Australian Government
Land & Water Australia

RipRap

RIVER AND RIPARIAN LANDS MANAGEMENT NEWSLETTER
Edition 32, 2007

River contaminants: salt, nutrient, sediment and their interactions

The Australian community is increasingly aware of the importance of our water resources and riverine environments to the future sustainability of agriculture, rural and urban water supply, estuaries and in-shore fisheries, recreation, and conservation of our unique aquatic biodiversity. Contaminants in rivers are central to this issue because they determine both the quality of irrigation and drinking water, as well as the condition of in-stream habitats for river-dependent plants and animals. Salt, nutrients and sediment are all contaminants that impact on our rivers, and we need to know more about them and how they interact, if we are to improve river restoration outcomes.

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RIPArian lands:

WHERE LAND AND WATER MEET

From the Editor

Welcome to another edition of *RipRap*. Following the end of the National Riparian Lands R&D Program we were unsure as to whether *RipRap* would continue, and this explains the delay between editions. However, after such positive feedback, we have decided to keep publishing *RipRap* when the opportunity and funds allow. This means that editions may not be quite as often, so check our website to find out what is new in between times. It also means we are interested in working with organisations to fund the production of *RipRap*, so if you would like to sponsor an edition that links to work Land & Water Australia is doing, we would be delighted to hear from you.

This edition is focusing on findings from the National River Contaminants Program, a joint Murray-Darling Basin Commission and Land & Water Australia research initiative. We have a beautiful new book that covers the main findings from now-completed Program, with *RipRap* giving you a preview of the contents. Thank you very much for being a *RipRap* reader, it is a pleasure producing something to assist, inspire and keep people connected who are working in river and riparian management. ■

Front cover main photo: *Lien Sim.*

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Salt, Nutrient, Sediment and Interactions: Findings from the National River Contaminants Program

By Brendan Edgar

River contaminants fall into two broad categories — firstly, substances that occur naturally, but in larger than normal amounts contaminate the environment, and secondly, those that do not occur naturally, for which even small amounts may contaminate the environment. Examples of the first category are salt, nutrients, and sediments — about which we need to understand the sources of excess loads, their ecological effects, and options for improved management. Examples of the second category are agricultural chemicals and heavy metals, about which we need to understand their ecological effects and the extent to which we need to improve their management.

River contaminants are a major threat to receiving waters (estuarine, coastal, wetland and reservoir). To improve our understanding and management of river contamination issues and, ultimately, to help reduce the associated environmental, social and economic costs, the National River Contaminants Program (NRCP) was established in 2001 by Land & Water Australia (LWA) and the Murray-Darling Basin Commission (MDBC). This continued the partnership between LWA and the MDBC from the preceding National Eutrophication Management Program, which focused on the causes and management of algal blooms in waterways, including the role of phosphorus as a contaminant.

The NRCP Strategic Plan canvassed the views of catchment and river managers about the most important river contaminant issues. Using this data, outlined in Figure 1, it was agreed to focus the Program on developing strategies for better managing salt, nutrients and sediments as priority contaminant issues.

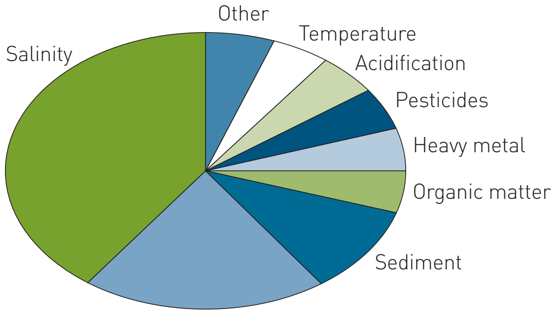
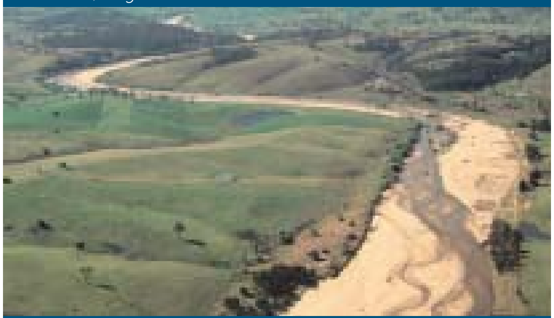


***Figure 1**. Indicative national significance of river contaminant issues.*

Left: Macquarie Marshes. Photo Bill Johnson.
Right: Gorgonian sea fans off Whitsunday Island. Photo courtesy of FRDC.

***Salt**, Yenyenning Lakes. Photo Jenny Davis.*

***Sediment**, Bega River. Photo Andrew Brooks.*



***Nutrient**, Victoria Park Lake. Photo Paul Boon.*

The National River Contaminants Program is a joint collaboration between Land & Water Australia and the Murray-Darling Basin Commission.

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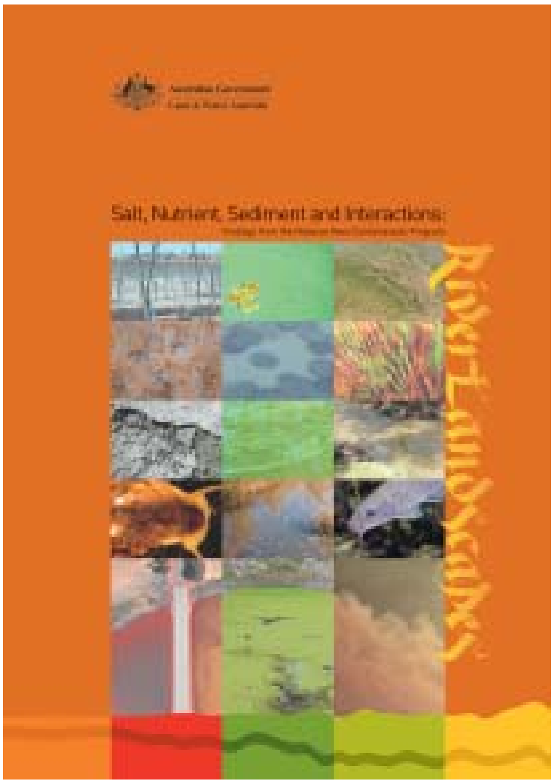


Salt, Nutrient, Sediment and Interactions is available from CanPrint, free call 1800 776 616 Product code PK071328

The ultimate goal of the NRCP was improved water quality of Australian streams and rivers to meet the community's objectives of maintaining ecological integrity and biodiversity, and to underpin sustainable use of the water resources for current and future generations. This edition of *RipRap* provides a snapshot of some of the key findings from the NRCP, as well as highlighting other LWA research being conducted in the area of river contaminants. The NRCP has recently produced a new synthesis publication that brings together these key findings, and you can order your copy from CanPrint Communications.

RipRap summarises this new publication and is broken up into four areas of research: salt, nutrient, sediment and interactions between contaminants. Articles about other projects funded by LWA in the same topic area are also provided, so you get the most up to date understanding of what is new in the area of contaminants research. ■

Are you interested in taking part in a workshop on the *Salt, Nutrient, Sediment and Interactions* book?

