such as reservoirs *and* decentralised supplies such as household rainwater tanks, in combination with water conservation strategies, can make a city's water supply more reliable and improve resilience to water shortages," says Coombes.

Roofs feeding rainwater tanks in urban areas appear to be actually more efficient than conventional water-supply catchments. A roof, being impervious, only experiences a small loss of water when rain first starts, and so it is able to harvest nearly all rainfall, up to the tank capacity," says Coombes.

By comparison, in conventional water-supply catchments in years with less than 500 mm rainfall, the annual runoff to reservoirs is insignificant. In these years, the soil and atmosphere take up most of the rainfall, so urban users are really relying on the water stored in these reservoirs during more bountiful years.

"As a result, rainwater tanks can harvest beneficial volumes of water even during drought years, and so supplement the yield of supply dams," says Coombes.

"And widespread rainwater tanks would also catch some of the large volumes of water that currently run away from our coastal cities, unused, as rainwater, stormwater and wastewater," he says. "Only a very small proportion, about 1% and 5%, respectively, of urban water demand is met by rainwater harvesting and wastewater reuse, while some 83% comes from dams."

Effects of climate

Delving further, Peter Coombes recently joined with Dr Michael Barry (an Associate at BMT WBM Pty Ltd and also a member of eWater CRC) to explore the effects of climate variation, and climatic region across Australia. For Brisbane, Sydney, Melbourne and Perth, they used long climate records, as well as climatic changes predicted up to the year 2030, and simulated catchment-runoff into metropolitan reservoirs compared to the yield from 3000-L rainwater tanks connected to suburban houses.

For all four regions, the findings supported Coombes' and Kuczera's earlier observations. In periods of low rainfall, water supply catchments yielded proportionally much less volume, but tank water-yields were only a little affected. For example, 50% less median rainfall in each city reduced catchment runoff by 60-85%, and tank yields by only 15-30%.

In periods of good rainfall the reverse was true, largely because the 3-kL tanks overflowed.

"Our analysis argues for rainwater harvesting from roofs to be included in a suite of strategies to improve water security in our capital cities," says Coombes.

"When we considered the potential effects of climate change, we found that catchment runoff reduced by 19-53% in the worst-case scenario simulations, while yields from rainwater tanks fell merely 5-8%. Perth supply dams fared worst in these scenarios."

The important finding is that metropolitan water-supply across Australia looks likely to be more secure when it is sourced both from metropolitan reservoirs and rainwater tanks (used for laundry, toilet and outdoor purposes), especially during drought and predicted climatic changes.

Averages too generous when modelling rainwater tank yields

When considering rainwater tanks in Australia, urban water policy-makers and strategic planners use modelling to predict the total volume of water supplied and volumetric reliability (the supply/demand ratio).

These predictions must be accurate as they contribute to estimates of potable supply, but if the modelling uses averaging to represent tank behaviour it may give a wrong result.

Researchers at Monash University and CSIRO have found that the overall behaviour of a group of household rainwater tank systems, comprising a diverse mix of roof catchment areas, tanks' storage capacities, and end-use demand characteristics, is not identical to the behaviour of a single household rainwater tank system which has the mean characteristics of the group of rainwater tank systems.

In scenarios representing a range of system characteristics and water usage options (toilet only, garden only, and toilet and garden) for Melbourne, the total volume of water supplied from a simulated cluster of roof areas and tanks was 9–24% lower, and the volumetric reliability was 8–13% lower, than from a rainwater tank system estimated using mean roof area of the same size.

These results have significant implications for the incorporation of rainwater collection systems in urban water resource planning, as the volume of water supplied from actual rainwater tanks in practice may be considerably less than spatially lumped modelling would suggest.

The magnitude of this variation is significant enough to warrant further attention.

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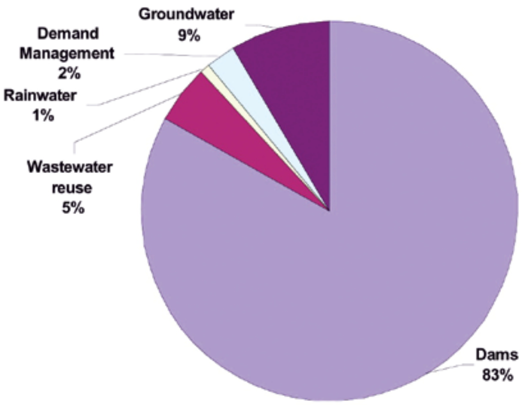
For more information



Sources of urban water (2004/05 water year) in Australia. As in Coombes & Barry 2008.

Energy and economic impacts

Water supply involves more than just volume, of course. The costs and energy use of water treatment and transport also warrant consideration.

In a separate study of 12 areas of NSW in a range of climatic zones, Dr Coombes and his team analysed the impact of rainwater tanks on water security, replacement of water treatment and transfer infrastructure, pumping, water treatment and maintenance costs, and greenhouse gas emissions from the operation of each city's water system. A single alternative scenario was investigated, involving installation of rainwater tanks to all new houses and to 2% of existing houses per year.

According to the analysis, widespread installation of rainwater tanks to supplement mains supplies can produce considerable reductions in operating costs and greenhouse gas emissions for regional water systems.

