H2O thinking

eWater CRC

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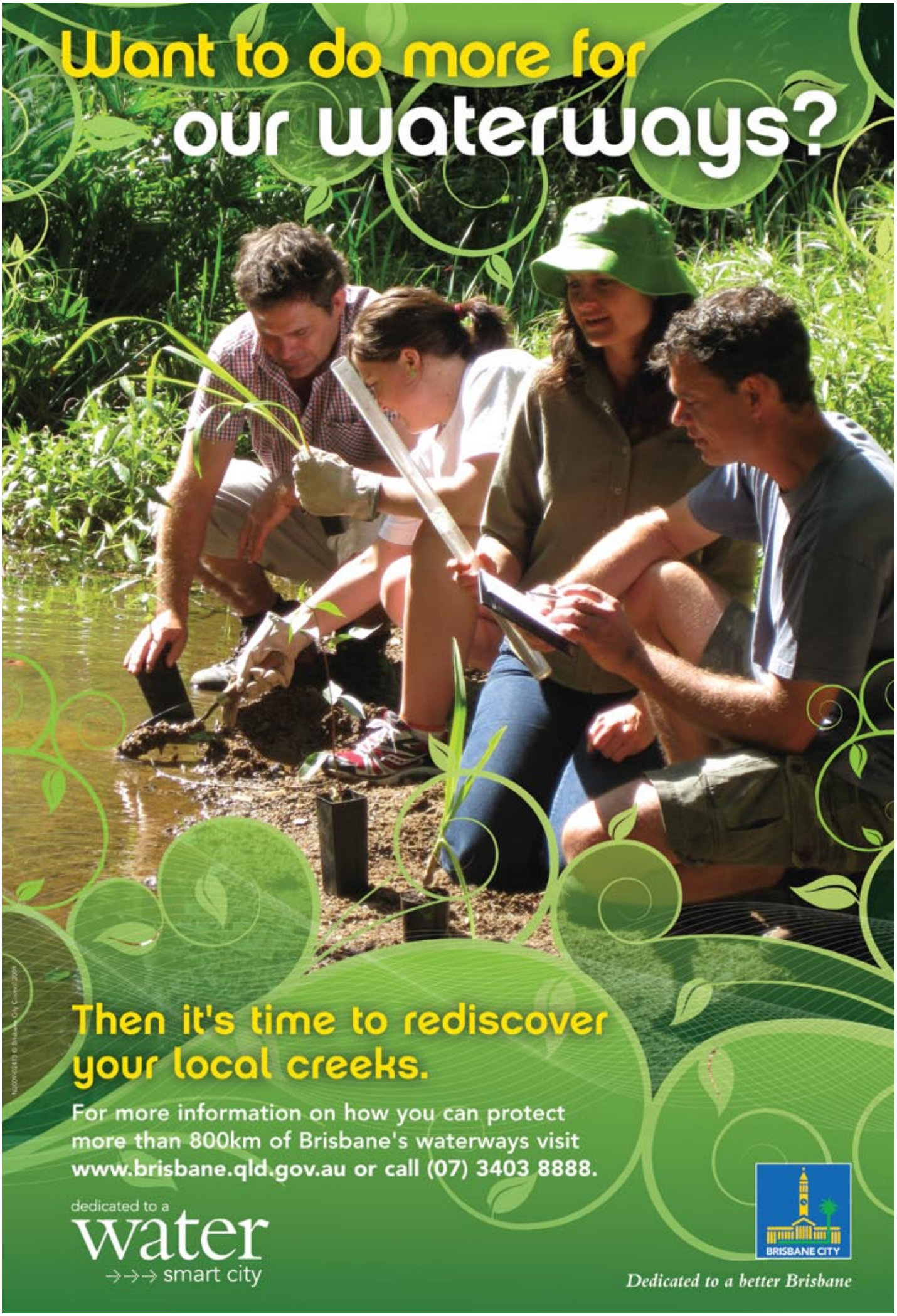
Seeking balance in water use

Managing Melbourne's water: an interview

River Manager model

Prescribing environmental water

California Dreaming...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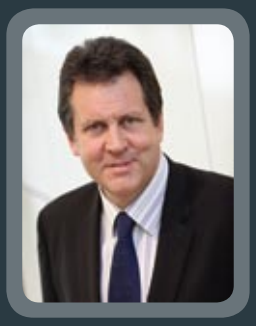
CALIFORNIA DREAMING...



Professor Gary Jones
CEO, eWater CRC

"Few things have played as large a role in shaping California into a global economic power as the ability to access, manage and utilise its most precious natural resource — water. Californians battling over water is nothing new — they've been doing so since the Spanish arrived in the late 1700s."

(California-based freelance journalist Rich Ehisen, September 2009)

In California with an Austrade water industry delegation in January, Gary Jones reflects on the striking parallels in water use and abuse between south-western USA and south-eastern Australia …

It is pouring outside as I wait in Los Angeles airport for my flight home. The cab driver told me it is the first time it has rained this heavily in years. Cars are aquaplaning across the freeway and mud slides threaten to drive people out of their luxury homes in the Hollywood Hills. Southern California is expecting its entire annual average rainfall in the next few days.

Hundreds of kilometres inland from Los Angeles, in the barren, treeless desert of Nevada and Arizona, the massive Hoover Dam, and its upstream partner Glen Canyon Dam, hold back the vast waters of the Colorado River. Completed in 1936 and 1961 respectively, the two dams so completely retain river flows that the dams' spillways have been needed to pass floodwaters only once in their history.

The Colorado River irrigation areas downstream of the Hoover and Glen Canyon Dams, including the famous Imperial Valley scheme, are vast and productive, and the parks and lawns of Beverly Hills and Bel Air are green and lush.

Yet, conflicts between upstream irrigators and downstream cities vying for access to limited water supplies have been going on for decades. Indeed, the first fights started back in the late 1800's. Mark Twain was talking about the south-west USA when he famously said: "Around here, whiskey is for drinking and water is for fighting over".

Water abstraction by Colorado Valley irrigators and major cities such as Los Angeles, Las Vegas and Phoenix is so high that the Colorado River delta in Mexico often runs dry, with catastrophic impacts on river ecosystems. Things are equally grim just north towards San Francisco where biodiversity losses in the delta of the Sacramento-San Joaquin River, another major source of water for southern Californians, have prompted authorities to drastically limit further abstraction for human use.

Does any of this sound familiar? It certainly did to me and the other Australians on our delegation. And the similarities between south-east Australia and south-west USA don't stop there.

Like south-east Australia, the US south-west is suffering from prolonged drought. Water restrictions for Los Angeles are being mooted by local politicians for the first time in many years, cut-backs to irrigators mean that 100 000 acres of farmland were left fallow in 2008, and only six of the 16 hydro-electricity turbines below Hoover Dam are currently being operated due to low dam levels.

In a final, almost uncanny parallel with Australia, the California legislature has recently passed a new Water Act and proposed a $12 billion funding package to drive water reform activities. I can only wonder if Governor Arnold Schwarzenegger was talking about more than just climate change with Minister Penny Wong in Copenhagen!

If approved by Californian voters later this year, the 'Water Bond' package will include funds for recycling and water conservation, groundwater protection and quality, ecological conservation and watershed protection, drought relief, river delta sustainability, regional water supply reliability, and water systems operations. As part of his water reform agenda, Governor Schwarzenegger has set a target of 20% reduction in per capita water use by 2020 (mind you, enforcing this will be a challenge as many urban areas don't yet have water meters, though they are apparently being hooked up). Irrigation areas will be required to develop water management plans with information on water efficiency and there will be new penalties for illegal water diversions.

Finally, if state water utilities and authorities don't meet water reform benchmarks they will lose their eligibility to access water bond funding.

The Schwarzenegger plan also includes revisiting what is, according to local journalist Rich Ehisen, one of the most controversial water proposals in California's history: a north-south peripheral canal to channel water from the Sacramento River to the large cities of southern California. Southern California already has an extensive urban water grid channelling water from the north and east to San Francisco, Los Angeles and San Diego. But the new canal may be needed because of the restrictions on water abstraction from the Sacramento River delta, mentioned earlier.

First proposed in 1980, opposition to the canal by irrigators stopped the project in 1982, but Governor Schwarzenegger now has it back on the agenda. While being aware of the different outcome, you would not be on your own if you saw similarities with the controversy surrounding Victoria's Goulburn River to Melbourne pipeline.

I also couldn't help but wonder whether another series of tough US federal court decisions to return water to the fragile Colorado River delta ecosystem might not presage future government, or even court, water allocation decisions for the River Murray's Lower Lakes and Coorong. US decisions have fuelled a long-running battle between environmental groups and irrigators suffering through a drought and the worst economic downturn since the Great Depression.

In one important lesson for Australia, in Orange County immediately south of Los Angeles, residents have been relying on indirect potable reuse of sewage since 1976. The big difference is that, in that situation, ultrapure treated sewage is recharged into local aquifers, rather than into surface water storages, before it is reticulated to households. This treatment-train difference seems to be enough to keep the otherwise vociferous and litigious Californian citizens placated. Orange County also had the additional pressing need to keep its critical drinking water aquifers sufficiently topped-up to avoid seawater intrusion. Recycled sewage was the only water source that was available to meet this critical need.

Probably the one notable difference between south-west USA and Australia is the currency of water, or more specifically the lack of it, in the USA. To quote Californian Senator Abel Maldonado, "I understand water's not a sexy issue … people turn on the water at home and take a long shower and say, 'what water problems?' ". Our American hosts were amazed to hear that almost every Australian taxi driver could give a 10 minute unbroken oratory on water use efficiency, and that shower timers were now 'de rigeur' in Australian bathrooms!

More significantly, there is not yet a national water reform agenda running in the USA, though a number of people, including some we met, are lobbying hard in Washington for this to start. There was enormous interest from our delegation's American hosts when National Water Commission Chair Ken Matthews spoke about the National Water Initiative and new Commonwealth Water Act. They were particularly interested in our national coordination between states in water policy, especially across the Murray-Darling Basin. Indeed, one of the US water industry leaders mentioned how impressed he was at our 'collaborative' approach to water management. That, I have to say, caused more than one-raised eye-brow among the Australian delegates! Yet, while the term 'collaborative' might seem humorous to those who have any close experience of the jurisdictional jousting around the Murray-Darling Basin, the MDB has seen a far more collaborative inter-government approach to water sharing and management than in the USA, where disputes are inevitably settled in the courts, not inside Ministerial Councils.

It is easy to forget amongst all our self-recrimination and hand-wringing at home, and notwithstanding the obvious need to address historic over-allocation of water through the new Basin Plan, that the Murray-Darling Basin 'experience' is regarded in the USA and around the world as a benchmark for trans-boundary water governance and management. Internationally people seem to care little that we have made mistakes — many countries suffer from a history of over-allocation of water — as they see the uniquely Australian way in which we are going about rectifying them.

The Austrade delegation to the USA was full of insights for both sides, and also a great opportunity to meet potential collaborative and commercial partners. To quote Grame Barty, Australian Trade Commissioner to the Americas, who organised and promotes the 'G'day USA' event in which we participated, "This is the beginning of what we hope will become an important annual exchange of issues and solutions between the USA and Australia — two regions that are inextricably linked to the serious changes and challenges of an accelerating decreasing availability of water and its supply juxtaposed to the demands of ever increasing populations."

Some Australian companies are already doing well in the USA and looking for opportunities to expand. I was both surprised and pleased to hear that the 'Total Channel Control' company Rubicon now has two offices in the USA. The Austrade-organised visit is furthering opening opportunities for Rubicon and other Australian public and private sector businesses to work more closely with this part of USA. More regular exchanges between our water industries and researchers can only benefit both countries.

The Hoover Dam.