Following the success of the series of National Riparian Lands R&D Program workshops we are thinking about running a couple of similar workshops to communicate the key findings from the National River Contaminants Program. However, we need to know if people are interested in attending, and which location suits the most people. Possible locations are Canberra, Brisbane, Adelaide, Melbourne and Sydney (happy to go to Perth and Darwin but will need help with costs!). If you are interested in attending a workshop based on the new *Salt, Nutrient, Sediment and Interactions* book would you please register at **www.rivers.gov.au** and follow the prompts off the front page.

Salt as a contaminant

Pink Lake, WA. Photo Jenny Davis.

Salinisation of landscapes has been identified as one of Australia's most serious environmental issues in southern regions, and is also a high risk for some warm temperate and dry tropics parts of Australia. In many areas salinisation has already affected terrestrial ecosystems, leading to losses of habitat, biodiversity, and native vegetation, with increasing salinity predicted to cause deterioration in infrastructure, such as roads, buildings and bridges. Dryland salinity (secondary salinity) will also add to the salt loads in rivers to the point where it is estimated that by 2020, the Murray River's salinity will exceed drinking water standards for nearly 150 days a year (MDBC 1999). Increasing riverine salinity levels will also affect aquatic biodiversity in rivers and wetlands — which is the focus of this section.

Primary and secondary salinity: Primary salinity occurs solely through natural processes. Secondary salinity is where increases have occurred due to human activity such as widespread clearing of deep-rooted vegetation or over-application of irrigation water.

Much is now known about the causes of dryland salinity, and a number of effective strategies have been demonstrated to reduce the problem. However, little research has been conducted on the specific environmental impacts of salinisation on rivers (Bailey & James 2000). In particular, few investigations have examined the biological changes in salinised rivers or wetlands and, in general, knowledge concerning the effects of increasing salinity on aquatic ecosystems has been inadequate to guide decision making. We need to understand how aquatic species respond to changing levels of salt in river and wetland systems, and learn what is happening to ecosystems across the wide variation in primary and secondary salinised sites across Australia.

While there are some commonalities in understanding the effects of salinity across the fresh to hypersaline continuum, there are also many important differences in the characteristics of organisms and the communities inhabiting waters along this continuum. There may also be important differences in the major biological, physical and chemical processes that occur across this range of salinity values. The chapter authored by Ben Kefford and colleagues (see page 6) looks at this issue and addresses the effect of salinity increases in fresh, or only slightly saline, waters (≤ 3 mS/cm or 2.3 g/L) in eastern Australia. Lien Sim and colleagues (page 7) consider further increases in salinity within saline waters (10–100 g/L or 13–130 mS/cm) and hypersaline water (>100 g/L or >130 mS/cm) in Western Australia. Both these areas of research examine how salinity targets can be set to trigger management intervention to protect biodiversity.

It is not enough to just understand the causes of salinity and the environmental consequences; preventative and remedial management actions also need to be developed. There is a range of management options that can be used to influence the salinity of rivers and wetlands in the short- to medium-term, including:

- release of environmental flows,
- altering the amount of water extraction,
- management of weir pool depth,
- interception of saline water inputs, and
- managing the disposal of saline water, including into freshwater systems.

Over the long term, salinity of waterways can in many places be influenced by altering landuse, vegetation (water use), drainage and hydrology in a catchment.

The detection and management of salinity impacts on aquatic ecosystems requires natural resource management standards that are based on scientific evidence. As the next two research summaries illustrate, there is now sufficient information available for these standards to be set for both saline and hypersaline conditions. Establishing these standards is a task for river managers. ■

Bailey, P.C.E. & James, K. 2000, *Riverine and wetland salinity impacts — assessment of R&D needs*, Report for Land and Water Resources R&D Corporation, Canberra.

MDBC 1999, *Salinity Strategy — 10 years on*, Murray-Darling Basin Commission, Canberra.

Salinity thresholds in freshwater biodiversity

By Ben Kefford[1], Jason Dunlop[2], Dayanthi Nugegoda[1] and Satish Choy[2]

1. RMIT University,
2. Queensland Department of Natural Resources and Water

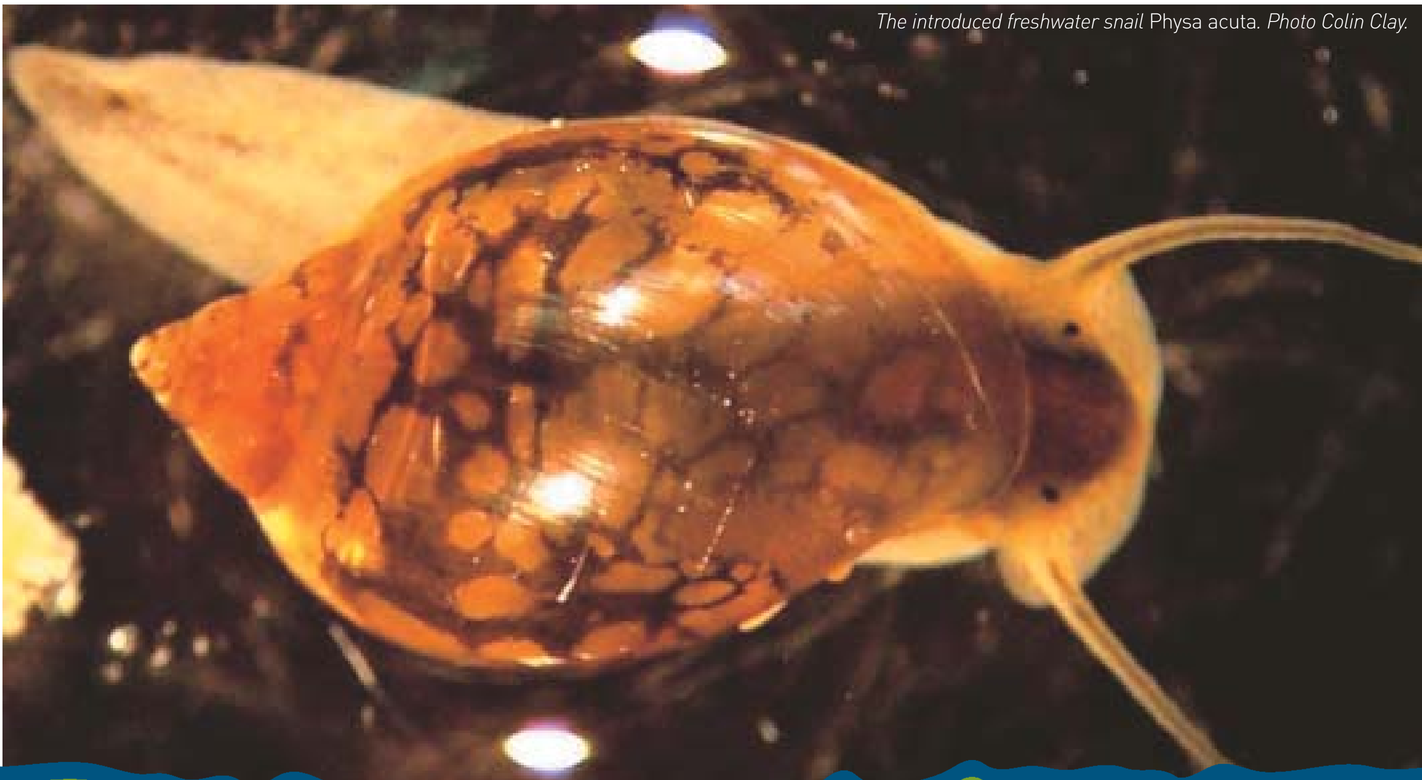
LCx value = the (salinity) concentration lethal to X% of individuals over some specified period. If, for example, X is 50% and the period of exposure is 72 hours, it would be expressed as the *72h LC_{50} value*.