However, for householders, the study showed that the cost of rainwater ranged from $7.95 per kL at Broken Hill to $0.88 per kL on the Central Coast of NSW. Except for Sydney and Newcastle, the average cost of rainwater for households was greater than the price of mains water, which, in the real world, might dissuade many householders from installing tanks.

"But for several of the coastal NSW areas simulated, the simulated extra household rainwater tanks meant that those regions' existing water supply systems would be sufficient for the near-to-medium future. That is, in these simulations, authorities in Central Coast, Eurobodalla, Newcastle and Sydney would be able to defer building new dams or desalination plants for several years. And we observed reductions in greenhouse gas emissions of up to 75%, because less energy would be used in transporting water."

"We need to be cautious about findings that depend on certain assumptions, as in this analysis", says Coombes. "Nevertheless, we conclude that our research overall reveals the potential value of authorities including domestic rainwater tanks or, indeed, other decentralised water management options, when they are investigating and planning the operation of water systems around Australia."

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For more information

BRINGING Groundwater information to the surface

Bores into surface water bodies give access for measuring local groundwater.

How often have you seen a stream flowing along quietly, though there has not been rain for weeks? The flow, known as 'baseflow', is probably feeding into the stream channel from groundwater near the stream.

Historically, people have tended to forget that groundwater is the underground part of the local water resource. As a result, water has been drawn extensively from streams and also from bores or wells in the same area, in the belief that they are two separate sources of supply. But in fact, a stream and the adjacent shallow groundwater are a bit like the above- and below-surface parts of a tree or iceberg.

"Groundwater extraction from sources that are hydraulically connected to streams will reduce stream flows," says Ian Jolly, of CSIRO's Water for a Healthy Country and eWater CRC. "Depending on the volume of water extracted and other factors, the stream flow could be seriously depleted over the long term" he says, "especially if groundwater use grows unchecked. There are implications for water security and for the health of the riverine ecosystem."

"It is important to know more about the groundwater resource, but as you can imagine it's relatively difficult and expensive, compared to collecting data on surface-water," says David Rassam, also of CSIRO's Water for a Healthy Country and eWater CRC. "Commonly, we need to install bores and piezometers via drilling programs so as to measure groundwater flow, volume and depth.

"Therefore, groundwater data tend to come from small studies, and computer-modelling has had to fill in many gaps in our ability to understand and predict what groundwater will do."

The eWater CRC team led by Ian and David is filling in three model gaps for estimating the interaction between surface-water (SW) and groundwater (GW) near rivers and streams, and how that exchange depends on land and water management.

It is a common misconception that groundwater is only held in aquifers — which are relatively porous layers of soil or rock containing (possibly) large volumes of water.

In fact, groundwater is also normally found near the ground surface, both below the water table in the 'saturated zone', and above it (in the 'unsaturated zone'). The water table is the boundary beneath which the soil or rock pores are filled with water and salts and roots, rather than being shared also with air or other gas-mixtures.

Besides being accessible to bores and pumps, this shallow groundwater may be being lost into the air, pulled by evaporation from damp topsoil and via roots as evapotranspiration.

Groundwater is usually also moving downwards or sideways under the influence of gravity, from recharge areas (where rain or surface-water entered the ground) to outlets, often seeps or springs, at the ground surface up to hundreds of kilometres away. The rate of groundwater movement can be fast, or very slow indeed — in low-conductivity clays for example.

In a wide-ranging literature review in 2008, the team has found that many existing groundwater models are not good at handling the interaction with surface-water. In simple models, the river is just modelled as a boundary. While there are more sophisticated models, they are hampered by lack of data for testing and validating them in Australian river basins, and often they are too complex to run on the computing resources available in groundwater-management offices.

"When choosing modelling tools it is important to strike the right balance between surface-water processes and groundwater processes," says David. "We are doing this by building special-purpose models to answer specific management questions."

The team's reach-scale 'GW-SW Link' model is designed to bring more intelligent information about groundwater processes into existing river (surface-water) models for regulated river reaches within river valleys. The model estimates the GW-SW interactions as simple volumes gained or lost due to seepage into or out of the river, evaporation, or pumping; and feeds them into each time-step of the river model.

For the smaller scale, the team is building a 'Floodplain Processes' model, to simulate the water moving within streambanks, in evapotranspiration, and during recharge from flooding. This model interfaces well with ecological response models. It differs from the reach-scale model in its higher resolution modelling of the detail and timing of water movements, and because it can simulate SW-GW interactions due to overbank flooding as well as from seepage through river banks.

And for unregulated upland catchments, the team is adapting concepts from the existing '2CSalt' model of groundwater flow and salt transport so that it interfaces with eWater's 'WaterCAST' software for modelling catchment runoff and water quality. The adapted model will capture differences in travel time for groundwater, in steep versus shallow slopes or sand versus clay, for example, or because of distance from stream. The groundwater is routed from the 'recharge areas' within a catchment through both deep and lateral flow pathways to the stream or river where it is added to the estimates of surface runoff from other modules within WaterCAST.

"We are making steady progress," says David. "We have developed and tested ways to predict the effects of potential ('head') and flux during SW-GW interactions, and written them in TIME (The Invisible Modelling Environment), which is the language common to all eWater models."