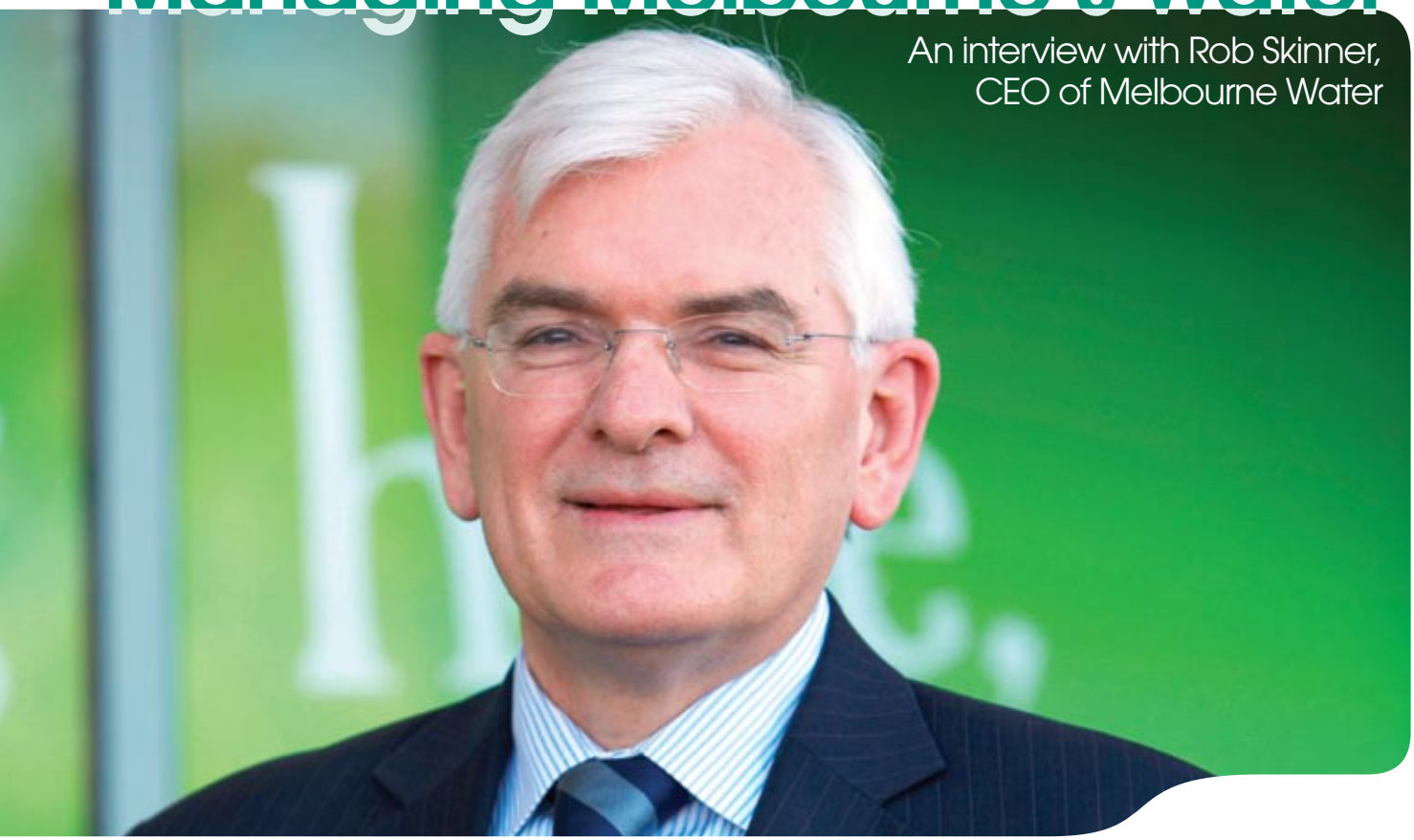
And we should recall that such US-Australia water exchanges are not new. As far back as the 1880s the Canadian-born Chaffey Brothers, George and William, translated their experiences in the Californian Santa Ana irrigation settlement into the Victorian and South Australian mallee. In spite of a few serious hiccups along the way, including a Royal Commission, the Chaffey brothers eventually proved that US water know-how could work in Australia. The opportunity seems perfect now for Australian businesses to return the favour … perhaps best without the Royal Commission!

More reading

For those interested to learn more about the politics and history of water management in south-west USA, try a number of informative articles from journalist Rich Ehisen available on the Internet, on which I have drawn for my article, and also the 1986 book 'Cadillac Desert' by Marc Reisner.

Managing Melbourne's Water

An interview with Rob Skinner, CEO of Melbourne Water



On a day when wild storms are lashing Melbourne and stormwater carrying nutrients and debris rushes down the gutters into suburban waterways, Melbourne Water head Rob Skinner describes an exciting plan to install 10,000 raingardens in Melbourne's homes over the next four years.

While implementing major initiatives to secure Melbourne's water supply is the immediate challenge for Melbourne Water, Mr Skinner, who is also a member of the International Water Association's steering committee on Cities of the Future, says in the longer term, the big challenge is to develop 'smarter' cities.

"Major central supplies of water will continue to be an essential part of providing safe and secure water supplies," he says. "But, in a future characterised by climate change and a growing population, cities need to be smarter in terms of more emphasis on water-sensitive urban development that continues a focus on water conservation and matching diverse customer needs to a diverse array of supply sources."

He says that in the water sensitive cities of the future, we will need to be thinking about a wide range of water supply options including decentralised options and this will require effective engagement and coordination across a range of organisations.

"It is not just a challenge for wholesale water managers like Melbourne Water but also for water retail companies, state and local government and the private sector.

"Melbourne Water has long been a champion of water sensitive design in both new developments and existing urban infrastructure. These initiatives range from encouraging local governments to incorporate water sensitive design features in new car parks or drainage systems, to integrated water planning in housing developments.

"One of the aims of water sensitive urban design is to keep the water where it falls and reduce nutrients and sediment loads in waterways," says Mr Skinner.

"You can do that by creating raingardens and bio retention systems, or using rainwater tanks.

"This type of integrated water planning is already being incorporated in new developments. For example, in a new industrial development currently being considered by Yarra Valley Water at Kalkallo on the outskirts of Melbourne, stormwater will be collected, treated and returned to the site for a range of beneficial uses. Parklands and gardens will be

A raingarden is an area of planted ground (or even a planter box) that soaks up rainwater directed into it from a downpipe or a paved area. Typically, they incorporate an underdrain to carry excess water directly to the stormwater system. Designs and information are available on the Internet for most states, e.g.:

http://raingardens.melbournewater.com.au/raingarden.html (Victoria)

http://www.rtbg.tas.gov.au/index.aspx?base=495 (Tasmania)

http://www.planning.sa.gov.au/go/wsud (S. Australia)

Championing WSUD

Melbourne is a leading exponent of urban stormwater quality management (USQM). Over four decades, the concept of protecting aquatic ecosystems by controlling the stormwater that enters watercourses has grown in strength, and many institutions and stakeholders have entrenched its principles into the urban design process.

The idea has evolved into the concept called 'water-sensitive urban design' (WSUD), which adds in the notion of waterway amenity.

To study how and why Melbourne has been so successful in its drive to become 'water sensitive', Associate Professor Rebekah Brown, Program Leader of Monash University's National Urban Water Governance Program (http://www.urbanwatergovernance.com/), and colleague Dr Jodi Clarke interviewed 28 movers and shakers in USQM. Their aim was to see what institutional cultures helped Melbourne bring what was once a way-out notion into daily practice.

The resulting report has three key messages:

- An important driver of USQM was a committed and innovative group of 'champions' working across multiple sectors. The authors acknowledge Melbourne Water as an organisational champion that, early on, transformed a niche into a mainstream activity.
- WSUD is yet to become mainstream anywhere and will require a concerted, multisectoral approach.
- There is a strong need to provide guidance to urban water managers and others on how to enable *effective institutional change* towards WSUD.

The report identifies a number of key ingredients needed for advancing institutional change towards WSUD. They include, among others, trusted and reliable science, binding targets, accountability, demonstration projects, market receptivity (meaning well articulated business cases), and strategic funding.

While wide adoption of WSUD has been slow, the Melbourne case study suggests there is a solid platform of evidence that widespread change in social attitudes and practice can occur.

Reference:

Brown R.R. and Clarke J.M. (2007). The transition towards Water Sensitive Urban Design: The story of Melbourne. Report No. 07/01, Facility for Advancing Water Biofiltration, Monash University: pp, 67

http://www.monash.edu.au/fawb

watered with treated grey water systems as well as recycled water. The potential for use as drinking water is also being investigated as an option.

"This approach makes sense at Kalkallo because it's an elevated site and the cost of pumping water back to the reservoir offsets the cost of local treatment," explains Mr Skinner.

"In this case, local treatment is more energy efficient than putting new pipes in to connect to the main water supply system.

"But, every location will have a different local solution, determined by the geology, geography and population density."

Water sensitive design features have also been incorporated in the heart of the city of Melbourne. In Little Collins Street, for example, stormwater running off asphalt areas is captured at the base of trees and filtered before it enters stormwater pipes.

At a household level, in a major new initiative, Melbourne Water is aiming to have 10,000 'raingardens' installed in households around Melbourne over the next four years.

Rob Skinner has recently installed a raingarden, alongside the rainwater tank in his own back yard. A spout from the roof is directed into the garden, which he describes as "like a big pot plant". Instead of running into a stormwater pipe, rainwater flows across the garden and seeps into a drainage outlet, before any excess flows out into the stormwater system.

Melbourne Water supports the use of rainwater tanks particularly for their potential benefits in relation to managing the effects of stormwater on rivers and creeks.

"Rainwater tanks have a number of advantages in the urban setting. They reduce peak flood flows – in heavy downfalls you reduce peak flows and subsequently the scouring of waterways, and they are certainly effective in reducing nutrients in stormwater."

But Rob Skinner is quick to point out that while tanks are a part of the solution for reducing demand on scarce drinking water supplies, they are by no means a 'silver bullet'.

"From a water supply perspective tanks are still dependent on rainfall and even if we rolled out tanks with a connection to the toilet and the garden to every house in Melbourne the time required and the amount of water saved means that even though they represent part of a future water smart city, tanks alone would not alleviate the current pressure on Melbourne's short term water supply needs," he says.

Rob Skinner spoke with Robin Taylor in Melbourne for H2O.thinking

Raingarden at Federation Square, central Melbourne.

H2O news

LAUNCHES: MUSIC V4, 'BIOFILTRATION ADOPTION GUIDELINES', 'MUSIC MODELLING GUIDELINES FOR SEQ' | GROUNDWATER SHORT COURSES NAME CHANGE | NATIONAL GROUNDWATER FORUM | H_2OZ WEBSITE 'ONE STOP SHOP' FOR JOBS IN WATER-RELATED FIELDS | NOWRA SCHOOL WINS NATIONAL WATER-MANAGEMENT GAME COMPETITION | NEW AUSTRALIAN KNOWLEDGE HUB TO BUILD WATER EXPERTISE IN THE ASIA-PACIFIC

Speakers and guests at the **music** v4 launch in Melbourne.

Launches: music v4, 'Biofiltration Adoption Guidelines', 'MUSIC Modelling Guidelines for SEQ'

Stormwater design planning and management can now be fully up to date with the release of new research-based guidelines, and the latest version of MUSIC 'online', in the last few months.

'**music** v4 by eWater', released in October, joined important guidelines for stormwater biofiltration and 'music' modelling at formal launches in Melbourne and Brisbane in November and December.

In Melbourne, over 120 guests were introduced to the FAWB Biofiltration Adoption Guidelines which include current research on stormwater biofiltration. And they saw how this research is implemented within **music** v4 – a much changed new version of the MUSIC software – and how the changes will benefit stormwater quality modelling. For planning the design of biofiltration and bioretention, this new science makes MUSIC (**m**odel for **u**rban **s**tormwater **i**mprovement **c**onceptualisation) the most capable software available.

In Brisbane, around 100 guests additionally heard about the MUSIC Modelling Guidelines for SEQ from the Water by Design Team at SEQ Healthy Waterways. These guidelines, launched at the event along with **music** v4, provide direction for use of MUSIC within SEQ, including recommendations on the best modelling practices for SEQ.

Professor Tony Wong (AECOM and Facility for Advancing Water Biofiltration (FAWB)) spoke at both events about MUSIC development, while Professor Ana Deletic (FAWB), Dr Belinda Hatt (FAWB) and Dale Browne (AECOM) in Melbourne, and Associate Professor Tim Fletcher (FAWB) and Tony Weber (BMT WBM) in Brisbane spoke about FAWB's science in MUSIC, and specific applications of the tool.