Ben Kefford and colleagues have investigated salinity thresholds in freshwater biodiversity and, in particular, have focused on the freshwater to saline transition that is occurring in many rivers in Australia. Changing salinity in freshwater systems can have detrimental impacts on biodiversity, so in order to prevent or minimise such impacts, it is beneficial to be able to set salinity targets that should not be exceeded. It is also important to identify taxa or other indicators of salinity impacts so that biomonitoring programs can identify salinity impacts before they become severe or irreversible.

To examine these issues, the relative salinity sensitivity (measured as 72h LC_{50} values) of a wide range of macroinvertebrates was assessed in six locations chosen to represent a wide biogeography range across eastern Australian regions likely to be affected by secondary salinisation. In Victoria these were the southern Murray-Darling Basin (MDB) (Goulburn, Broken, Loddon and Campaspe River Catchments in central Victoria) and south-west Victoria (Barwon River Catchment). In Queensland, the regions assessed were the south-east Queensland (Brisbane and Logan-Albert River Catchments), northern MDB (Condamine River Catchment), the dry tropics (Burdekin River Catchment) and the wet tropics (Mulgrave-Russell River Catchments). These results have shown that, in general, the salinity sensitivity of related macroinvertebrate species is similar across eastern Australia.

However, across eastern Australia there is considerable variation in the macroinvertebrate communities present, giving rise to differences in the salinity sensitivity of these communities. Consequently, there is a need to derive regional salinity guidelines for freshwater systems as these can differ in their sensitivity to salt. Based on results of laboratory experiments and the occurrence of macroinvertebrate families in the field, generalised salinity sensitivity scores have been assigned to families from which a salinity index (SI) can be calculated for a site which indicates the sensitivity of the macroinvertebrate community present. Although there is limited data for some biological groups, the available evidence suggests that protecting salt sensitive freshwater macroinvertebrates from salinity changes will protect all biological groups found in freshwater. This principle will need to be re-evaluated as new data is collected.

The findings reported in this chapter of the *Contaminants* book can be used by managers to develop regional guidelines for salt sensitivity, within a risk assessment framework. The chapter also describes the major technical steps involved in this process. ■



The introduced freshwater snail Physa acuta. *Photo Colin Clay.*

Understanding thresholds in the transition from saline to hypersaline aquatic ecosystems: south west WA

By Lien Sim[1,2], Jenny Davis[1], Jane Chambers[1] and Karin Strehlow[1]

1. Murdoch University,
2. Department of Environment and Conservation, WA

Large areas of the Australian continent are currently affected by secondary salinisation. In some parts of Western Australia, particularly the 'wheatbelt' region which lies between the 600 and 350 mm rainfall isohyets, salinisation, primarily as a result of land clearing and the associated rise in saline watertables, has been occurring for over a century. As a consequence, very few freshwater systems remain in this region, and in order to manage the changing landscape, a key question facing natural resource managers is which physico-chemical or ecological thresholds have most importance in the change from saline to hypersaline conditions? Knowing this will allow these systems to be managed so that further losses of ecological function and biodiversity can be prevented.

In a landscape where there is little prospect of restoring freshwater ecosystems due to the scale and severity of salinisation (Hatton et al. 2003), saline macrophyte-dominated wetlands have structural and functional importance, and their replacement by benthic microbial communities is likely to lead to a reduction in these ecological values. Our results suggest that salt-tolerant macrophyte communities are unlikely to develop in seasonally-drying wetlands where the salinity is consistently greater than 45 ppt, and that salinity should not exceed 30 ppt until propagules have been produced if the macrophyte-dominated ecological regime is to persist.

Little White Lake has a long history of salinisation. Photos on this page Lien Sim.

Ruppia polycarpa *a common salt-tolerant submerged macrophyte species found in south-western Australian wetlands and* Chelodina oblongata *(oblong turtle), in the Meeking Lake.*

Although benthic microbial communities appear to be favoured by high salinities, they are likely to be out-competed at low salinities in the field by macrophytes or by phytoplankton blooms if water column nutrient levels are high. However, the year-round dominance of benthic microbial communities at relatively low salinities in a permanent wetland indicated that physico-chemical stability driven by water regime may significantly alter ecological dynamics.

The dynamics of regime change in saline wetlands appear not to be driven by any single variable, but by the combined effects of salinity and water regime on species life histories and competitive abilities. Consequently, the development of management guidelines that recognise the presence of different ecological regimes and that consider the interactions between water regime, salinity, and primary and secondary production will be more useful in protecting biodiversity and ecological function in these systems than managing salinity as a single factor.

The knowledge generated by this research is likely to have great relevance to management planning for salinising wetland systems elsewhere in southern Australia, particularly due to its focus on hydrologically-dynamic wetlands that are subject to regular drying. Many northern hemisphere models of wetland function are developed for systems that experience much greater stability in conditions than the majority of shallow waterbodies in southern Australia. ■

Salinity in the rivers of the Lake Eyre Basin

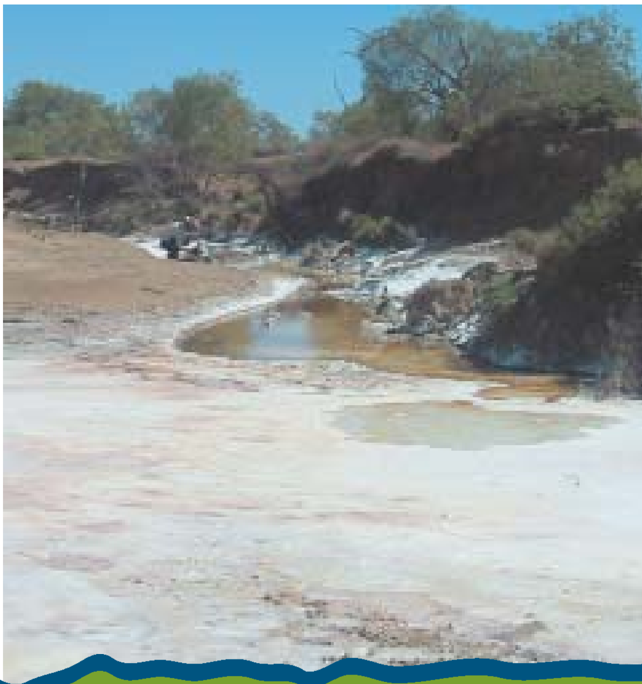
By Liz Irvine

The vadose zone extends from the top of the ground surface to the water table ("vadose" is Latin for "shallow").