"And we've made field studies of SW-GW interactions using novel isotope tracer techniques and more traditional hydraulics methods," adds Ian. "We are putting our work on a solid grounding of field observations to support a thorough understanding of existing approaches from all over the world."

Extra funding received recently from the federal Dept of Environment, Water, Heritage & the Arts and the National Water Commission is helping support this research team, whose members are based at five eWater partners: Monash University, Queensland Dept of Natural Resources and Water, Victorian Dept of Primary Industries, and NSW Dept of Environment and Climate Change, as well as CSIRO.

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For more information

National groundwater centre at Flinders University

The $60 m Centre for Groundwater Research and Training, announced in January, is to have a major role in training new groundwater specialists and in supporting research on groundwater resources and their links with ecosystems and climate.

The Australian Research Council and the National Water Commission have provided $30 million support for the initiative. Backed by a consortium comprising 12 universities across Australia, Geoscience Australia, CSIRO, the NSW and SA Governments and numerous companies in the water sector, as well as the federal Government, the centre is expected to make use of all available groundwater infrastructure and facilities including field sites and analytical capability.

Flinders University, which will lead the new Centre, has been the home of the Centre for Groundwater Studies in recent years. This new initiative recalls the university's longstanding leading role in groundwater research and training, which Professor John W. Holmes developed and led during the 1970s and 1980s at the School of Earth Sciences. He would surely have been very pleased and proud to see his work continued in this way.

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Groundwater infrastructure such as this bore near Menindee, NSW (owned by Dept of Water & Energy), will be a valuable resource for the new Centre's research. Photo: Geoscience Australia

Creature.feature

REDCLAW CRAYFISH *CHERAX QUADRICARINATUS*

A large male redclaw crayfish.
Photo: Adam Kerezsy

The redclaw (*Cherax quadricarinatus*) is a freshwater crayfish native to northern Australia which is invading and threatening the ecology of isolated waterholes in the Lake Eyre Basin. In waterholes with large populations of redclaw, the endemic blue-claw crayfish (yabbies) seem to be either non-existent or extremely rare.

In their natural habitats redclaw are found in fast-moving shallow creeks and headwaters, as well as slow-moving or still, deep billabongs that may be stagnant or turbid. They use aquatic vegetation for cover, but often climb out of the water and are thus able to colonise separated waterholes by overland migration. Their main predators are cormorants, herons, eels and water rats.

The redclaw body is smooth and greenish in colour. Mature male redclaw crayfish have distinctive red patches on their claws. The species is distinguished from other *Cherax* species by the 4 carinae (or ridges) on the dorsal surface of the carapace. They grow to around 90 mm carapace length and up to 600 g weight.

Redclaw have been brought into the Lake Eyre Basin as bait for recreational fishing and for aquaculture. Now populations — most likely derived from farm escapees and liberated bait — have been detected in waterholes of the Georgina system in far western Queensland, as well as in the Diamantina and Cooper catchments.

The species is farmed commercially in Queensland and Northern Territory. Individuals live for 4-5 years, and are mature after the first 12 months, spawning all year especially when water temperature is above 20°C.

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For more information

Western Australia

Cooperation the key to vital groundwater future

STATEVIEW: WESTERN AUSTRALIA

Currambine, a Perth suburb on top of the Gnangara Mound. Photo courtesy WA Dept of Water.

By Peter Collins
Media and Communications Officer
WA Dept of Water

A number of competing land uses affect the health and sustainability of Western Australia's 'Gnangara Mound' groundwater system. As a result, its management strategy requires a joint partnership approach.

The groundwater stored in the Gnangara system has historically provided up to 60% of Perth's scheme-water needs. Large volumes of water drawn from the aquifer are used for agriculture, forestry and market gardens, by local government and private bore users. The water is also important for maintaining wetlands and native vegetation.

From the early stages, it was decided that the partnering would go beyond mere cooperation, and that a dedicated office would be established to effect its aims and objectives.

And so the Gnangara sustainability strategy (GSS) was born.

To ensure the long-term sustainability of Gnangara's groundwater within the state's overall water security objective, the Department of Water (DoW) was assigned lead agency status.

"While DoW leads the partnership, the strategy and its programs involve the departments of Agriculture and Food WA, Environment and Conservation, Planning and Infrastructure, and representatives from the Forest Products Commission, the Water Corporation and CSIRO," said John Loney, the DoW's Director of policy and planning.

In 2007–08, the GSS task-force determined the climate ranges, planning horizons and local management areas against which proposed management actions were to be modelled for their effect on water balances and other environmental impacts.

Proposed management actions include but are not limited to: establishment of a horticultural precinct; replacing the pine plantation with a mixture of urban development and native bushland; using treated wastewater for watering horticultural activities and watering public open spaces; or a combination of these or other options.

The management and planning process is assisted by expertise and real hard scientific data from each agency, showing what works and what doesn't in keeping the groundwater system viable as a water source option.