Speakers and guests at the launch in Brisbane.

There was great interest from these audiences of water industry figures – very rewarding for the teams that have worked so hard in developing these sets of guidelines and **music** v4.

The launches were given practical support (much appreciated) by Clearwater and Stormwater Victoria in Melbourne, and Healthy Waterways Partnership in Brisbane.

www.ewater.com.au/music,
http://www.monash.edu.au/fawb/products/
http://www.waterbydesign.com.au/content/guidelines;
Luke.McPhail@ewatercrc.com.au

For more information

Groundwater Short Courses name change

Looking for the short courses in groundwater?

Note the courses are still running, now as part of the new National Centre for Groundwater Research and Training (NCGRT). And so they are now called 'NCGRT Groundwater Industry Training'.

www.groundwater.com.au/industrytraining

For more information

National Groundwater Forum

Around 60 active projects on aspects of groundwater were reported on recently at the National Water Commission's national groundwater forum.

Development of eWater's software called 'Groundwater-surface water interaction tool' (GSWIT) was among the work reported to over 100 groundwater-focused participants at the forum. Project leader Ian Jolly (CSIRO and eWater) presented a summary of progress so far, explaining that the methods and science for the GSWIT are close to being incorporated into the major integrated software tools 'WaterCAST' and 'River Manager'.

The forum participants recognised the need for the community and management to have better understanding of groundwater and its connection with surface water, and also the continuing need for data and information on groundwater resources.

Ian.Jolly@csiro.au

For more information

H_2Oz website 'one stop shop' for jobs in water-related fields

Visit the new H_2Oz *careers in water* website, www.h2oz.org.au, to find current job listings in the water industry, all over Australia and overseas, and in many different fields.

The site, managed by the Australian Water Association (AWA), is actively supported by over 30 subscribing organisations in the Australian water industry, which regularly list their new vacant positions there.

The website is the public face of an AWA project to generate awareness and provide information on the unique aspects of the Australian water industry. It offers tailored job alerts; perspectives on and a summary of the water industry; information on job categories, qualifications and resources to help newcomers start their career in water; and a place to lodge a general application to attract headhunters.

www.h2oz.org.au

For more information

The school was proud of its class 6H.

Nowra school wins national water-management game competition

The Illaroo Road Public School in North Nowra, NSW, was the winner of $1000 in eWater CRC's national Catchment Detox Competition.

Catchment Detox is an online game, developed by a joint team from eWater CRC, CSIRO, the ABC, and Moon Communications. The game puts users in charge of a water catchment area to decide what activities are undertaken – whether to plant crops, log forests, build factories or set up national parks. The aim is to fix environmental problems as well as provide food for the population.

The competition, advertised on eWater's website during winter and spring 2009, involved schools playing the game in class and submitting a five-minute video about what they had learnt.

Presenting the award, Aapo Skorulis, Business Operations Executive Manager at eWater CRC, said: "We were very impressed. The children of Class 6H produced a compelling video, based on their understanding of what makes a healthy river."

Illaroo Road Public School received a framed certificate announcing their success, as well as the cheque. Individual personalised certificates were also presented to each student in the winning class-team.

LeAnn Hanson, teacher of the winning 6H Class at the school, said "Catchment Detox has provided a launch pad for an enormous amount of learning. The game has provided the motivation to get my students out of the classroom for some real hands-on experience and to become better informed about the catchment in their own backyard."

The game is available online at the ABC Science website: www.catchmentdetox.net.au

Jessica.Mack@ewatercrc.com.au

For more information

Representatives of partners that signed the MOU at the launch.

New Australian Knowledge Hub to build water expertise in the Asia-Pacific

The first and only Australian-hosted Knowledge Hub for Healthy Rivers and Aquatic Ecosystems has been launched in Brisbane.

The overall aim of the Knowledge Hub is for water to be used more wisely and more efficiently, for both human and environmental purposes, everywhere in the world.

Seventeen Australian organisations, including the International Water Centre, eWater CRC and representatives of the government, education, research and private sectors, have signed up to help develop long term collaborative projects and information sharing.

The hub enables the organisations to share their strengths, and be more effective in building up a critical mass of capacity to solve contemporary water management challenges and help create healthy rivers and aquatic ecosystems.

The new hub joins a family of 17 other water-knowledge hubs in the Asia-Pacific region. Each one is a group of internationally recognised institutions committed to building dialogue and capacity across the water sector. Knowledge Hubs is an initiative of the Asia-Pacific Water Forum (APWF).

www.apwf-knowledgehubs.net

For more information

Big river challenges!

A new scientific software tool, River Manager, is under construction to support Australia's river management teams faced with the management of complex regulated river systems.

eWater is building a new multi-faceted river systems model called 'River Manager'.

The River Manager tool, with its related software, lets managers and planners describe and model the behaviour of complex working river systems, over periods ranging from days to centuries.

This tool is being designed particularly so it can handle the challenges posed by large regulated river systems such as the Murray-Darling and its tributaries. Such systems might water several different jurisdictions, catering for a range of competing uses: for instance, livestock industries and irrigated agriculture as well as mining, rural communities and natural ecosystems.

A single modelling tool such as River Manager that can be used across an entire river basin will aid management because everyone involved will have access to the same information and the same frameworks for testing scenarios. The tool will help with long-term planning of how to use available resources, balance competing demands, and develop complex policy to support integrated water resource management. And River Manager will facilitate cooperation between regions, water management organisations, and across state borders and territories.

Overall, use of River Manager should generate significant benefits for users and managers alike, in terms of the day-to-day operating and regulating of water.

Why a new river model

Software modelling that creates a virtual river system to help in management is not new. For river management in the Murray-Darling Basin there are already models in use, such as IQQM, REALM, MSM-BigMod, WathNet, Mike Basin. Why build another one?

This is a good question, easily answered. First, River Manager is based on new software technology that is much easier to support into the future.

Second, River Manager and its companion river systems tools are being designed so that when linked they are able to simulate the rivers and water activities of *whole basins* of the scale of the Murray-Darling Basin. That is something of a challenge with existing models.

River Manager will holistically cover the whole length of a river system, from source to mouth. At present, for example, river waters in Victoria typically are managed by the Victorian Government using REALM; but when the water enters the Murray the management changes over to the Murray-Darling Basin Authority, which uses the model MSM-BigMod. It's a bit like the old situation on Australia's railways, with management and physical widths (gauge) changing at the state borders. But with River Manager as the software for all agencies, staff will be able to use the same modelling platform, and apply the same skills, whether they work in the Riverland of South Australia or the Darling Downs of Queensland.

Third, River Manager will be up to date. It is designed to accommodate the challenges around water sharing, water trading, complex management rules and policy, and the impact of climate change. It incorporates the latest and best available science from professional hydrologists in the jurisdictions involved in the project, as well as from organisations such as CSIRO. And it will include realistic simulations of groundwater interactions – unlike some models that treat groundwater as a black box.

River Manager will be able to consider the entire water balance so that rivers can be simulated as they really are – that is, a central part of the larger environment, for which they shape and sustain a broad range of systems.

Fourth, River Manager is highly flexible, able to adapt to different catchments across Australia, and extendable, able to link other models and data and integrate them with its main surface-water planning and management capabilities. Users will be able to 'plug in' related software that expands the tool's functionality – for modelling ecological response for example. It will be able to use 'external' data, such as from Hydstra and Oracle databases, or use water data transfer standards as developed by the Bureau of Meteorology.

Swings and roundabouts?

No-one likes to exchange an old trusted tool for a new-fangled multi-tool that does not do everything that the old one did. This is why River Manager is being built so that it can replicate the functionality of the most common existing models in use in south-eastern Australia: MSM-BigMod, IQQM and REALM.

As part of the rigorous ongoing quality control on River Manager, early versions of the software have been tested against these industry standard models, and proved to generate comparable outputs for the same tasks.

A prototype was released to eWater partners in July 2009 as promised, after the tool had undergone extensive examination to ensure it met the functionality and quality-control standards demanded by the project partners.

All-round capability

River Manager and its related software tools are based on eWater's common, flexible software framework ('E2'). This means they are intimately compatible

with eWater models for ecological response and demand, rainfall-runoff, water quality and urban systems. Therefore, planners and managers will be able to see the 'bigger picture', including catchments, riverine ecosystems and rural communities as well as the river and its direct users.

River modellers, planners and managers will be able to optimise decision-making around management action and policy. By integrating a range of functions, they will be able to simulate and examine the impact of proposed policy changes, and other factors, on a river system, to decide on the best river management rules for achieving objectives.

The River Manager tool provides information on river behaviour over a long time period (up to centuries). In particular, this can be used to understand the impacts of water resource policy on system storages, flows and water shares in the long term.

For the short term, day-to-day operations of river systems, eWater is building a related software tool known as River Operator. It relies on the same underlying structure as River Manager, so that users will be able to move from the 'planning' mode to the 'operations' mode at the flick of a switch.

Using River Manager

A basic outline of the steps in running River Manager is illustrated below.

To illustrate River Manager's capability, take the hypothetical situation of a relatively undeveloped (but well gauged) catchment with a natural flow regime where two significant developments are proposed:

- an irrigation area and damming of the main river for hydropower generation,
- partial blockage of water entering a large wetland in the lower reaches, to make more water available for irrigation.

Both hypothetical proposals are expected to change flows in the river, particularly to the wetlands in the lower reaches of the river.

Using River Manager, users would be able to determine:

- how often the wetlands receive water and become inundated, by comparing inflows with the storage capacity of the wetland,
- how often the dam meets the required demands of the proposed hydropower station, by comparing the storage capacity of the dam and inflows with the demands of the hydropower station,
- how often the agricultural land receives its water needs from the wetland diversion, by using existing wetland inflows to determine the likely volume of water that the diversion would deliver, and comparing this to irrigation demands.

In other words, River Manager gives managers and planners a scientifically defensible and repeatable tool for exploring the viability of such developments and assessing their long term impacts on a river system.

Real world

A model for river management must be able to effectively simulate the real world. River Manager has just been sent out on trial in selected catchments: the River Murray, Macintyre Brook (Queensland), Namoi River (NSW), and Goulburn-Broken, Loddon and Campaspe (Victoria).

This 'road-testing' program is designed to adapt and refine River Manager to deal with actual situations ranging from the highly complex management rules and multiple jurisdictions in the River Murray, to the extensive groundwater use of the Namoi catchment.

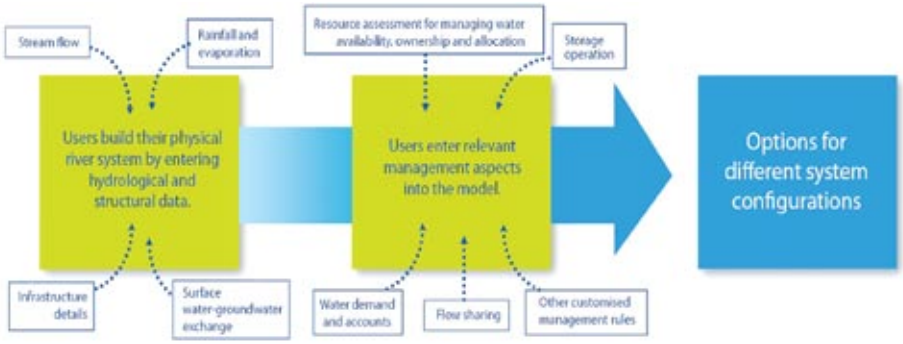
In these trials, partner organisations such as water authorities and state agencies will apply River Manager to their own catchments and provide feedback on its performance and usability. Then the model developers can iron-out any issues before the tool's planning-model release in 2011.

Broad interest

Building River Manager is a national project that draws in the skills, experience and input of researchers (at CSIRO, Bureau of Meteorology and universities), and staff of water industry organisations – water authorities, state government agencies managing natural resources, consultants – and government agencies who deal day-to-day with the challenges presented by water resources.