The rivers of the Lake Eyre Basin (LEB), located in Australia's arid core, drain approximately one seventh of the continent, yet remain a relatively unregulated resource. This is due mainly to an inherent variability in flow, low local demand and access to Great Artesian Basin groundwater. However, there remains continued pressure to regulate flows of these rivers for water resource utilisation. It is foreseeable that increased regulation and extraction would result in the disruption, or a 'smoothing out', of the highly variable flow regime that is essential to the health of the basin's unique and internationally significant riverine flora and fauna. Perhaps less immediately obvious, but potentially as damaging to riverine health, is the change that any river regulation could make to salt storage and transport dynamics in the basin.

Very little is known of the natural salinity dynamics in the LEB, or of the effects any flow regulation could have. River transmission losses are high across the LEB and most flows terminate in the lower reaches. Thus, waterholes that persist after flow events provide essential aquatic refugia. In the lower reaches these waterholes can display a high variability in salinity, both temporally and spatially. This variability determines their usefulness as a water resource for pastoralists, as well as for native flora and fauna. In a recent study, funded by the Australian Research Council and supported by Land & Water Australia, environmental tracers, namely the isotopes of water ($^{2}H/^{1}H$ and $^{18}O/^{16}O$) and ionic constituents are being used to improve our knowledge of the processes affecting the river salinity at these locations. The role of evaporation and interactions between groundwater, surface water and the vadose zone are the key to understanding the salinity dynamics.

During the natural flow cycle (which includes extended periods of no flow) hydrological, ionic and isotopic models show that evaporation during transmission and from temporary stores (including waterholes, ponding on floodplains and the shallow soil zone) is the dominant water loss mechanism, not infiltration. Most shallow groundwater in the lower reaches of the LEB is saline to hypersaline, even in the floodplain environment, which is consistent with the dominance of evapoconcentrative processes. Floodplain groundwater level increases are observed during high flow periods indicating some recharge during these times, however, hydrochemical mass balance models detect freshening of the groundwater only in the bank or inner floodplain (< 100 metres from the stream) environment. From these findings, it is inferred that exchange is dominated by lateral flow moving horizontally through the bank rather than via vertical recharge through the floodplain. Discharge of the bank store to the river during flow recession appears to be the limit of sub-surface influence to the surface water system in most areas studied. Sustained baseflow to surface flow appears largely absent.



Rivers of the Lake Eyre Basin. Photos Liz Irvine.

Investigations indicate that following flood events, the persistence of most large waterholes in the lower reaches of the LEB is controlled by waterhole morphology, water depth at cessation of flow and evaporation. With this information, waterhole persistence and salinity over time following a flood event can be predicted. Evapoconcentration is the dominant mechanism for increasing salinity levels, however, the role of bank discharge following flow events also requires consideration. Both fresh and saline bank discharges have been observed across the LEB and it appears to be the main mechanism by which saline groundwater is transported to the surface water system. Bank discharge can result in the development of highly saline residual pools through some channel reaches, and with any change in flood volumes or frequency it is possible that the bank store and saline residual pools will be less regularly flushed. This could result in longer periods of highly saline conditions in some channel reaches and more saline additions to the surface water system when flow events do occur. Any discussion or proposal to regulate flow in the LEB must consider the effects of the changes on the flushing and salinity dynamics of the bank store if the ecological and economic value of these downstream waterholes is to be preserved. ■

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5th National Waterwatch conference

The Conference titled 'Sustaining, Showcasing and Sharing — building on the past, steering towards the future' will be held at the Australian National University's Manning Clark Centre in Canberra from 26 to 29 November 2007.

We would like to invite Waterwatch, Bushcare, Landcare, Coastcare, natural resource management facilitators, executive and program managers of regional NRM bodies or catchment management authorities, environmental community group members, local government officers, state and Commonwealth agency staff, water management authorities and related organisations, representatives from research and development organisations, environmental educators and teachers to participate in the conference.

As well as providing a forum for participants to share their knowledge and experiences, the Conference will offer professional development opportunities for the Waterwatch network and showcase how Waterwatch is working towards better integration into regional NRM and sustainable education. The Conference aims to further enhance Waterwatch partnerships with a range of supporters, hosts and participants. The Conference also aims to present emerging issues in policy and practice in NRM and sustainable education.

The Conference will include presentations, workshop sessions and many opportunities for networking.

Registration or for further information

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Additional information on the Waterwatch website: www.waterwatch.org.au

Does salinity reduce the tolerance of aquatic plants to fluctuating water regimes?

By Jacqueline Salter, Kay Morris and Paul Boon

In Australia, an estimated 80 high-value wetlands are already affected by secondary salinisation and this number is likely to rise to 130 by 2050 (National Land & Water Resources Audit 2001). Many wetlands across Australia have already been significantly modified by changes to their water regime, including the depth, timing and duration of flooding and drying. Despite the increasing prevalence of these two threatening processes, there is little understanding of how the interaction between water regime and salinity may affect wetland biota.

Aquatic plants vary dramatically in the range of water regimes that are optimal for their growth and regeneration. For example, submerged plants grow beneath the water surface and can regenerate from seed under flooded conditions. In contrast, wetland trees are tolerant to only episodic flooding. Fluctuations between wetting and drying cycles in wetlands, therefore, provide opportunities for the growth and reproduction of different plant growth forms, enabling a diverse suite of plants to persist. Understanding the mechanisms that permit the persistence of a range of vegetation types during unfavourable conditions is critical to developing appropriate guidelines to protect and rehabilitate wetlands threatened by modified water regimes. Unfortunately, responses observed under fresh conditions are unlikely to apply to salinised wetland systems. This work tests if salinity restricts the capacity of aquatic plants to tolerate changes in the duration of wetting or drying phases in wetlands

The emergent tree, *Melaleuca ericifolia* (swamp paperbark) and the submerged plant, *Vallisneria americana* (eel weed) are two common native wetland plants representing extremes in growth form. Constant flooding favours eel weed, which grows and regenerates from seed beneath the water surface, but prohibits the establishment of swamp paperbark seedlings, that require moist soil to regenerate from seed. Although re-instating a more natural wetting and drying cycle is likely to benefit swamp paperbark, it may result in the loss of eel weed. We tested the ability of swamp paperbark to tolerate temporary submergence, and of eel weed to tolerate drying, under fresh (0.1 dS m^{-1}) and saline (18 dS m^{-1} — approximating 1/3 seawater) conditions.