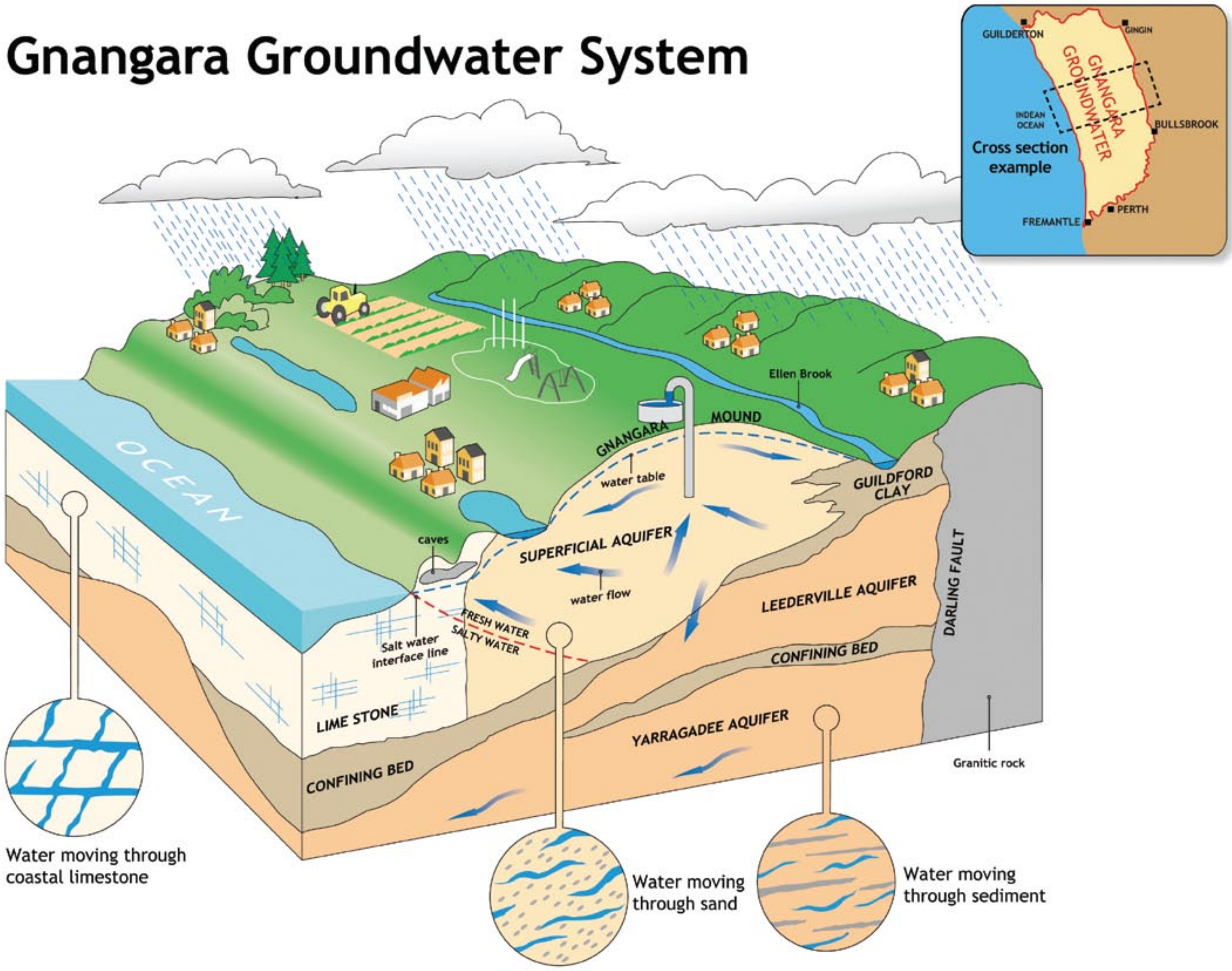
"The Gnangara Mound metering project run by DoW has seen a total of 800 meters installed across the mound's 12 key sub-areas. They are providing more accurate information on how much water people are using, and enabling us to work with them to improve water efficiency," Mr Loney said.

"Fieldwork has included biodiversity surveys by the Department of Environment and Conservation. These help us understand the natural environment's response to a drying climate, and the environmental factors — for example vegetation, soils, fire regime, water availability — contributing to the location of species and communities.

"The Forest Products Commission is assessing the effect of forestry on recharge rates, and possible opportunities for other commercial tree plantations that require less water.

"The Department of Agriculture and Food has looked at the land use and practices of the local horticulture industry, while supporting development of the Vegetables WA e-irrigation system to help in efficiency and the wise use of fertilisers," he said.

"Yes, we have had cooperation between agencies before, but not in regard to a vital source of water like Gnangara.



"One lesson from the Murray-Darling collapse, and the east-coast water woes in general has been that problems can be caused by one sector not knowing what others have been doing," said Mr Loney.

At the end of December the Gnangara groundwater system levels had continued to improve for six months in a row on the previous year's averages, despite an equivalent annual rainfall — preliminary evidence that new efficiency measures resulting from better knowledge may have improved the mound's management.

"These gains appear to be through a combination of improved efficiency, tighter controls and a reduction in the annual abstraction quota," the DoW's Director of water resource use, Rob Hammond, said.

"Overall the levels are still quite low and there is no reason for complacency in drawing on the Gnangara water source.