In one of the largest collaborations of its kind, the National Water Commission and the federal Department of the Environment, Water, Heritage and the Arts have joined the CRC's partners in funding this R&D for river systems tools. These national bodies recognised the need to develop a new and integrated modelling framework that could be used across Australia for the next 10–15 years, and to engage all states and territories in a more consistent approach to water management.

River Manager is being relied upon to meet complex needs. And there is already overseas interest in its capacity to tackle the broader challenges around river management in major basins worldwide.



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http://www.ewatercrc.com.au/technologies/riversystems/index.html

For more information

Creature.feature

ESTUARINE CROCODILE *CROCODYLUS POROSUS*

A saltwater crocodile beside the South Alligator River at Yellow Waters in Northern Territory. Photo: Richard Norris.

Estuarine crocodile

The saltwater or estuarine crocodile *Crocodylus porosus* lives in estuaries, freshwater rivers and billabongs across northern Australia, up to 300 km inland. Males grow to up to 5 m or more in length and weigh 200–300 kg, while females grow to about 3 m.

The freshwater crocodile *C. johnstoni* is smaller.

Crocodiles are survivors from the age of dinosaurs. But they are neither slow nor retarded, with an advanced brain and the agility to swiftly pounce on prey when it unwittingly comes within range. Their closest relatives today are the birds.

Hunting by stealth and ambush, saltwater crocodiles grasp their prey with sharp teeth that are continually replaced. They eat small and large animals – including fish, snakes, rats, bats, wallabies, buffalo, pigs, turtles – and the occasional human.

Crocodiles do not chew their food. However, they do swallow stones, a larger version of the grit their bird relatives use, which help their digestion. The stones also work as ballast, allowing the animal to achieve neutral buoyancy.

Female saltwater crocodiles lay about 50 eggs on the river bank in a mound of decomposing vegetation, which keeps the eggs warm. Most eggs are eaten by goannas, fish, birds and larger crocodiles. As with some turtles and some other reptiles, the sex of the hatchlings is determined by the temperature of incubation.

The biggest threat to saltwater crocodiles is habitat destruction.

Saltwater crocodiles in the Fitzroy River at Rockhampton mostly live in the town's freshwater supply above the barrage, but a few, including this one, live below it in the saline estuary. Photo: Robert Packett.

Mark Kennard and colleagues measuring ecological effects of flow in the Daly River, Northen Territory. Photo: Q Allsop.

Faster prescriptions for environmental water

How much water does a river's ecosystem need, when, and how often? These three questions underlie the environmental water allocations prescribed for rivers, and they are not easy to answer, usually needing long study.

Professor Angela Arthington, of the Australian Rivers Institute at Griffith University, and eWater CRC, believes that science can now provide much faster workable solutions to prescribing environmental water allocations.

Professor Arthington is the lead guest editor of a special issue (January 2010) of the international journal *Freshwater Biology* which addresses the core questions above. The issue provides novel insights into the science and management of environmental flows, including papers describing advances via a new framework called ELOHA, and via three methods using Bayesian statistics.

ELOHA – one river on the basis of many

The aim of ELOHA is to enable water resource managers to set scientifically based, socially acceptable, and testable standards for environmental flows.

"We have been working to construct flow–ecology models for different types of rivers," says Arthington, "because we want to derive *generic* management rules for *each river type*. Our aim is to produce a universal profile of necessary environmental flows," she says.

'We' is a group led by LeRoy Poff of Colorado State University, and including Angela Arthington, Stuart Bunn, and 15 other prominent scientists from around the world. They have come to a consensus view, ELOHA ('ecological limits of hydrologic alteration'), which is a synthesis of a number of existing hydrologic techniques and environmental flow methods.

ELOHA essentially depends on recognising that a river's flow regime is the master variable controlling the structure and function of riparian ecosystems.

"One must first build a 'hydrologic foundation' – hydrographs of stream and river segments throughout the region – which serve as baseline. The hydrographs need to cover a period before development as well as after, and need to be long enough to cover climate variability," says Arthington.

Next, you need to classify the river segments into a few distinct types, each with associated ecological characteristics. There are several ways of doing the classification: one powerful method involves Bayesian statistics (see next page).

The third step is to calculate, for each reach, how much the present developed-condition flow deviates (on a percentage basis) from the baseline-condition flow. For this you need a small set of flow statistics which are known to be linked strongly to ecological conditions.

The fourth and final step involves forming an input–output picture of the ecological responses that can be seen when flow volume increases or decreases, or the length of dry periods becomes attenuated, or floods are less frequent. Ecological data – for example, aquatic species richness, riparian vegetation abundance, or larval fish biomass – will be sensitive to flow alterations, and so they stand as good proxies for the 'limits of hydrological alteration'.

Each river type needs to have its own set of validated (if possible) ecological responses to flow. These will be based on flow statistics and a library of ecological variables built up from existing hydroecological literature, expert knowledge and field studies.

The key point is that the flow–ecology relationships that emerge are not, in general, exclusive to single rivers, but can be expected to apply to rivers of a particular hydrological type: arid zone rivers, or snow-melt rivers, for example. Rivers that have similar hydrological characteristics or flow regimes should also have assemblages with similar composition, species traits, community functioning and ecological requirements.

These groups of related rivers can also be expected to respond to changes in flow regime in more or less the same way. This means that environmental flow rules or guidelines can be constructed that hold true for all rivers of a certain class, avoiding the need to develop such relationships anew for each river.

ELOHA offers a powerful framework not only for prescribing environmental flows to protect an unmodified river. It can also help to decide on flows needed to restore ecological and societal benefits in a regulated river.

Environmental watering, autumn 2009, Lindsay Island Icon Site, River Murray. Photo: Mallee CMA, by Bob Merlin.

Rivers by numbers

Classifying a river into a distinct type is the key process that makes the ELOHA framework so useful. Among several different classification methods, one promising technique draws upon Bayesian statistics.

Using the Bayesian technique called 'mixture modelling', Dr Mark Kennard and his colleagues at the Australian Rivers Institute have classified all Australian rivers into 12 distinct classes, as explained in this special journal issue. This river classification is based on just a handful of basic characteristics such as seasonal flow pattern, permanency of flow, and variations in flood magnitude and frequency.

"We have identified 120 metrics describing ecologically relevant characteristics of the natural hydrological flow regime," says Kennard. "We derived the metrics by using our fuzzy classification scheme on data collected over 15–30 years from 830 stream gauges across Australia. From this work, we have established 'decision trees' based on natural flow regime classes," he says.

These classes, which reflect the key climatic and topographic factors at work in a catchment, can be generalised to other catchments where flow data are lacking. In this way, the team has arrived at a classification scheme covering the whole continent. This national classification scheme is already supporting environmental flow assessments for preserving and restoring Australian rivers threatened by factors such as development, drought, and climate change.

Ecological responses to flow, with Bayes

In ecology, numerous factors are intimately intertwined. Human impacts on rivers, such as those from dams and land use, seldom occur in isolation from each other. How then to pick out the causes and effects, and decide how to fix river degradation?

In their paper in this special issue of *Freshwater Biology*, Ben Stewart-Koster, an eWater PhD student also at the Australian Rivers Institute, and his supervisor Professor Stuart Bunn and colleagues, explain how they have modelled relationships between flow (and other environmental drivers of stream ecosystem health) and ecological response, using a Bayesian network technique.

"The model indicates that environmental flow provisions may not always necessarily be the most effective restoration solution. In some situations they may make virtually no difference ecologically, compared to, say, pollution abatement, riparian management, and habitat restoration," says Stewart-Koster.

Bayesian networks and their associated decision networks consider the costs of available river restoration options and balance them against their expected benefits, giving the manager a numerical answer to solve an ecological problem. It doesn't eliminate the subjective element, but in all cases it is able to focus on the key cause-and-effect relationships at work.

Wimmera River, Victoria, before and during an environmental flow in spring 2007.
Photos: Wimmera CMA, by Greg Fletcher (before) and Mark Toomey.

Salient evidence

Environmental flows do have ecological effects. Scientists and community observers have documented numerous cases where changing river flow has generated ecosystem changes. One example is shown in this issue by Dr Angus Webb of the University of Melbourne and eWater, and his collaborators. They have used Bayesian hierarchical modelling to quantify the ecological effects of river flow changes, either natural or artificial.

With this new method, the authors have been able to examine whether delivered environmental flows have actually resulted in the anticipated ecological benefits.

They took monitoring data from the Wimmera and Glenelg rivers in Victoria, and showed that salinity can be managed through increased summer base flows. This parameter could be predicted from discharge figures alone.

The authors' method will shortly be implemented in assessing the results of the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP), which is measuring ecosystem responses to environmental flow enhancements in eight key regulated rivers in that state.

A way forward?

Environmental flows are neither a luxury nor a competitor to human needs for water. A healthy, flowing river repays us many times over in ways both tangible and intangible. The ELOHA framework, and the Bayesian methods that can be applied within it, provide clear ways of demonstrating this logic.

Angela Arthington monitoring effects of high flows in outback Queensland.

Nevertheless, even though ELOHA is a major advance in calculating environmental flows, we should not latch onto it as a panacea. Arthington acknowledges that in certain situations a careful river-specific approach will still be needed, fully considering the factors that influence that river's health.

But, applied to most of our rivers, ELOHA will make environmental flow assessment so much quicker and easier.

Further reading

Arthington A.H. *et al.* (2010) Preserving the biodiversity and ecological services of rivers: new challenges and research opportunities. *Freshwater Biology* 55(1), 1-16. http://www3.interscience.wiley.com/journal/117962093/home **Special issue**.

Poff N.L. *et al.* (2010) The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards. *Freshwater Biology* (special issue) 55(1), 147-170.

Kennard M.J. *et al.* (2010) Classification of natural flow regimes in Australia to support environmental flow management. *Freshwater Biology* (special issue) 55(1), 171-193.

Stewart-Koster B. *et al.* (2010) The use of Bayesian networks to guide investments in flow and catchment restoration for impaired river ecosystems. *Freshwater Biology* (special issue) 55(1), 243-260.

Webb J.A. *et al.* (2010) Detecting ecological responses to flow variation using Bayesian hierarchical models. *Freshwater Biology* (special issue) 55(1), 108-126.

Arthington A.H. *et al.* (2006) The challenge of providing environmental flow rules to sustain river ecosystems. *Ecological Applications*, 16, 1311–1318.

ELOHA toolbox (http://conserveonline.org/workspaces/eloha)

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For more information

Free passage for fish

The causeway below after work to make it more fish friendly. Photo: Industry & Investment NSW.

In New South Wales, alone, more than 4000 weirs and dams have been installed across inland and coastal rivers. These cause problems for native fish because they interfere with fish movements, both upstream and downstream.

Australian native fish are not as athletic as salmon or trout when it comes to negotiating stream obstructions and a step-up in water level of just 10 to 30 cm will usually stop their progress.

Fish move around for many reasons, including spawning migrations, to search for food and shelter, or to move into habitats suited to stages of their life cycles.

And it is not just a few freshwater fish species that travel. For example, of the 55 species of native freshwater fish living in NSW, 32 have been shown to be migratory, requiring free passage to sustain their populations, say Garry Thorncraft and John Harris in a report on fishways in rivers.

At a larger scale, the flow of genetic material within fish populations, through the movement of individuals, maintains the fitness of the species and its adaptability, say the biologists.

"The principle is that all fish need to be able to move freely between habitat areas within their environments," they say.

Even partial barriers that allow fish passage to occur when flows are adequate can still have a serious impact on fish. The conditions that allow fish to pass may not correspond to the natural timing of fish migration each year, or suitable conditions may not prevail long enough to permit movement of enough of the population between its various habitats.

The former NSW Fisheries department (now Industry & Investment NSW) has produced a toolkit page on its website www.dpi.nsw.gov.au/fisheries/habitat/protecting-habitats/toolkit for information about works within waterways that are key fish habitat. Those works that may require a permit include (some omitted here): causeways and bridges, temporary or permanent road crossings, retaining walls, groynes, weirs and dams.