All swamp paperbark seedlings survived five and 10 weeks complete submergence in freshwater followed by 14 weeks re-exposure (Figure 1a). Salinity reduced the ability of seedlings to tolerate submergence. Moreover, increasing the period of submergence in salt water from five to 10 weeks exacerbated the reductions in growth and survival associated with salinity. Under saline conditions, 90% of seedlings submerged for five weeks and then re-exposed for 14 weeks survived, whilst only 56% of seedlings survived when submerged for 10 weeks.

*Swamp paperbark (*Melaleuca ericifolia*). Photo J. Salter.*

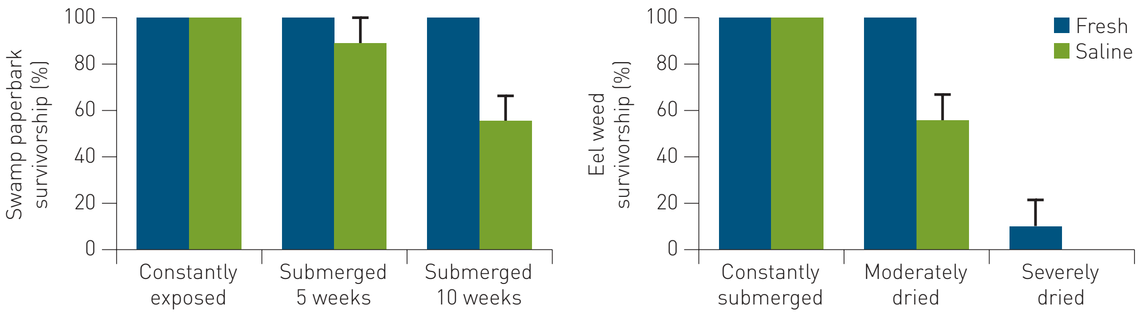

Figure 1. *Mean survivorship of swamp paperbark following 14 weeks re-emergence (left) and eel weed following 11 weeks re-submergence (right) under fresh and saline conditions. Bars represent standard error.*

*Top left: Eel weed (*Vallisneria americana*). Above: Eel weed experiments. Photos J. Salter.*

All eel weed plants recovered from drying when re-submerged in freshwater for 11 weeks if only the shoots and not the soil was dried (moderate drying) (Figure 1b). When the soil was dried until it cracked (severe drying), only ~11% of plants recovered upon re-submergence. Salinity halved the number of plants that recovered from moderate drying following re-submergence, and prohibited severely dried plants from re-growing.

Our studies indicate that the capacity of aquatic plants to tolerate changes in the duration of wetting and drying cycles in wetlands is likely to be significantly restricted under saline conditions. Although prolonged periods of drying or flooding may eliminate some vegetation types, particularly under saline conditions, it is possible that plants may regenerate from seed.

We found that swamp paperbark seed can germinate and float on the water surface for at least six weeks until water levels recede, at which time germinants can successfully establish on moist soil at salinities of at least 15 dS m^{-1}. This means that the continued survival of adults, which provide the potential for regeneration from the aerial seedbank, is likely to be important for recolonisation following flooding. Eel weed seeds may germinate even after 16 weeks of drying, and at salinity levels of at least 22 dS m^{-1} (approximately 1/2 seawater). The persistence of seed in the soil is therefore likely to be an important source for recolonisation following drying of the sediment, especially under saline conditions.

These findings have implications for the management of aquatic vegetation in wetlands subject to modified water regime and salinity. In freshwater systems, alteration between drawdown and flooding may allow the persistence of species with contrasting growth forms. However, tolerance to water regimes considered unsuitable to a plant's growth form may be compromised by salinity, and a plant's persistence in a saline wetland may be reliant on the longevity, salinity tolerance and germination requirements of seeds. As part of the ongoing management plan for salinised wetlands, it may be useful to identify significant species, and to understand their response to periods of wetting and drying under a range of salinity levels that plants may be exposed to. Water regimes of saline wetlands can then be modified to promote the persistence of key species. ■

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Land use impacts and in-stream salinity

By Vincent Versace

My PhD study is based in the Glenelg Hopkins region in south-west Victoria, an area where land use change is having an increasingly evident impact on natural hydrological systems. The early part of my study involved examining land use maps from 1980, 1995 and 2002, and relating this information to in-stream salinity. This was a logical first step, as currently there are no models linking land use to salinity in the region, and the mechanism leading to secondary dryland salinity is not clear. Funding from Land & Water Australia under their travelling fellowship scheme allowed me to work with colleagues at Wageningen University in the Netherlands and Cornell University in the USA. The results indicated subcatchments with higher proportions of native vegetation experienced lower in-stream salinity levels. This trend was consistent across all time periods examined and at all spatial scales, including whole subcatchment and 500 metre and 100 metre riparian buffers. Following on from this was an investigation of the root depth and distribution of the major land use classes in the region. This information was derived from reclassification of an existing database for natural vegetation, and a database I helped construct while in the Netherlands concerned with agricultural crops. Analysing this data in relation to in-stream salinity data revealed subcatchments with greater mean root-depth also had lower salinity levels. This implies that, within the study region, perennial landscapes are linked to lower in-stream salinity.

The latter part of my PhD has involved looking at random and systematic land use changes and what effects this may have for regional water balance. While reducing recharge is recognised as desirable in some areas to control water tables, this may not be the whole story. A preliminary outcome from my work shows a systematic increase in dryland cropping in an area where in-stream salinity is rising, yet local groundwater levels are falling. This is an interesting result in an area where rising groundwater tables following clearing of deep-rooted perennial vegetation does not appear to be the main mechanism responsible for secondary dryland salinity. The large scale revegetation that is planned may, in fact, increase in-stream salinity in the short term by reducing available stream flow. The systematic increase in plantation forestry is also likely to impose a similar stress. It is anticipated the results from this analysis will begin to link landscape patterns to landscape process, and ultimately direct research that will lead to tangible land management guidelines.

While early results of this study indicate perennial landscapes are more likely to have lower in-stream salinity, from a management perspective, it appears rapid revegetation may not necessarily be the answer. Water quantity as well as water quality need to be considered, especially during the long-term period of below average rainfall the Glenelg Hopkins region is currently facing. River managers interested in the results of this work are encouraged to contact the author who will happily supply electronic copies of published work generated so far, and discuss the random and systematic land use change work which is in review. ■

Above: *The Grampians mountain range in the background are at the northern extent of the Glenelg Hopkins region.The foreground shows an area of dryland pasture which has been sytematically replaced by blue gum (Eucalyptus globulus) plantations during the period of 1995 to 2002.*
Below: *An intermittent stream in the north of the Glenelg River basin. Water quantity is already an issue in the region. The expanding plantation forestry industry coupled with proposed revegetation plans are likely to further reduce stream flows, and exacerbate in-stream salinity levels in the short term. Both photos Trevor March.*

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Managing leaching efficiency for river health

By Liz Chapman

Recent work on the leaching of salt from soils under precision irrigation has shown that achieving the correct leaching of soils to maintain salt levels below the critical thresholds that would affect plant production, is strongly affected by the salinity of the river water used for irrigation.