"Our state is developing at an unprecedented rate. Add declining rainfall to that equation and it becomes essential that we conserve and protect our existing water supply and look at alternative water sources to meet the huge demands being placed on our supply system," said Mr Hammond.

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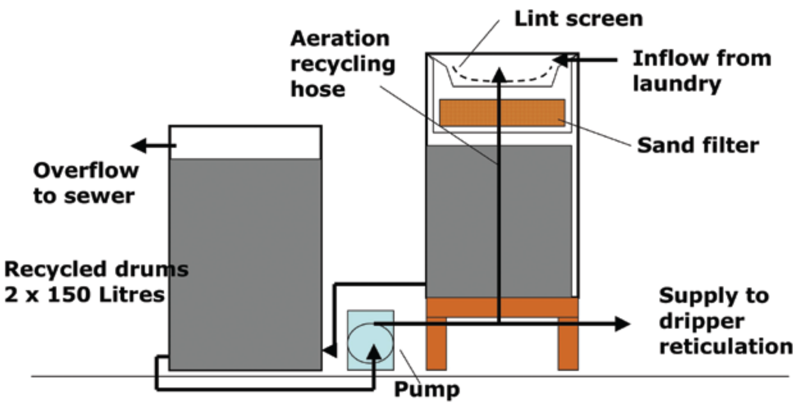
For more information

Grey(water) POWER



Lawrence greywater tank & treatment arrangement: recycled drums (tanks) & pots; sand & flywire filters; 25 mm PVC hose & valves. Cost <$130. Photos and diagram: Ian Lawrence.

Several years ago, water engineer, Ian Lawrence decided to drought-proof his garden and, as a first step, he set about designing and building his own grey water recycling system.

All the components were purchased from a hardware store or, as in the case of the drums that act as holding tanks, second hand.

"The system, which is connected to a dripper irrigation system for the garden, has now been operating effectively for 6 years and has been inspected by thousands of interested people," says Ian, who also happens to be an Adjunct Professor in Landscape Design at the University of Canberra.

"I kept it simple so that anyone who is practical and handy with tools could install their own version," he says. "The science behind the design is sound, but not rocket science.

"The nature of treatment required to re-use grey water depends on the proposed water use and the means of delivery. So for toilet flushing, the grey water will need advanced filtration plus a biological or similar treatment to remove colour and odour. For spray irrigation, it is necessary to filter plus either disinfect the water or take measures to limit aerosol drift.

"However, for under-mulch dripper irrigation of plants you simply need to filter out the suspended solids, which would block the drippers, and in the laundry it is advisable to use detergents low in phosphorus and sodium (salt), and preferably pH neutral," he says.

The Lawrence system collects the laundry water and runs it through a lint filter on a fine wire screen that sits in a basin arrangement at the top of a 150-litre plastic drum. Below that is a sand filter that removes fine particulates from the water which is then held in a second drum for 24 hours. This allows cooling and further settling out of sediments before the treated water goes to the under-mulch dripper reticulation system (see the diagram).

Professor Lawrence cleans the filters just once every three months, swirling the sand around to remove the occluded solids. He says grey water is a reliable, drought proof, and economical source of water for the garden. His treatment system cost him less than $130, excluding the pump and irrigation gear, and the water cost works out to be just 15 cents per kilolitre. He has no plans to manufacture or market the system.

Footnote:

State and territory governments and water authorities do not generally discourage the use of grey water systems. The New South Wales Government says (www.waterforlife.nsw.gov.au) it is 'making it easier for individual homes to take up water recycling by simplifying the approval process for household greywater diversion systems.'

And the ACT Government advises that using grey water 'instead of potable water (drinking water from the mains system) makes an important contribution towards conserving our precious water supplies.' (www.thinkwater.act.gov.au)

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For more information

Fish ecology in the desert

Postgrad. THINKING

Adam Kerezsy holds a healthy Yellowbelly from the Diamantina River in far western Queensland.

Setting nets at a rarely flooded waterhole in the eastern dunefields of the Simpson Desert.

Photos: Michael Brigden.

Adam Kerezsy, a PhD student at Griffith University's Australian Rivers Institute and eWater CRC, is investigating the distribution, recruitment and movement of fish across a vast arid area of western Queensland that includes all rivers west of the Murray-Darling Basin.

"I'd watched drought, river regulation and the impact of alien species contribute to the deterioration of my local waterway at Lake Cargelligo, in the Lachlan catchment," says Adam. "And I figured a good way to try to understand Australian dryland river systems was to find an area that hadn't been regulated, hadn't been intensively farmed and didn't contain a suite of alien species."

His work to date has included seven field trips, 35 000 fish samples and about 40 000 km of travel in some of the most remote parts of outback Australia.

"The best thing about the Bulloo, Cooper, Diamantina and Georgina catchments is their isolation," he says, "but it means that more than a little planning is required to make sure you get there, get your data … and then get home again."

His results suggest that quite subtle processes are at work in the arid zone, underlying the accepted 'boom and bust' theory of the zone's ecology. Therefore, he is proposing a new source--sink model to describe the ecology of fish communities that are mostly based in permanent waterholes.