To block or not to block

Key fish habitat, according to the NSW government department, includes:

- rivers and creeks (3rd order and above, Strahler method) whether permanently or intermittently flowing, to top bank;
- freshwater lakes and impoundments to top water level;
- billabongs, lagoons, wetlands whether permanent or ephemeral, to top water level;
- any type of habitat (natural, modified or artificial) that is known to support threatened species.

Anyone wishing to do anything to an Australian waterway that could create a barrier effect or impact on fish habitat would be well advised to check with the local state or territory fisheries office. 'Anything' could include a pile of rocks and logs.

Putting unapproved obstructions in streams is a clear breach of the *NSW Fisheries Management Act 1994*, and similar legislation or policy in other states, including Victoria's *Flora and Fauna Guarantee Act 1998* and the *Queensland Fisheries Act 1994*.

Section 219 of the NSW Act, for example, states that a person must not:

- construct or alter a dam, floodgate, causeway or weir or
- create an obstruction across or within a bay, inlet, river, creek, or flat so that:
    - fish will or could be blocked and left stranded
    - immature fish will or could be destroyed or
    - the free passage of fish will or could be obstructed.

A further thing to consider is that the definition of fish, at least in the NSW Act, is broad. It includes, not just fish as we know them, but (among others) aquatic molluscs, aquatic insects and crustaceans, such as mussels and freshwater crayfish.

Landholders building unauthorised barriers in NSW streams have found they incur significant fines and perhaps also the cost of removing or redesigning the barrier.

This causeway in northern NSW may seem to provide fish passage, but the water often flows too fast through the pipes for native fish to swim through. Photo: Industry & Investment NSW.

Are fishways the answer?

One potential way to overcome fish barriers is to provide fishways or 'fish ladders' – that is, engineered structures that allow fish to pass. The common fishway types include pool fishways, locks, Denils, trap-and-transport, rock-ramp, bypass and eelways.

Rock-ramp fishways mimic the riffles that often occur naturally in streams, between pools, and are less expensive than other designs. A series of small pools and falls are formed by careful placement of rockwork below the weir, on a gentle slope and according to engineered hydraulic designs. It is conceivable that landholders could include rock-ramp fishways in the design of approved weirs or other low barriers on their properties, provided they have suitable expert advice and the appropriate approvals (see case study p.18).

However, there are also some pitfalls associated with fishways. Virtually all 44 of the pioneering fishways installed by authorities in south-eastern Australia, between 1925 and 1985, failed to perform effectively. In most, design failures made them user-unfriendly to native migratory fish (see box at right).

Expert help, based on more recent (post-1985) research, is important for anyone contemplating fishway design and maintenance.

In a rock-ramp fishway, incorrect placement of rock, even on a small scale, can result in a fishway that doesn't work well. Designs should be discussed in detail with the state/territory fisheries department.

"Rock ramps are certainly one way to achieve a weir effect in streams, while maintaining fish passage," says Dr Harris, "but they are far from simple to design properly, not least because of typically extreme variation in stream flows in Australia. They require expert guidance and formal approval."

"I would not recommend that farmers attempt fishway construction without good advice and a permit in hand," he says.

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Weirs obstruct spawning migrations and other fish movements, and landholders who construct them without approval could face large fines. Photo: Industry & Investment NSW.

The Torrumbarry vertical-slot fishway near Echuca.

Australian fishways: tough start, good progress

In 1985, Dr Martin Mallen-Cooper at the Fisheries Research Institute in NSW was given a brief to find out how to make the state's fishways constructed since 1913 much more effective. Populations of native fish were declining dramatically and something had to be done about it.

The researchers found that the pool-type fishways in use, consisting of a 'staircase' of pools, designed for large northern-hemisphere adult salmonoid fish, mostly had gradients steeper than 1:8 with a step height of at least 30 cm. Water flowed through these at a velocity of about 2.4 m/second and the turbulence was high.

Dr Mallen-Cooper and his colleagues found that our native fish can only swim against water at much lower velocities, even though they can cover large distances during spring and summer. For instance, Golden Perch and Silver Perch travel more than 1000 km or 500 km respectively, but adults of these species could only cope with water flowing at 1.8 m/second or less through fishway slots. Juvenile fish had still lower limits.

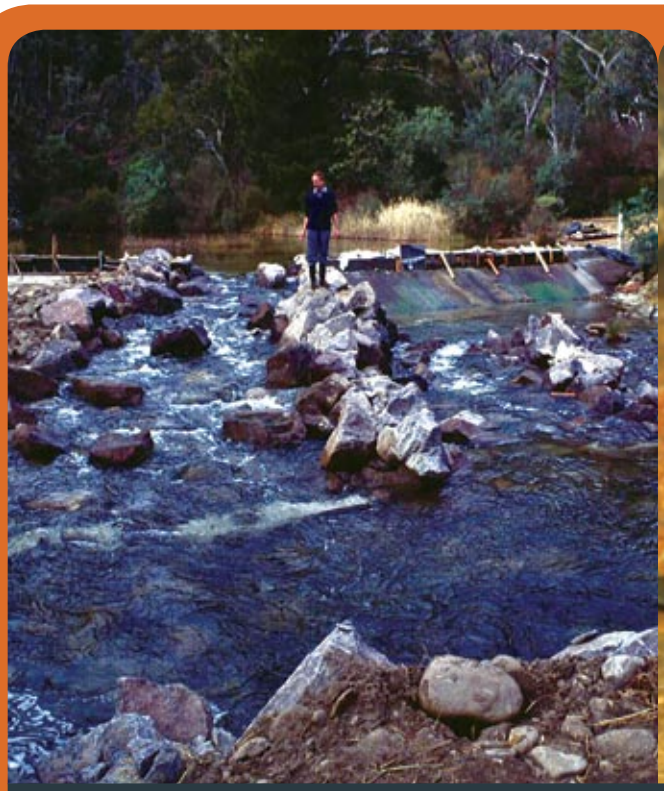
Armed with this and other research findings, authorities in NSW and elsewhere have been able to greatly improve fishway designs, and the results have been outstanding. For example, in the Murray-Darling Basin, the program to improve fish passage over some 2000 km of the River Murray 'from the sea to the Hume Dam' intends to restore fish passage for the migratory fish community.

Ten new fishways (as at 2007) are allowing passage of many fish – more than 50,000 over 40 days in one study – including 13 different species and fish ranging in length from 31 mm to 1040 mm. The report of the program estimates that, as the Murray fishways near completion, about a million fish migrating in the river each year will use at least one of the new fishways – a great result and a fine example of restoration at a catchment scale.

More information:

MDBC (2008) *The Sea to the Hume Dam: Restoring Fish Passage in the Murray River*. Murray-Darling Basin Commission, Canberra. http://www2.mdbc.gov.au/__data/page/672/The_Sea_to_Hume_Report.pdf

Mallen-Cooper M. (1994) How high can a fish jump? *New Scientist*:1921. See http://www.newscientist.com



A rock-ramp fishway, for Macquarie Perch, under construction at Vanity's Crossing on the Cotter River, ACT. Perch can now spawn upstream of the crossing. Photo: Mark Lintermans.

Macquarie Perch require a fishway that has a gentle slope as they are not particularly strong swimmers and, like other native fish species, do not like to jump. Photo: Mark Lintermans.

A rock-ramp case study

When Vanity's Crossing, a road crossing on the Cotter River west of Canberra, ACT, was upgraded by concreting in the late 1970s, the new structure had no pipes or culverts for water flow, so it effectively formed a weir.

Its one-metre drop meant that the Macquarie Perch of the Cotter could no longer move upstream to spawn. The then ACT Department of Parks, Conservation and Lands decided to construct a rock-ramp fishway at the crossing, specifically to allow passage of Macquarie Perch, an endangered species. They wanted to enable repopulation of the upstream stretches of the river.

"Macquarie Perch are thought to be less powerful swimmers than their close relatives Australian Bass and Golden Perch," says Associate Professor Mark Lintermans of the Institute for Applied Ecology, University of Canberra (then with the Department). "So specifications for the fishway we designed included a maximum slope of 1-on-30, as well as a V-shaped cross-section to concentrate low flows, a minimum depth of 35 cm to accommodate adult fish, and several other features, also based on their biology."

"The fishway was constructed in 2001, and for several years there was little evidence that Macquarie Perch were using it," says Lintermans. "However, more recently, adult and sub-adult fish were observed in the river above the fishway, where previously none occurred, and others have been captured by electrofishing and angling."

Mr Ben Broadhurst, also of the Institute, has been investigating the efficacy of the rock-ramp.

"Until 2001, the Macquarie Perch's spawning grounds were restricted to just 6 km of the river from the Cotter Reservoir to Vanity's Crossing," he says. "However, snorkelling surveys during 2006 and 2007 revealed that juvenile perch were present both downstream of the rock-ramp and in 13 of the 14 pools surveyed upstream of the ramp. It confirmed that adult fish were using the fishway to access upstream spawning grounds. This potentially increases the length of river available for spawning to 27 km.

"Summer netting surveys, in 2007 and 2008, showed not only that adults were using the upstream stretch to spawn, but that a population of resident fish was starting to establish."

"This is a timely result for this endangered species," says Ben Broadhurst, "given that expansion of the Cotter Reservoir, due to commence in late 2009, will flood most of the spawning grounds that were available to the perch, below the fishway."

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For more information

Victoria: A perspective from North East Victoria

By John Riddiford

STATEVIEW: Victoria

The North East region of Victoria supplies 38% of the total surface water supply for the Murray Darling Basin, whilst only occupying 2% of the Basin area.

Average inflows (pre 2000) for the total Murray system, including the Darling were about 15,000 GL per annum. In recent years this has fallen by as much as 90%, or down to 1,500 GL. Under climate change, average inflows for the Murray will decline over the longer term. This makes managing the water resource for different uses very challenging.

Government policy is striving to achieve a balance in water use for stock and domestic, urban, irrigation and environmental demands.

In the Northern Sustainable Water Strategy discussion paper, under a more severe climate change scenario, modelling shows available water for consumptive use in the Murray system will decline by 15%, and available water for the environment would decline by 51%. Current inflows are tracking below this modelled trend, and the Northern Sustainable Water Strategy released in December 2009, outlines a number of policy areas to strike an appropriate balance in resource sharing. This will also subsequently feed into the development of the Basin Plan for the Murray Darling system.

The Ovens River, a heritage river, has the most important environmental values in the North East and is listed as one of two Victorian rivers requiring special management. It also acts as a significant tributary to trigger flood response in the Murray River.

Management rules have been established to release environmental water from Lake Hume to add value to natural flood flows in the Ovens, for downstream environmental assets such as Barmah Forest. The North East CMA, in conjunction with other water authorities and the Department of Sustainability and Environment, is working on dry inflow contingency planning processes for the Ovens River.

From an environmental flows perspective, the first priority was to reset the flow trigger rules on the operation of the two Ovens storages – Lake Buffalo and Lake William Hovell – to ensure equitable sharing of the resource under unprecedented low flow conditions. These new rules formed the basis of a memorandum of understanding between the water authorities, and were approved by the State Minister of Water. This will also allow for continuity of flow in the Ovens under very low flow conditions. In early 2007 the Ovens stopped flowing and the authorities are endeavouring to not repeat this situation under similar inflow conditions.

Lower Owens River March 2001.

Lower Owens River March 2007.

The second priority is to look at the impact of groundwater extraction on river flows. It is believed that surface flows and groundwater in the Ovens (upstream of Wangaratta) are highly connected. A major study is currently being undertaken to test this relationship in a more quantifiable manner. Under current rules there is no requirement for a licence to take and use water for stock and domestic purposes from groundwater. Policy processes for changes in groundwater management are being investigated.

The third priority is to ensure environmental flows are secured with future augmentation of town water supply. Currently the CMA is working with North East Water in designing an off river storage for the township of Bright which would reduce the impact of direct pumping of the river in ultra low flow conditions in summer, which currently occurs, and enable pumping of water in winter. This would ensure continuity of flow in critical periods.

The impact of fires has yet to be fully realised. In the region there were megafires in 2003 and 2007, and there were smaller but more catastrophic fires in the Beechworth area as part of 'Black Saturday' in February 2009. Research bodies, including the University of Melbourne, are looking at the impact of these fires on water yield over the longer term.