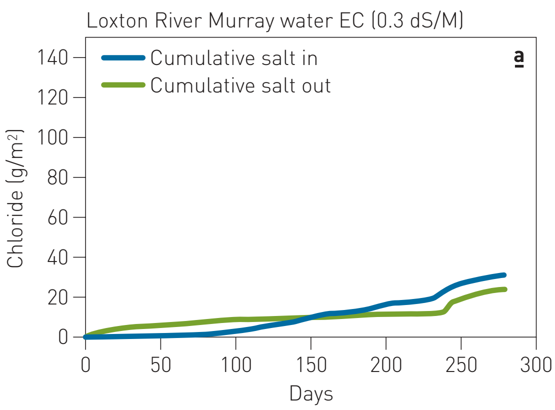
The opposite is also true — that achieving sufficient leaching of soils to move salt away from the root zone is also likely to have strong effects on the salinity of water that may eventually make its way back into the river.

Leaching of the root zone of plants is essential to prevent the accumulation of salt around the plant roots. Historically this was not a problem — leaching was achieved by winter rainfall and, often, the over-application of water. As water use efficiency has increased, particularly through the use of drip and sprinkler systems ('pressurised systems'), an allocation of water above and beyond that required by the plants must be made to leach the salt.

The amount of water required for leaching varies depending upon the time of year and the type of soil. When plants are actively growing and the level of biological activity in the soil is high, there tends to be larger numbers of macropores in the soil. This allows the water straight through the soil, without necessarily picking up as much salt as would happen if the water percolated slowly and evenly through the soil. This research, commissioned by the National Program for Sustainable Irrigation (NPSI), has found that application of leaching water during late winter is desirable, as this can supplement the leaching achieved naturally by winter rains.

The researchers, led by Dr Gerrit Schrale and Tapas Biswas at the South Australian Research & Development Institute (SARDI), have also looked at the effects of the salinity of the irrigation water on the accumulation of salt in the root zone. This was achieved through modelling the effects of using typical river salt concentrations at Loxton (300 EC) and anticipated river salinity at Morgan (800 EC) during high salinity years as shown in Figure 1. Under the scenario of drip irrigation with less than 10% root zone drainage and 300 EC (= 0.3dS/m), about 130 kg/ha (see a) of salt in each metre depth of soil is likely to accumulate during each irrigation season. If river salinity rises to 800 EC (= 0.8dS/m) then it will add 2000 kg/ha of salt (see b) in the same metre depth of root zone during a normal grape growing season.

Researcher Tapas Biswas at the South Australian Research & Development Institute (SARDI). Photo NPSI Image Library.



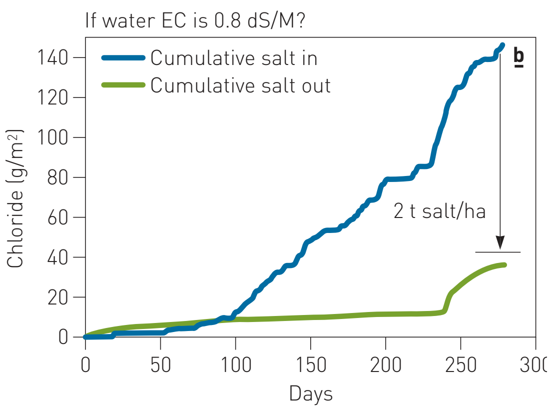


Figure 1*. Results of salt model that predicts salt build up in the root zone with two different salinities of river water, the 300 EC (current level), and 800 EC the Morgan benchmark.*

Above: Salt-affected grape vines. Managing the movement of salt out of the rootzone is a major challenge for irrigators, while ensuring that they don't apply so much water that the salt is mobilised into the river systems. Photo SARDI. ***Left***: Managing the movement of salt out of the rootzone is a major challenge for irrigators, while ensuring that they don't apply so much water that the salt is mobilised into the river systems. Photo NPSI Image Library.

Managing the movement of this huge quantity of salt out of the rootzone is a major challenge for irrigators, while ensuring that they don't apply so much water that the salt is mobilised into the river systems, via either recognised drainage programs or re-entry of groundwater into the river.

The researchers, who are working in the Sunraysia and Riverland areas of the Lower Murray, have developed three important but inexpensive tools/methods to measure salt accumulation, the amount of water flushing the root zone and salt leaching efficiency. These are significant achievements for permanent irrigated horticulture. One of the most significant outcomes is the design and development of a locally-constructed SARDI soil water extractor, 600 of which are already working in Australia to monitor salt build up and leaching. Another affordable tool, known as a wetting front detector (FullSTOP), can also be used to monitor irrigation and the progress of leaching fronts down through the soil.

Uptake of newly developed tools and strategies by the horticultural community is dependent upon effective extension activities. With this in mind, the NPSI funded project staff at SARDI maintain regular communication with growers participating in their trials. These simple and affordable tools are becoming more widespread, as irrigators recognise the benefits both for themselves (in purchasing the minimum amount of water necessary for leaching), and the river systems (by ensuring that excessive rates of leaching water are not applied).

More information about the 'Salinity Impact on Lower Murray Horticulture' project is available from the NPSI site www.npsi.gov.au ■

NATIONAL PROGRAM FOR **Sustainable Irrigation**

Want your say on a new climate change research strategy?

Australia's agriculture, fisheries and forestry industries will be better equipped to deal with climate change following an agreement between state and federal government agencies and rural research and development corporations to develop a 'National climate change research strategy for primary industries'. The research strategy will seek to identify opportunities to link research efforts on issues that apply across industries and jurisdictions, and will address both adaptation to climate change and the management of greenhouse gas emissions.

To find out further information and to have your say on what you think the new research strategy should cover, visit our website http://lwa.gov.au/ccrspi

Nutrient as a contaminant

At the levels typically found in Australia, nutrients in rivers do not generally constitute a serious issue for irrigation or drinking water quality. Rather, it is the ecological effects of nutrient enrichment (for example, eutrophication) and the associated water quality degradation that present problems. Nutrient enrichment of rivers stimulates primary production resulting in aquatic plant growth, and sometimes excessive algal growth. This risk is exacerbated by the loss (or non-regeneration) of riparian vegetation and consequent loss of shade over the stream, leading to increased light intensity and higher water temperatures during periods of low flow. These conditions favour the development of problematic algal blooms.

The key nutrients studied to date are nitrogen and phosphorus. Both can influence in-stream production. Both have multiple potential pathways into streams attached to sediment or in dissolved or colloidal forms, in surface or sub-surface flows, and in readily bioavailable or sequestered forms. Both have become increasingly available and more mobile following catchment development for agriculture or urban land uses. Improving the management of these nutrients has become a priority in many catchment plans, with targets established for their loads and/or concentrations in rivers and receiving waters.