"It's interesting because most species seem to recruit fairly continuously, even if they're living in a waterhole that is likely to go dry before a re-connection event occurs. If dry conditions prevail, successful breeding can still occur, but when a flood happens, the entire catchment gets turbo-charged," he says.

The highlight of his research was a rare flood event in the Simpson Desert in 2007, which has recently flooded again in January 2009.

"The Mulligan River, which forms the north-eastern boundary of the Simpson Desert and flows through the eastern dune-fields, filled with floodwaters in January 2007. I made sure we were out there in April to see the consequences. We found that several native fish species had migrated up to 300 km into newly-inundated country … and a very uncertain future," says Adam.

His research has recorded range extensions for up to seven species in the Simpson Desert and also for cryptic (rarely seen) species such as the Golden Goby in the Diamantina River.

"What we still don't know about our inland rivers is fairly staggering, especially when you consider how much we're now spending on trying to repair the Murray-Darling," says Adam. "I hope work like this in the western rivers will help in managing the Lake Eyre Basin, and guide restorative work in other dryland areas as well."

Adam is working with supervisors Professor Angela Arthington and Professor Stuart Bunn.

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For more information

Trapping sediment in stormwater wetlands

Ruffey's Creek Wetland in Melbourne.

Open-channel flow tests, under strictly controlled conditions.

Constructed wetlands and ponds are now widely used for the treatment of urban stormwater contamination, but the better they are understood the better they may work.

"Given the financial cost and amount of land taken up in constructing stormwater ponds and wetlands, it is highly desirable that we can reliably predict their performance in trapping sediment," says Yong Li, a PhD candidate at Monash University in Melbourne, and eWater CRC.

An efficient system collects sediments and reduces the concentrations of suspended solids, total phosphorus, total nitrogen and heavy metals in stormwater, to protect the condition of creeks and other receiving waters downstream. It often consists of a 'train' of structures combined in series or parallel to suit the sources of contaminants.

While there are already computer models, such as MUSIC[1], that help stormwater managers predict and assess the performance and cost-effectiveness of potential stormwater management strategies, Yong decided to try a different approach.

She has undertaken a comprehensive series of laboratory, field and modelling studies to investigate two key physical processes — sediment deposition and re-suspension — both within and between individual storm events, in wetlands and ponds.

"I conducted about 80 experiments at the Monash Hydraulics Laboratory to explore the factors controlling sedimentation, and, based on statistical analysis of the results, developed a simple 'N_f model' for the prediction of the sediment trapping efficiency in constructed stormwater wetlands," says Yong.

"This proposed model is physically based, with the key coefficients being independent of flow rate and sediment characteristics. So it has broad application.

"To test the findings of the laboratory studies, I collected field data at Ruffey's Creek, a monitored wetland in Melbourne. As a result, I modified the model to account for the effects of wash-off and re-suspension of fine particles caused by environmental factors and new solids generated within wetlands through biochemical processes."

The model that Li has developed can deal with variable flow conditions in real wetlands, in both wet and dry periods.

When she compared her modelling results with those generated by the widely-used ' k-C* ' model, she concluded that the new N_f model, when combined with the CSTR (continuously stirred tank reactors) flow hydrodynamic model, was better suited to simulating different flow conditions in constructed stormwater wetlands, without the need for complex calibration.

"However, further field studies are required for model verification and future refinements," explains Yong. "And that's probably another thesis!"

Yong Li's supervisors at Monash University are Dr Ana Deletic and Dr Tim Fletcher and her PhD thesis has been submitted for examination. She is currently working for the Department of Sustainability and Environment.

[1] www.ewatercrc.com.au/toolkit/music

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For more information

Murray Hardyhead, which are 3-5 cm long when adult, live in wetlands and sheltered lake edges. Photo: M.Hammer

Banking water for rivers

Water is scarce, our river systems are doing it tough, and nobody knows when it will end, but a small organisation called **Healthy Rivers Australia** (formerly called Waterfind Environment Fund) has devised a new way to find water for stressed freshwater ecosystems.

The Fund was started in 2004, by volunteers who wanted to put something back into the community, given the stories coming from people on the land about the state of the river system. With a voluntary board of directors, the organisation's mission was to improve the health and sustainability of Australia's rivers, but in a somewhat novel manner.

What differentiates this fledgling non-government organisation Healthy Rivers Australia (HRA) from others is that it seeks actual donations of water, especially (but not solely) from generous irrigators, which it then channels into worthwhile projects, such as water for wetlands, via its environmental Water Bank. More recently it's been decided to also accept donations of money that can be used to purchase water or fund other works, such as projects to save native species that have been threatened by the drought.

"Healthy Rivers Australia holds water for the environment," explains Business Development Manager, Suzanne Keith. "We have a licence to hold water for environmental purposes, and individuals or companies can donate water to the Fund. These donations are held in the Water Bank until needed for community projects of benefit to rivers or wetlands. Alternatively, monetary donations from the community can be used to purchase a mix of temporary (one-year's worth) or permanent (ongoing) water via the water trading market."

Waterfind Pty Ltd is the founding corporate sponsor for HRA. A Water Smart Australia grant from the Australian Government, received towards the end of 2006, allowed HRA to set up a clever web-based water banking and delivery system that is the first of its kind in Australia.