In wetter type forests, such as of Alpine Ash, which have been severely burnt, a short-term water yield increase can be expected over 3 to 6 years followed by a reduction in water yield over the longer term (100 or so years). Whilst studies in the Melbourne water supply catchments have confirmed this trend, the current studies in the north east should provide more accurate yield predictions, and potential impact on the Murray system. In addition, to add to the complexity, some wet forests have been 'double burnt' which could lead to the regrowth of other vegetation types and have an, as yet, unknown impact on future water yield.

It is safe to say, that climate change, drying conditions, scarce water and large fires present some interesting challenges!

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For more information

South Australia: A personal view from one South Australian

By Peter Hoey

In March 2008, the Commonwealth *Water Act 2007* was amended and passed by the Australian Government. This Act was supported by the states' referral legislation. Among other things, the Act created the Murray-Darling Basin Authority (MDBA), which took over the responsibilities of the Murray-Darling Basin Commission, which was abolished.

I regard the passage of this legislation as the most significant management change in the Murray-Darling Basin since the signing of the *River Murray Waters Agreement* in 1914. I also believe that this change itself will be eclipsed within 5 years by an even greater intergovernmental decision: the transfer of full powers to the Commonwealth Government to manage the water resources of the Basin, including the operational management of all of its rivers and streams. Let me explain.

Commencing in 2004 the Commonwealth Government shifted from its position as a passive onlooker within the Murray-Darling Basin Initiative to take a clear policy leadership role in Basin management. The drivers for this change were the current protracted drought, on top of an emerging demand for a better deal for the environment. The National Water Initiative of June 2004 is now firmly linked to the intergovernmental agreement of July 2008 on Murray-Darling Basin Reform, which in turn is underpinned by the Commonwealth's ten year $12.9 billion Water for the Future program. The Basin Plan, to be delivered in 2011, is a key element of the Commonwealth's intervention. The Plan will influence all of the major programs of the Murray-Darling Basin Initiative, including the volume of water available for diversionary uses, environmental watering, salinity management and water trading.

Being both the economically weaker state jurisdiction, and the downstream state where many of the impacts of Basin management are felt first, South Australia has, since 2002, encouraged and embraced a more active Commonwealth involvement in the Murray-Darling Basin Initiative.

Once the MDBA's Basin Plan is unveiled in 2011, and its limitations (imposed by the states) are realised, the call for full Commonwealth control will accelerate. Perhaps even sooner than that, an intervention by the High Court on the interpretation of section 100 of the Australian Constitution could be the trigger for an expansion of Commonwealth powers.

On top of these major changes in governance, the communities of the southern Murray-Darling Basin face a significant reduction in water available for irrigation, perhaps up to a 50% reduction. This paradigm shift in the allocation of water entitlements from consumptive to non-consumptive uses will emerge strongly over the next 10 years due to a combination of climate change, buy-backs and transfers to secure supplies for the urban sector. Only the Commonwealth Government will be in a position to manage this inevitable transition.

Challenges for the MDBA

A range of problems for water management in the Basin have been documented[1,2], and some results are 'on show' in the last third of the River Murray:

- Excessive regulation of the rivers and streams of the Basin;
- Rapid expansion over 30 years of water storage in the Murray-Darling Basin, in the 1950s, accompanied in the last decade of that time by over-allocation by state governments of water entitlements;
- Exchanges between the river and its floodplain are now limited;
- Artificially raised water levels have led to a general shift in wetland type from temporary to permanent;
- Reducing floodplain inundation frequency lowers the reserve of invertebrates that can contribute to the floodplain foodweb after inundation;
- Stabilisation of the water level through flow regulation has promoted the growth of filamentous green algae;
- The shift in phytoplanton composition has had repercussions up the food chain, with the riverine freshwater mussel, Murray Crayfish, and the river snail having either declined or become regionally extinct;
- Decline in the populations of many native fish, including Murray Cod, Trout Cod, Golden Perch and River Blackfish has been reported under regulated flow conditions. Populations of five native species in the lower Murray have shrunk, and another two are threatened. Native fish represent only about 5% of the total fish biomass.
- There are fewer opportunities for recruitment in species because of the elimination of small floods;
- Sudden operational changes in water levels below weirs and barrages can strand fish eggs and cause fish to abandon nests.

These problems have been identified and extensively studied over many years. Scientific consensus exists for the solutions to these problems, and all solutions depend on more water for the Lower Murray.

The Lower Murray (the lower one-third of the length of the River Murray below Wentworth in NSW) is dying because of excessive water extraction upstream of the junction of the Murray and Darling rivers. The opinion of leading limnologists in Europe, North America, Southern Africa and Australia is coalescing around a figure of 20–30% as being the maximum amount of flow that can be diverted to consumptive use for a prolonged period without having a major impact on river health[3]. Currently, 60% of the natural flow in the river system has been extracted upstream of Wentworth.

The Murray Darling junction near Wentworth, NSW, September 2001. Photo: Ted Lawton.

The difficulty in comprehensively addressing this problem lies in water sharing arrangements within the *Murray-Darling Basin Agreement 2008*. (This problem is not new, and has its origins in the first agreement between the states and the Commonwealth on water sharing: the *River Murray Waters Agreement 1914*). Victoria, NSW and SA share only the waters of the River Murray system. The major tributaries (including Murrumbidgee and Goulburn), which produce about half of the water resources of the southern Murray-Darling Basin, are excluded from the Agreement and, as a consequence, the Lower Murray is denied a reasonable share of Basin water.

Issues for South Australia

The role of the Commonwealth Government

The first tentative steps towards central management of the Basin have been taken, and after the inevitable teething problems the trend for centralised control is likely to continue. South Australia needs to maintain its leadership among jurisdictions in advocating for greater Commonwealth control of the management and sharing of the water resources of the Basin.

It is likely that present water sharing arrangements will fail to satisfy the expectations of the South Australian (and perhaps the wider Basin) community within the next year or so. Pressure will build for total Commonwealth control.

South Australia should be advocating centralised control so as to achieve a Basin-without-Borders approach to water sharing. Such an approach would assess the availability of the Basin water resources on a multi-year basis, at least updated in April and October of each year. The first allocation of water would be to meet defined end-of-system and within-system volumetric, environmental and water quality targets, which in turn would be related to high level goals and objectives. Then the remaining water would be available to divert for consumptive uses. This would require the extension of the powers of the Murray-Darling Basin Authority (MDBA) at the expense of the states.

South Australia's Strategic Plan (SASP)

Target T3.10 of the SASP seeks an increase in environmental flows by 500 GL in the River Murray by 2009 as a first step towards improving sustainability in the Murray-Darling Basin, with a longer-term target of 1500 GL by 2018. The target of 1500 GL of additional average annual flow in the River Murray will not be enough to achieve sustainability in the Lower Murray.

A revised target of a long-term average flow of 7000 GL per annum at Wentworth by 2018 is a more appropriate signal from South Australia. The message underpinning this revision is simply that the Lower Murray is dying because too much water is being extracted upstream of Wentworth.

Reducing South Australia's dependence on the River Murray

Undoubtedly we need to reduce our reliance on the River Murray in times of river drought, but it is also a fact that Adelaide's take from the River Murray has no measurable impact on river health.

Clearly, the new desalination plant will provide security for Adelaide's drinking water supply in times of drought or water-quality problems, and enable greater operational flexibility. Adelaide will continue to use its current metropolitan water licence from the River Murray to supplement local reservoir supplies to meet base demand. The desalinated water will generally be used as the third major source of supply.

In conclusion

The MDBA has been given the task of preparing a Basin Plan, to be released in 2011. Central to the Basin Plan will be the establishment of long-term average sustainable diversion limits on water use in the Basin. Two other parts of the Plan are the environmental watering plan and the water quality and salinity management plan. These three elements of the Plan are, of course, quite interlinked. The Commonwealth Parliament requires the MDBA to address environmental issues first and foremost in the Basin Plan. The definitions in the *Water Act 2007*, which combine to make up the full description of a long-term average sustainable diversion limit (SDL), are heavily weighted towards environmental outcomes. This is a reversal of past practice.

How the MDBA arrives at a Basin SDL, and SDLs for particular water resources offers an opportunity to address the plight of the Lower Murray. It needs to be influenced by an evidence-based argument on what it sees as a reasonable long-term median flow in the Lower Murray. An argument for a long term average flow of around 7000 GL per annum at Wentworth NSW by 2018 could easily be mounted on the basis of currently available scientific information.

Peter Hoey retired in 2007 from his role as Executive Director in the Dept of Water Land & Biodiversity Conservation.

[1] Jones G. et al. (2002) *Independent Report of the Expert Panel on Environmental Flows and Water Quality Requirements for the River Murray System.* http://www.thelivingmurray.mdbc.gov.au/__data/page/1482/ERPreport1.pdf

[2] Gippel C.J. and Blackham D. (2002) *Review of Environmental Impacts of Flow Regulation and Other Water Resource Developments in the River Murray and Lower Darling River System.* http://thelivingmurray2.mdbc.gov.au/__data/page/1480/Final_Review_reg_impacts_eflow1.pdf

[3] Leece D.R. (2003) *Water Management Issues in New South Wales.* Briefing for Dr John Paterson – 28 January 2003.

Biodiversity
in headwater streams

Postgrad. THINKING

Preserving macroinvertebrate samples to take back to the laboratory.

Headwater streams, which are often narrow enough to step over and have a catchment smaller than 100 hectares, may seem insignificant by comparison with higher order streams. But trickling headwater streams punch well above their weight … or size.

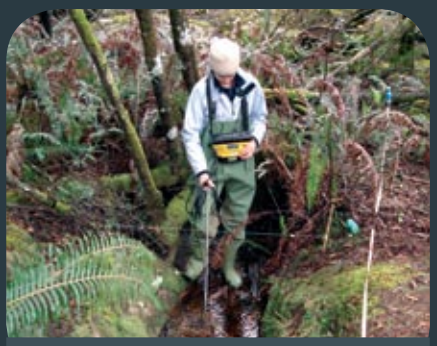
Amber Clarke, a Monash University and eWater PhD student, is investigating the diversity of macroinvertebrates[1] in headwater streams in the predominantly Mountain Ash forests of the *Wallaby Creek Designated Water Supply Catchment Area*, of Victoria, for her thesis.

After reviewing the literature, she says such streams are actually a major component of river networks. Collectively they may constitute more than three-quarters of the total stream channel length in drainage basins.

"Headwater streams are ubiquitous and serve as important sources of water, sediments and biota for downstream reaches," says Amber. "They are also critical sites for organic matter processing and nutrient cycling and probably help to maintain the health of whole river networks.

"My project is focusing on their biodiversity, in particular the patterns and determinants of aquatic macroinvertebrate diversity in three upland catchments."

Amber's research has three main themes and addresses some interesting questions:



Measuring flow in one of her nine study streams.

1. Diversity partitioning: How is macroinvertebrate diversity partitioned into alpha and beta components, both at the reach scale and at the sub-catchment scale? And is diversity partitioning affected by spatial scale?

(Alpha diversity describes the 'species richness' (number of species present) in an ecosystem. Beta diversity is a measure for comparing richness between ecosystems or along environmental gradients).

2. Determinants of diversity: Is the diversity of macroinvertebrate species in headwater streams related to one or more environmental factors? At which scale do these factors predominantly occur?

3. Diversity in temporary streams: What is the effect of flow permanence on macroinvertebrate diversity and community composition in upland streams?

"I am looking at headwater streams as branched networks, and I'm doing that at a landscape-scale rather than from the more usual linear perspective," Amber says. "When we do this, we realise that while alpha-diversity may be low in individual headwater streams, there can be high beta-diversity among headwater streams within and between catchments. This can result in high total diversity."

Aquatic macroinvertebrates have different abilities and opportunities when it comes to spreading out from a site, and that can contribute to high beta-diversity. Diversity can also be a result of the range of physical habitats in headwater streams and a wide range of local environmental conditions.