Traditionally, algal blooms were believed to be triggered by high levels of phosphorus, because that was the nutrient that was believed to limit their growth. Research during the 1990s into inland Australian rivers showed that low river flow was the primary trigger for causing algal blooms, although the amount of phosphorus present in the waterbody could still control the size of the bloom that developed. This was because the damming of these inland rivers, and low but continuous water releases to meet the needs of irrigators over summer, had effectively turned them into a series of shallow lakes where thermal stratification occurred. This provided the necessary conditions for rapid algal population growth.

Although phosphorus can limit the size of the blooms, the research also demonstrated that, in contrast to the conventional view, nitrogen can sometimes limit phytoplankton growth. Consequently, a better understanding was required of the nitrogen cycle and its role in controlling algal biomass and species composition. The research described in this section builds on these findings.

The research that has been conducted has contributed to understanding the nitrogen cycle by investigating nitrogen that enters waterways from adjacent farmland (see Fellows et al. article page 16) — probably one of the sources that are most easily controlled by land managers. This work investigated the surface and sub-surface nitrogen movement through riparian zones and riverine sediments, and the potential of these zones to denitrify the dissolved nitrogen and thus remove it before it entered waterways. The chapter by Edgar and Davis (page 17) discusses the options available to manage algal blooms, while the final article for this section about the chapter by Gourley et al. (page 18) considers how management of fertilisers can be improved to reduce the amount of nutrients reaching waterways in agricultural areas.

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Near Captain's Flat, NSW. Photo Roger Charlton.

Managing diffuse nitrogen loads: in-stream and riparian zone nitrate removal

By Christine Fellows[1], Heather Hunter[2] and Michael Grace[3]

1. Griffith University,
2. Queensland Department of Natural Resources, Mines and Water,
3. Monash University

Riparian soils and in-stream sediments have the potential to reduce nitrogen loads reaching downstream environments, particularly through the process of denitrification (which converts nitrate to inert nitrogen gas). The microbes that carry out denitrification require organic carbon as a source of fuel, and an environment with low or no oxygen, conditions that are often met in riparian zones and stream sediments. Riparian environments favour denitrification when nitrate-containing groundwater passes through the carbon-rich root zone of riparian vegetation. Many factors influence the amount of nitrate removed, including the flow rate, nitrate concentration, soil properties and riparian setting.

Research comparing 16 sites from contrasting environments in south-east Queensland, Victoria and Western Australia showed similar rates of denitrification potential across the three regions for some soil types, although there were several distinct regional differences. At all sites, rates of denitrification potential were highest at the surface of riparian soils, with rates decreasing down the soil profile. Rates were relatively high for in-stream sediments, indicating their potential to remove nitrate within the water body itself.

Based on these findings, combined measurement of nitrate and organic carbon concentrations may provide a useful rapid assessment of the denitrification potential of riparian soils and in-stream sediments. Findings from this and other recent research (reported in full in *Salt, Nutrient, Sediment and Interactions*) have been used to propose guidelines for the management of riparian lands, with the focus on increasing the potential for denitrification and thereby reducing the loads of nitrogen entering surface water bodies.

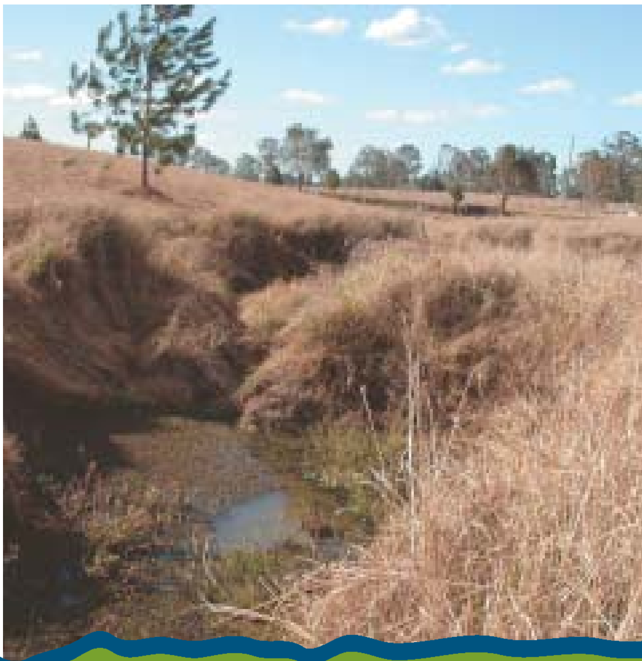
While these guidelines can enhance nitrogen removal in riparian zones, it should be emphasised that overall management strategies for nutrients should aim to minimise nutrients at their source.

In essence, the guidelines contain two main recommendations:

1. maintain and/or increase organic carbon levels in riparian soils, and
2. identify areas where conditions are optimal for denitrification to occur.

While the focus of these guidelines is on nitrogen management, they are also supportive of the aims and recommendations of many existing riparian guidelines, particularly those that seek to enhance riparian vegetation — for example, to improve stream and bank stability, stream-shading and temperature control, and terrestrial habitat. Overall, restoration of riparian vegetation will have multiple benefits which include enhanced nitrogen removal through denitrification, but also enhanced habitat for biodiversity, and stream and bankside shading to avoid temperature extremes. ■

Photos from the south-east Queensland study sites. A well-treed site at left, sparsely treed at right. Both photos Carol Conway.



Managing algal blooms in Australia

By Brendan Edgar and Richard Davis

Land & Water Australia

Algal growth depends on the availability and supply of the nutrients nitrogen and phosphorus, light and warm water temperature. Most inland rivers in Australia are slow flowing and have weirs placed along them for water storage, this slows the flow even further. Rivers often have high levels of turbidity (dirty water) that limits light penetration, and can become stratified with a warm surface layer of water over a colder bottom layer. This combination of low flows, stratification and turbidity favours blue green algal growth.

Most of the phosphorus and nitrogen found in rivers, storages and estuaries is located in the bottom sediments that have been eroded from the surrounding landscape over decades since the catchments were cleared for agriculture. These nutrients are released into the water column, particularly when the water column becomes stratified (not mixed) and the bottom waters turn anoxic (lacking oxygen), and can be an important factor in the onset of major algal bloom outbreaks.

The National Eutrophication Management Program (NEMP) 1995–2001 was established following community concern about outbreaks of algal blooms in rivers and lakes across Australia.

Some of the management techniques developed through the Program included:

- managing flows to reduce the stratification in the water column that promotes blue-green algal blooms,
- managing light penetration within waterbodies to control blue-green algal growth when light is the limiting factor — a common occurrence in Australia's turbid waters,
- using bio-manipulation to directly control concentrations and growth of blue-green algae,
- managing sediments in rivers, storages and estuaries so that the anoxic conditions favouring nutrient release and blue-green algae growth are avoided,
- managing nutrients so that they are not entering river systems in 'pulses' and promoting algal growth,
- controlling nitrogen to better manage algal blooms, and
- using tests to determine whether a particular waterbody is nitrogen or phosphorus limited and developing management strategies accordingly.

Fitzroy River Catchment, Qld. Photo Phillip Ford.