"Our initial target for the Water Bank is 10 gigalitres or 10 billion litres," says Ms Keith. "This is an optimistic goal; however, the more water we can hold for our rivers the better. For now, we are focusing on the River Murray system, given that it is struggling as a result of over-allocation, protracted drought and extremely low flows."

HRA received its first donation of water during 2008: namely 500,000 litres donated by landholders Ian and De Denny. This, together with water purchased with monetary donations, allowed the organisation to deliver its first batch of environmental water. The beneficiary was Little Duck Lagoon, a drought-affected wetland near Berri in South Australia that was in urgent need of a top-up (see box).

"An important aspect of our work, apart from securing and processing donations, is to work with various partners to identify and develop habitat restoration and other projects that will

deliver good outcomes for river systems, on time and within a budget," says Ms Keith.

"Most of our work involves highly motivated volunteers, which reflects our wish to involve communities in the care of their rivers and wetlands and the flora and fauna that rely on these ecosystems," she says. "We urge anyone interested in getting more involved in river restoration to contact Healthy Rivers Australia — including those able to make a donation to buy water or the precious water itself."

For more information

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Southern Purple Spotted Gudgeon, 4-7 cm long when adult, recently rediscovered in a drying wetland in SA. Photo: M.Hammer

Refreshment for Little Duck Lagoon

Little Duck Lagoon, a small wetland near Berri, is one of a string of wetlands in that part of South Australia that are not getting nearly enough inflow to maintain the natural wetting cycle needed for survival of trees, other plants and animals. It is habitat for six species of frog, including the Southern Bell Frog, 17 species of waterbird and four native fish species.

Healthy Rivers Australia delivered more than 4,000,000 litres of water to the lagoon during 2008 to relieve the dire situation for the wetland and its wildlife. This was made possible by a donation of water by Murray River landholders Ian and De Denny, as well as financial donations from many other people which were used to purchase additional water.

Environmental Manager with the SA Murray-Darling Basin NRM Board, Judy Goode, facilitated delivery of the water from the Water Bank to the wetland. HRA's Suzanne Keith was also there for the milestone achievement — this being the organisation's first delivery of environmental water — and felt real satisfaction at seeing the sluice gates open and water flooding into the lagoon.

Suzanne Keith at the Little Duck Lagoon sluice gate, June 2008. Photo: Healthy Rivers Australia

Doing it **My Way**

By divining rather than science

Mick O'Neill (ACE Drilling Bungendore NSW) with his divining rod

When deciding exactly where to enter the ground when drilling for groundwater, many water drilling contractors in NSW use water-divining rods, says Mick O'Neill. He does it himself.

"I don't know how it works, but I've had around a 75% success rate with divining," he says.

The divining rod is a piece of stiff wire, "no.8 wire or thicker", around 3-4 mm diameter. It has a bend at one end so you can hold it, and is about 60 cm long.

"You hold it pointing ahead of you, tight so it can't waggle around," says Mick, "and then you walk across the likely area. When the wire turns of its own accord to touch your shoulder, there's generally drillable water below." For left-handers, the wire moves to the right shoulder, and vice versa.

While some diviners will tell you the depth at which the drill should find water and the flow rate of the resulting bore, Mick's experience is that the rod is not generally that clever. He will not predict if the water will be a good supply, or whether it is shallow, deep, or very deep.

Mick learnt divining when he was a boy, from old timers in central-west NSW. With years of drilling experience behind him, he can go into a paddock and tell by eye the most likely area for a successful hole, but he likes to pick the exact spot with the divining rod.

Once the wire has moved, it stays by his shoulder while Mick is over 'water'. After he has walked a few more paces, the wire moves back to its initial direction, marking the other edge of the 'stream' (aquifer perhaps?) or fault or whatever it is he is sensing. Returning to the centre of the 'stream', Mick turns and walks at right angles until the wire moves again. Then they drill at the intersection of the two 'streams'.

When working with a hydrogeologist some years ago, Mick divined a spot to drill and pegged it. Separately, the hydrogeologist consulted the seismic record of the same ground and decided on the best place for the hole. When they compared their decisions the next day, they were apparently identical!

Mick says he has at least once drilled in an area 'by eye' alone, and found no water — in five holes. Finally he decided to use the divining rod and then drilled at the indicated site. "I don't know if the rod was reacting to a fault or what, but that hole was a good one," he says.

catchment Modelling Toolkit

www.ewatercrc.com.au/toolkit

Tools news

New on the Catchment Modelling Toolkit site in the last few months are the tools Concept, MCAT and WaterCAST.

WaterCAST (featured in the first issue of this magazine) is now available in a beta version. WaterCAST helps in evaluating flows, loads and concentrations of materials moving across catchments, in scenarios that include changed land use, land management and climate. It is a complex modelling framework that involves component submodels. To use WaterCAST successfully, you need to be already experienced in catchment modelling and understand the submodels and the implications of linking them. eWater will be offering training courses for potential users. See www.ewatercrc.com.au/toolkit/watercast.