Amber's investigation into the effect of flow permanence on diversity, conducted

Amber testing water-height loggers in Wallaby Creek.

during the current decade-long drought, gives some idea of the consequences of drying disturbance in headwater streams.

"I recorded changes in the diversity and assemblage composition of macroinvertebrates for three upland streams," she says. "One stream was perennial, one intermittent and the other ephemeral.

Results indicate that during a dry summer period, in the two streams where surface flow dried out, the mean biodiversity and abundance of the macroinvertebrates fell, and the drying period produced different patterns in community composition.

"However, during the wet spring period, the macroinvertebrate communities in the three little streams showed very similar diversity, abundance and composition. So it seems the differences between temporary and permanent streams may arise seasonally and relate to hydrologic permanency."

"Such findings," says Amber, "provide some insight into the changes we can expect in macroinvertebrate stream communities as local and regional climates become drier due to climate change and increased water abstraction."

Amber's PhD supervisors are Professor Sam Lake, Dr Nick Bond and Professor Ralph Mac Nally, of the Australian Centre for Biodiversity, School of Biological Sciences, Monash University.

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For more information

[1] Macroinvertebrates are organisms that are visible to the naked eye and lack a backbone.

Taking the pressure
off reservoirs

Postgrad.THINKING

Andrew Graddon at work.

In most coastal cities, every time it rains the water goes down the drain and heads out to sea. At the same time, the dam levels continue to struggle.

This struck Andrew Graddon as incongruous. He was inspired to investigate what Integrated Urban Water Management (IUWM) had to offer, to make better use of valuable rainwater.

Andrew is now engaged in PhD research on the topic, at the University of Newcastle, supervised by Professor George Kuczera and Dr Mark Thyer (School of Engineering) and Dr Matt Hardy (BMT WBM Pty Ltd, Melbourne), all of eWater CRC.

Andrew explains that IUWM is all about making the most efficient use of locally available water. "But before you can persuade companies and developers of the benefits, you need to provide software tools that explore the options in a holistic manner. Such tools would be used to demonstrate that centralised and decentralised water networks can work together to provide a guaranteed source of supply.

"Look at the Rouse Hill development in Sydney, where Sydney Water has laid on a recycled source of supply. That measure alone is enough to reduce potable supply requirements by 40%.

"And then there is the huge potential of rainwater tanks."

There are other possibilities, too – raingardens, urban wetlands, and all the rest – which quickly complicate the picture and make predictions difficult.

Andrew is a mathematician and computer programmer, so the aim of his PhD is to build a model of the urban water cycle up to the suburb scale. The model tracks how the inputs, storages and outputs of mains, stormwater and wastewater from suburban blocks are related so that overall savings can be readily calculated.

Andrew's innovative approach is to piggy-back two software methods that up to now have focused on separate ends of the urban water spectrum: individual houses and regional water supply networks. The result is a simulation method that can show how individual allotments, when grouped together into a decentralised water-sensitive network, can take the pressure off a central reservoir.

He started with an established software package called UrbanCycle, developed by Hardy, and he increased its power by embedding Network Linear Programming (NLP) to allow for multiple supply paths and feedback loops. NLP is a programming method that seeks the minimum in the cost of conveying a commodity (water in this case) through a network. The NLP used is a modified version of WathNet (written by Kuczera), dubbed UrbanNet.

Most prior models have worked within preconceived narrow and prescriptive frameworks. You take an individual suburban house as starting point and multiply it by the percentage of houses that are water-wise, to calculate the suburb-wide savings.

In contrast, Andrew's idea is to consider each house as part of a decentralised network, which is interconnected – with other houses and the central reservoir – via a range of water-saving and re-use measures. Examples include large (200 kL) tanks shared by a score of rooftops, scattered urban stormwater ponds, treated grey-water tanks, and the like. The modelling environment aims to be very free in the way in which the harvesting, supply and recycling system can be organised.

What is the best way (that is, the minimum cost) of linking together all these harvesting and recycling resources? Andrew is in the midst of finding out, but he has already glimpsed how it might be done. Some preliminary results were recently presented to the 32nd Hydrology and Water Resources Symposium in Newcastle in December 2009.

In all cases, appropriate storage seems to be the key, and he is convinced that a central tank serving a cluster of several to many properties is much more likely to work than relying on the goodwill of a percentage of water-aware householders. Annually, such a system will, according to UrbanNet's calculations, only consume a very small fraction of the mains water volume compared to a conventional arrangement, and could even be essentially self-reliant in regard to water use.

And how much will such a radical overhaul of traditional water supply cost? Andrew believes that, contrary to popular belief, adopting IUWM need not be any more expensive. With adequate forethought, building in IUWM at the start of a new urban development or during urban re-development could quite possibly produce a cheaper option.

"Making full use of our urban water resources doesn't need any new technology," he says. "Really, it's a matter of good management and good public education."

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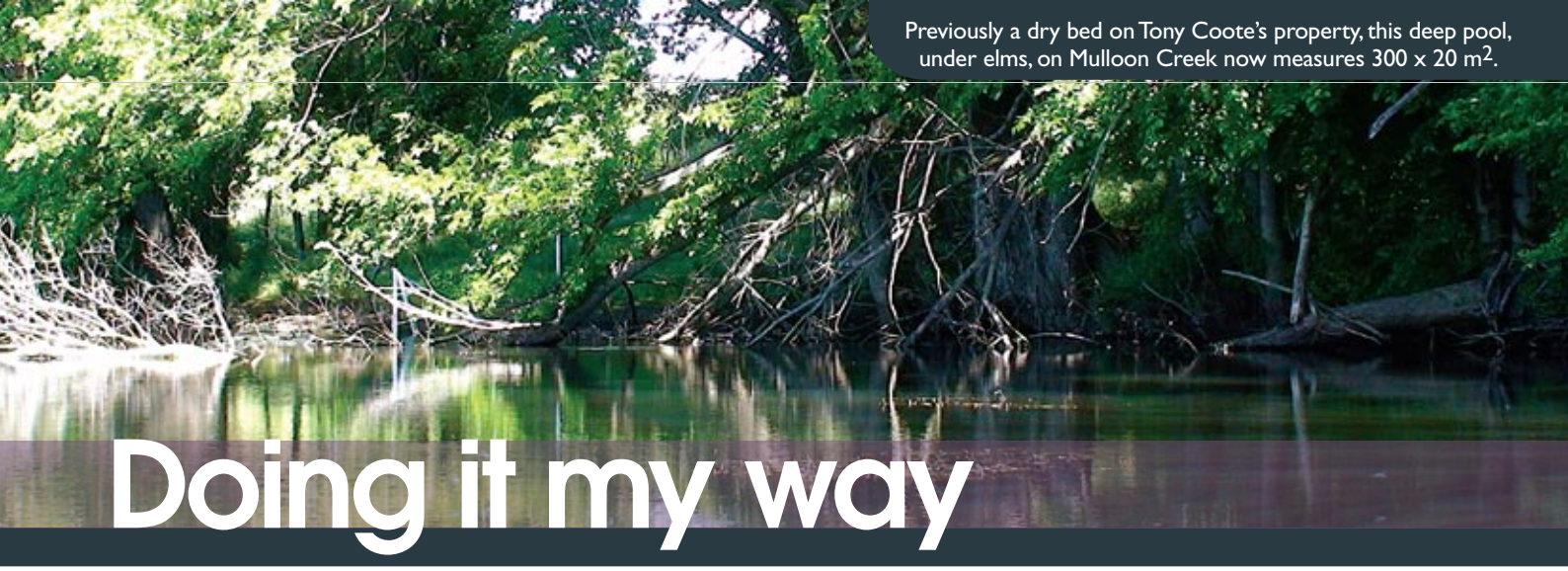
For more information



Previously a dry bed on Tony Coote's property, this deep pool, under elms, on Mulloon Creek now measures 300 x 20 m^2.

Doing it my way

Landscape restoration… the Peter Andrews way

Peter Andrews' unorthodox approach to landscape restoration has attracted both strong criticism and enthusiastic support. But he has now inspired many landholders to try his methods on their properties. Here we look at the Peter Andrews approach and how one of his advocates, Mr Tony Coote, has fared applying the principles of 'natural sequence farming' to his property at Mulloon Creek, near Bungendore, NSW.

As Peter Andrews, of '*Australian Story*' (ABC TV) fame, says in his first book[1], "since the Australian landscape functioned perfectly well on its own for millions of years, we ought to be able to solve the landscape's current problems by somehow reinstating whatever it was that enabled the landscape to function so efficiently then".

"Peter's key philosophy," says Tony Coote, "is to hydrate the landscape, to repair river systems by understanding how water, salt and carbon behave in the landscape and then to build leaky weirs to slow the flow of water and allow it to soak into the surrounding floodplain … just as it originally did. So, importantly, when heavy rain falls, it fills up the inground water storages that sustain paddocks and creeks in dry times, rather than rushing down deep eroded river channels all at once."

"This is what we have done at Mulloon Creek, with Peter as the architect," explains Tony. "We set up a national demonstration of his work through a consortium of Landcare, Southern Rivers CMA, and the Federal Government, and sponsored by Landcare, Mulloon Creek and the Government."

Around 200 people drove from Victoria, NSW and ACT to hear Peter Andrews (pale blue shirt) speak at a demonstration site in southern NSW.

Rocks, reeds and willows have been established in Mulloon Creek to slow the flow, 'banking' the water in the floodplain … as it naturally was before the erosion started 150 years ago.

But does this mean that downstream landholders get less water?

"Absolutely not," says Tony. "In fact, we argue that the opposite occurs. Because water is banked in the ground, just as you bank your money, it doesn't just race down the creek, past everyone's farm and out to sea. It is slowly released over time…and we can demonstrate this.

Peter Andrews speaking at a field day near Yass, NSW.

"The Australian National University is monitoring automatic flow sensors above and below the farm. While inflow to the farm has ceased several times in the past few years, outflow has never fallen below 100,000 litres per day."

"We encountered the same thing at Tarwyn Park, in the Upper Hunter," says Peter Andrews. "When I began partly blocking the creeks to slow the flow, some downstream neighbours thought they would get less water. As it turned out, they got more water, but it trickled downstream in the sand, that is underground. This meant the creek ran steadily, not all in a rush, and the surrounding landscape also benefited from the water."

Peter's methods have attracted more than a little criticism, and there are legal and environmental issues with blocking of creeks – see article on p. 16 of this issue. But he has many supporters, including some high profile Australians.

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For more information

[1] *Back from the Brink*, 2006, ABC Books

H2O business

The Peter Cullen Trust

The **Peter Cullen Trust** is an important new independent funding body offering unique opportunities for innovation in water and environment resource management.

The purpose of the Peter Cullen Trust is to:

- Spot new talent, and support early career researchers and people 'who can speak' for the rivers with clarity and credibility,
- Promote informed exchange and debate on important water-management issues,
- Build capacity in science and policy for water management,
- Build links between the scientific and political communities in order to promote effective management of our river systems.

Leadership programs

The Trust will be calling for 'Peter Cullen Trust Leadership Program' applications soon.

This first program aims to train a selected group of water scientists and policy experts, to think beyond their areas of expertise and to work together to achieve incremental and measurable outcomes.

Experienced exponents of science, policy and politics together with stakeholders in water management will be sharing expertise and strategic skills with up-and-coming early career professionals as they jointly explore particular challenges in water management. The end results of the program will include changes on the ground, as well as practical training for the people involved.

It is anticipated that the participants will take their newly developed skills back to their workplaces, to benefit their future work and their organisations.

The Trust's programs will help scientists to understand policy change, and to communicate science in ways that can better inform political decision making, and will train policy makers to communicate more effectively with scientists.

Achieving goals

The Peter Cullen Trust wants to strengthen the bridges between science, stakeholders in water-system management (with a particular focus on law and policy makers), and the needs of the environment.

Its goals are to enable scientists to work effectively with policy makers, and policy makers to understand scientists' thinking, by facilitating learning, communication and connections between these groups.

Important aspects are debate, positive differences, collaboration, scientifically informed decisions about water and environment in a real-world context, and the ability to communicate complex ideas with simplicity – something for which Peter Cullen was renowned.