MCAT (Multi-criteria Assessment Tool) and Concept are utility tools designed to help catchment and regional management bodies in decision making. **MCAT** helps in deciding the best way to invest limited funds aimed at improving water quantity or quality. It is easy to use, flexible, interactive, and offers a transparent approach to choosing among investment options. See www.ewatercrc.com.au/toolkit/mcat.

Concept is an interactive 3D diagram of a catchment which shows the interrelations between important elements of a river ecosystem and how they change under various management scenarios. See www.ewatercrc.com.au/toolkit/concept.

A version of Concept was adapted by eWater, the Australian Broadcasting Commission and CSIRO to form the online game **Catchment Detox** which became popular on the ABC website during 2008 Science Week. eWater is thrilled to find that Catchment Detox is a finalist in the Best Science category of the 2009 AIMIA Awards (Australian Interactive Media Industry Association). See www.aimia.com.au and www.catchmentdetox.net.au.

UPCOMING TRAINING courses

Upcoming training courses in MUSIC v.3 ($1650* incl. GST)

Location	Dates	Register by
Queensland	9-11 March	26 February
Sydney	25-27 March	13 March
Melbourne	29 April-1 May	17 April
TBA	27-29 May	15 May

To register, visit **www.ewatercrc.com.au/training**

*discounts for staff of eWater partner organisations.


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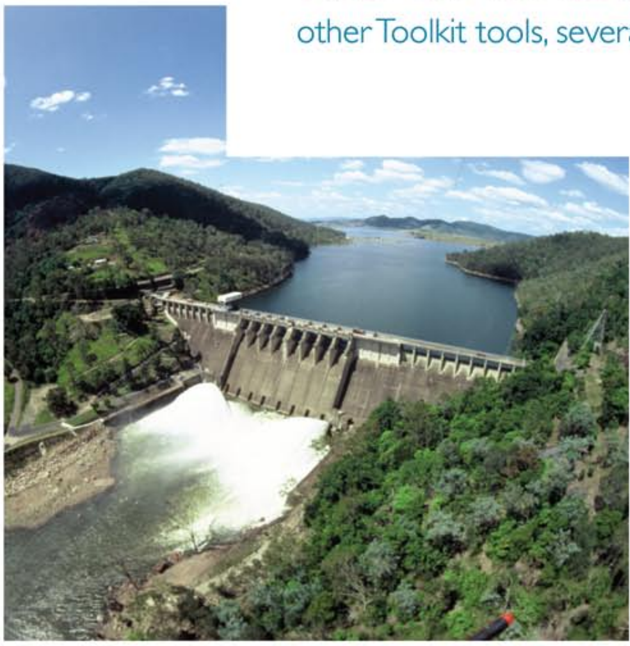
Catchment
Modelling Toolkit

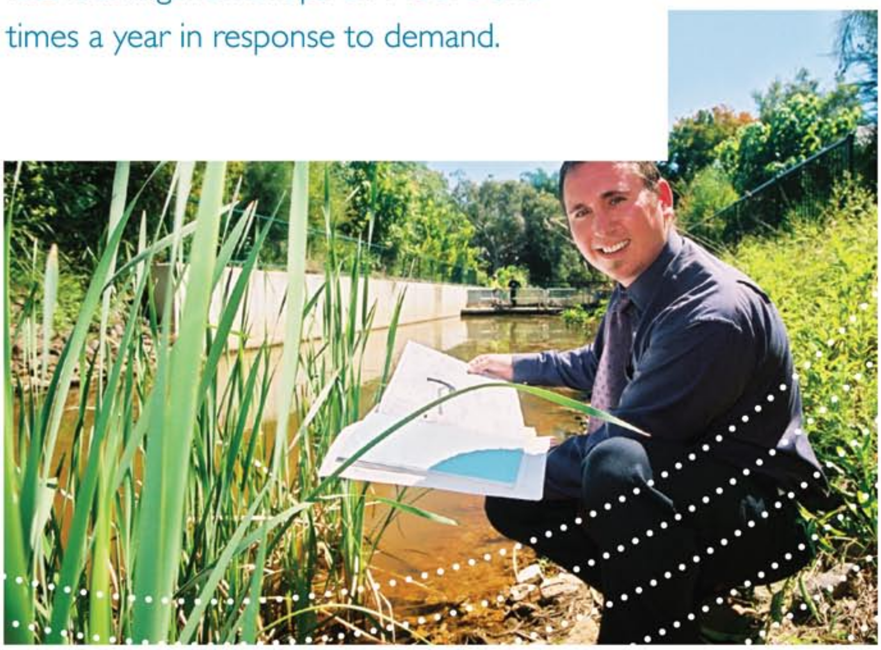
Software solutions for decisions about catchment management and planning, developed by leading environmental modellers.

Tools in the Catchment Modelling Toolkit help you predict the multiple impacts of land and water management across a whole catchment, e.g. in rivers, terrain, ecosystems, urban areas.

The Toolkit is also a portal through which you can search for data sets, web links and publications, and participate in discussion forums.

eWater CRC runs face-to-face training workshops on MUSIC and other Toolkit tools, several times a year in response to demand.





Find out more at www.ewatercrc.com.au/toolkit

TOOLKIT

The Catchment Modelling Toolkit is managed and supported by eWater CRC.

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