In achieving its goals the Trust is partnering with other organisations not only to fund its capacity-building programs but also to develop and support cross-fertilisation of ideas among program participants, via a community of practice.

The Trust

Professor Peter Cullen's significant contributions to water systems management, legislation and Government policy as well as to environmental education have led to enormous support for the Trust. Many prominent Australians with a wide range of knowledge have volunteered their time to work with the outstanding Australians whom the Trust aims to identify and develop.

The Board of the Peter Cullen Trust brings together highly respected leaders in water and environment management. It includes Professor John Thwaites, Professor Gary Jones, Professor John Langford AM, Mr Mike Logan, Mr Robert Purves AM, Dr John Williams, and Peter's daughter Ms Belinda Cullen.

The Vice Chancellor of University of Canberra, and the Institute for Applied Ecology at the university, generously provide support for the Peter Cullen Trust.

For further details, please contact Dr Sandy Hinson, CEO.

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Phone 02 6206 8606

For more information

Photo-point monitoring of vegetation change in a wetland on private property. Before watering.

12 weeks after provision of environmental water.

Working for wetlands

A grassroots group, known as the **NSW Murray Wetlands Working Group** (MWWG), aims to 'achieve a lot with little' in terms of wetland rehabilitation and management…and its history is perhaps as noteworthy as its achievements.

The group's activities include: adaptive environmental water management, rehabilitation and investigation, database development and management (wetland inventory and mapping), extension, and flagship projects such as the Moira Lake rehabilitation.

A core activity, since 2001, has been the delivery of water that has been allocated to the environment – that is Adaptive Environmental Water (AEW) – to wetlands in various parts of the Central Murray region. This 'Watering Wetlands on Private Properties' project has delivered 75,000 ML of environmental water to 215 wetlands, covering more than 67,000 ha, and involving 150 land managers.

Natural flooding of wetlands in these parts would have meant winter-spring inundation once every five to 10 years. But draining of floodplains and construction of dams and levees to serve agriculture and rural towns has separated many wetlands from the river and greatly reduced the frequency of flooding.

The MWWG aimed to ameliorate the ongoing decline in the region's wetland condition and biodiversity by targeted delivery of water to wetlands, to restore their ecological function.

At first, the water was delivered using irrigation channels. However, in 2005, the MWWG expanded to wetlands that had become isolated from the river channel, using large portable irrigation pumps transported to the banks of the Murray.

Monitoring of the project provided ongoing guidance. The group engaged organisations including the Murray-Darling Freshwater Research Centre, the Arthur Rylah Institute, CSIRO, and Birds Australia, to undertake research. It used the best scientific knowledge and technology available to assist with management and implementation of the watering projects.

For this ambitious project, the group was recently recognised, by the Global Restoration Network (www.GlobalRestorationNetwork.org), which listed it as one of the Top 25 Australasian Ecological Restoration Projects.

The MWWG is proud of the project's outcomes. As a result of its work over several years, vegetation in the wetlands, particularly the dominant and familiar riparian and floodplain trees, the River Red Gums – which had been showing signs of decline – have generally responded well to the provision of environmental water. Monitoring revealed a vast improvement in vegetation health and benefits to the fauna that use the wetlands. Water birds and amphibians, in particular, have benefited from the habitat provided by healthy aquatic plants.

Better late than never

"Apart from demonstrating the feasibility of delivering environmental water through use of irrigation channels and pumps," says Program Manager Dr Deb Nias, "the project taught us that wetlands that have been cut off from their natural water sources for up to 30 years are still able to respond and show positive ecological outcomes."

Some other valuable ecological findings from the group's wetland watering work are in the reports for 2002–03 and 2004–08 on the MWWG website. And the project has helped to highlight areas of policy and/or legislation where amendments could speed up approvals and enable state wetland and environmental water targets to be met.

The MWWG has received several awards in recognition of its contribution to wetland rehabilitation. It won the 2007 National Thiess *Riverprize*, was a finalist for the 2002 National Thiess *Riverprize*, and was awarded the Rivercare 2000 Silver Award for its 'Moira Lake Rehabilitation'.

Expanding operations

Originally, the MWWG was formed in 1992 by the Murray and Lower-Murray-Darling Catchment Management Committees, aiming to 'link community involvement and best scientific understanding' to address the loss and degradation of wetlands along the Murray.

"Our members include landholders, community group representatives, local councils, and non-government and government agencies. The group is made up of hard-working volunteers and a few professional government and non-government staff," says Dr Nias.

Recently the MWWG has set up a new company called Murray Darling Wetlands Ltd, a not-for-profit non-government organisation.

"We are looking at forming stronger relationships with a view to continuing the work of the MWWG," says Dr Nias, "but using our own water assets, obtained through purchases, donations or other market mechanisms. This is still an emerging concept in Australia. We're also expanding our area of business, and will operate in a variety of catchments in the Murray-Darling Basin. So we are re-inventing ourselves."

"At the moment," she explains, "government emphasis around Australia is understandably towards rivers and larger wetlands, especially those protected under national or international treaties. We believe we can achieve a lot with little by working at a different scale, and in so doing, fill in – not literally! – some of the wetland spaces or habitats that may not be on priority lists."

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For more information

A group in training.

Clearwater – training in sustainable urban water management

By Susie Buxton (for Clearwater)

In Victoria, an award-winning program called **Clearwater*** has been providing training and advice in sustainable urban water management for professionals who plan, design, construct and maintain the state's cities and towns.

Established in 2002 as part of the Victorian Stormwater Action Program, Clearwater aims to build capacity for urban design that integrates sustainable water use and stormwater treatment.

Clearwater offers training, tours, and events. Topics include integrated urban water management (IUWM), water sensitive urban design (WSUD), stormwater harvesting and reuse, and construction of raingardens and biofilters.

Clearwater Manager, Emily Kaye, says the audience for sustainable water management training is becoming increasingly broad as cooperation increases across disciplines and organisations.

"Everyone from engineers, strategic and sustainability planners, landscape architects and educators, through to councillors, State Government representatives and industry consultants have attended our sessions," she says.

"Over the past six years the focus of the Clearwater program has also expanded. Initially, the program focused on reducing the volume of stormwater and treating pollutant loads to support waterway health. Now stormwater treatment is part of a broader discussion about integrated urban water management (IUWM)."

Ms Kaye says IUWM not only considers waterway health but also promotes the most efficient use of all water travelling through our urban environment.

"This could mean harvesting stormwater for irrigation, reusing non-contaminated water, using 'third pipe' commercially recycled water, or incorporating stormwater features into urban landscaping. These initiatives have a range of benefits including reduced pressure on drinking water supplies, increasing biodiversity, cooling of the built environment, and the reconnection of people with water in the urban landscape."

Assessing elements of IUWM is possible using eWater's **music** v4 software, though MUSIC is best known for its value in urban stormwater planning. For 2010, Clearwater is partnering with eWater Innovation to deliver training in **music** v4 in Victoria.

Clearwater develops and provides training on special topics when there is a need identified by other organisations. Its courses and events are based on the latest thinking and research from industry professionals and academic research bodies. Examples include the National Urban Water Governance Program (NUWGP) and Facility for Advanced Water Biofiltration (FAWB) at Monash University.

In 2008 Clearwater developed a Raingarden Tour in co-operation with the City of Kingston. These tours offer participants a close-up view of working raingardens and biofilters run by council staff who have been involved in design, planning and maintenance of these features.

Clearwater also organises networking events that facilitate peer-to-peer learning and discussion. The quarterly Hot Topics seminars dedicate time to small and large group discussions of water sensitive urban design challenges and organisational change.

"The aim of the Hot Topics seminars is central to Clearwater's overall objective, which is to increase capacity and support for water sensitive urban design through collaboration, knowledge building, and discussion," says Ms Kaye.

The Clearwater program won the 2009 Education Award at the annual Stormwater Victoria Excellence Awards in October.


A raingarden tour.

See upcoming courses on page 28

www.clearwater.asn.au

For more information or access to the Info Resource Library

* Clearwater was initially funded by Environmental Protection Agency (EPA) Victoria, Municipal Association of Victoria, and Stormwater Industry Association of Victoria. Melbourne Water became a major funding partner of the program in 2006 and additional funding comes currently from the Department of Sustainability and Environment and EPA.

Water management resources

Upcoming courses by CLEARWATER

Stormwater Treatment Technologies (Monash University / Clearwater)
22-25 February 2010
A four day course covering the design and performance of stormwater treatment and harvesting systems, with emphasis on the latest advances and technologies.

Raingardens Essentials
Tuesday 16 March 2010
A three-quarter day workshop which provides detailed information on designing and building raingardens and biofilters.

Watch the Clearwater website www.clearwater.asn.au for other courses coming up.

For more information or to make a booking, info@clearwater.asn.au, or phone (03) 9235 5335.

MUSIC training courses (see below) in day-long modules

Day 1, 'Getting to know MUSIC', is designed for new users. You learn some of the theory of urban stormwater management; about the model and the assumptions behind it; how to simulate and evaluate the performance of stormwater treatment measures; how **music** v4 differs from version 3.

Day 2, 'Intermediate MUSIC', builds on Day 1. It gives you an in-depth working knowledge of the model, and practice applying **music** v4 to real case-studies. It suits people who have done Day 1, or who use MUSIC relatively often.

The courses include: training materials, the (online) **music** v4 user manual, presentation notes, worked examples, morning tea, lunch and afternoon tea, use of a computer and **music** v4 software for the duration of the course.

www.ewater.com.au/music

For more information on music v4

Groundwater Information Resources

For resources on groundwater-surface water interactions, try these websites:

- BRS Connected Water – Managing the linkages between surface water and ground water, http://www.connectedwater.gov.au/
- UNSW Connected Waters, http://www.connectedwaters.unsw.edu.au/
- Winter et al. (1998) Ground Water and Surface Water A Single Resource, http://pubs.usgs.gov/circ/circ1139/#pdf
- NHT/SKM (2006) Towards a National Framework for Managing the Impacts of Groundwater and Surface Water Interaction in Australia, http://www.nht.gov.au/publications/frameworks/pubs/ncc-ground-surface-water.pdf
- Jolly *et al.* (2008) Review of groundwater – surface water interactions in arid/semi-arid wetlands and the consequences of salinity for wetland ecology (In 'Ecohydrology' 1(1), 43-58). http://www3.interscience.wiley.com/cgi-bin/fulltext/117929307/PDFSTART
- LWA/SKM (2007) The impact of groundwater use on Australia's rivers, http://lwa.gov.au/files/products/innovation/pr071283/pr071283.pdf
- Hydrological Processes Journal Special Issue on the Hydrology and Ecohydrology of Australian Semi-Arid wetlands, http://www3.interscience.wiley.com/journal/122681193/issue
- Three reviews on groundwater-surface water interactions by the eWater groundwater team are downloadable from: http://www.ewatercrc.com.au/publications/index-nov08-downl.html:
  - Rassam D.W. and Werner A.D. (2008). Review of groundwater–surfacewater interaction modelling approaches and their suitability for Australian conditions. eWater Technical Report. eWater Cooperative Research Centre, Canberra.
  - Reid M.A. et al. (2009) Catalogue of conceptual models for groundwater–stream interaction. eWater Technical Report. eWater Cooperative Research Centre, Canberra. (134 pp.)
  - Turner J.V. (2009) Estimation and prediction of the exchange of groundwater and surface water: field methodologies. eWater Technical Report. eWater Cooperative Research Centre, Canberra.

UPCOMING TRAINING COURSES

Upcoming face-to-face training in music v4 (subject to change)

Location	Dates	Register by (Fridays)*
Melbourne	10–11 March	26 February
Adelaide	31 March–1 April	19 March
Gold Coast	21–23 April	9 April
Perth	5–7 May	23 April
Melbourne	26–28 May	14 May
Brisbane	9–11 June	28 May
Sydney	23–25 June	11 June

For more details or to register, visit www.training.ewater.com.au or contact James Robinson, toolkit@ewatercrc.com.au, phone 02 6201 5168

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- System planning and management
- Regulation

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eWater CRC

Photos: (left and right) BMT WBM; (centre) Storm Consulting.