The findings from the NEMP are still relevant today, and chapter 5 in the new *Salt, Nutrient, Sediment and Interactions* book discusses the research and the practical management options that have been developed to improve management of nitrogen and phosphorus. It includes updated and more-detailed guidelines for managing nutrients. ■

Making better fertiliser decisions

By Cameron Gourley, Alice Melland, Raquel Waller, Ivor Awty, Andrew Smith, Ken Peverill and Murray Hannah

Department of Primary Industries, Victoria

Most Australian soils are old and weathered, and most have an inherently low nutrient status, particularly phosphorus, sulphur, nitrogen, and in the coastal regions potassium. Not surprisingly, fertiliser applications to pasture land have been a routine practice since as early as the 1920s. The application of fertiliser is still considered to be necessary by many farmers to replace nutrients removed, fixed or lost in pasture soils.

The Better Fertiliser Decisions project was conducted to provide comprehensive information to improve fertiliser decisions for grazing industries across Australia. National in scope, the project compiled and interpreted results from pasture-fertiliser experiments and information on nutrient loss processes from all relevant regions.

The response relationships are based on a large amount of data collated from an extensive national review of fertiliser — pasture response experiments conducted in the past 50 years. Sources of this information included peer-reviewed scientific publications, government and industry reports and unpublished data. All experimental data used in the development of the response relationships were standardised and met rigorous quality assurance criteria.

The project has delivered soil test–pasture response relationships and critical soil test values for phosphorus, potassium and sulphur differentiated at regional, state and national scales, and also by soil characteristics such as soil texture, and phosphorus buffering index. The project also developed an interactive database containing all the data submitted on pasture response to nitrogen, phosphorus, potassium and sulphur fertilisers. The database serves as a comprehensive resource for information about pasture-fertiliser response experiments and provides the capacity to accommodate new data in the future.

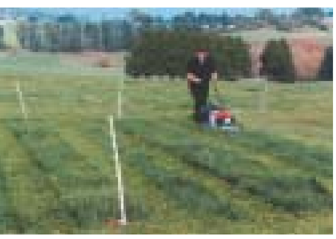
A Farm Nutrient Loss Index (FNLI) was developed, which is a decision support tool to assess the risk of nutrient loss from the paddock to the off-farm environment in the format of a user-friendly computer program. The FNLI was developed by collating regionally specific information on nutrient loss processes from scientific publications and existing data, and over 90 nutrient management researchers, extension experts and fertiliser company staff. The FNLI uses easily quantifiable inputs such as landscape features, climatic conditions, and pasture and stock management practices to calculate the risk of nutrient loss at the paddock scale and evaluate the effects of different management practices.

High or very high risk rankings using the FNLI indicate that aspects of the grazing system may need to be modified to minimise potential nutrient loss. Where a high or very high risk ranking is indicated, the main contributing factors are listed. These factors are intrinsic features of the landscape, such as surplus water and soil type, or imposed by management, such as stocking rate. Alternative management practices can be trialled to check strategies aimed at lowering the risk of nutrient loss.

More information about the project can be found at the Department of Primary Industries in Victoria — www.dpi/vic.au/dpi/, and also in a more detailed account of the research in chapter 6 of *Salt, Nutrient, Sediment and Interactions*. ■

'Making better fertiliser decisions for grazed pastures in Australia' which includes a Farm Nutrient Loss Index CD is available from CanPrint. Product code PK071334.

Research underway. Photos courtesy of the project team.



Land, Water & Wool — a whole lot more products...

More river and riparian information for woolgrowers has been produced in our three focus regions for the Land, Water & Wool Program. These products can be used by anyone working on river management in the three regions, and are of course particularly useful when working with the wool industry.

- South Australia — a Rapid Appraisal of Riparian Condition (RARC), a Report of the region-based project and three fact sheets (preventing creek erosion, managing weeds, and planned grazing management).
- New South Wales — a RARC, a Report of the region-based project and two fact sheets (managing gullies and managing in-stream wetlands).
- Tasmania — a RARC, a Report of the region-based project and an oral history collection called *Reflections of Tasmanian woolgrowers*.

The Land, Water & Wool Program has now come to an end, if you would like to learn about the key findings from not only the Rivers and Water Quality Sub-program but other areas such as native vegetation and biodiversity, climate and sustainable grazing on saline lands, get a copy of the final report: *Managing for sustainable profit*.

All these publications are available free of charge from CanPrint Communications (free call 1800 776 616) and from the Land, Water & Wool website at www.landwaterwool.gov.au

South Australian products

PX061155

PX071294

PF071289

PF071290

PF071291


New South Wales products

PF071292

PX071293

PF061166

PX061168


Tasmanian products

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The final report

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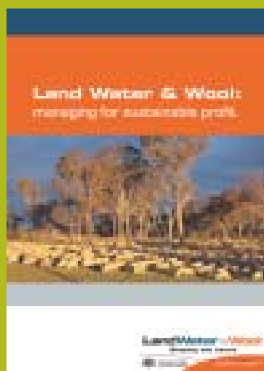
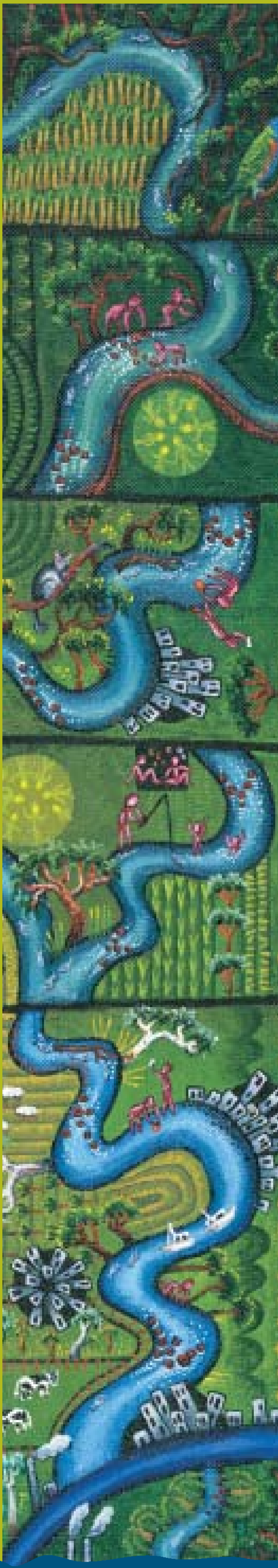
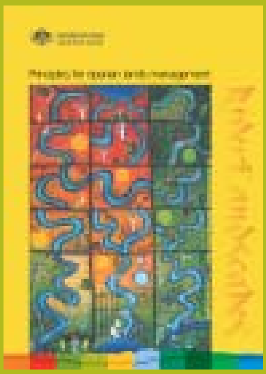


National Riparian Lands R&D Program workshop — now on the **www**

For those of you who attended one of the workshops in the series of National Riparian Lands R&D Program 'Researcher into the regions' you will know how beneficial participants found interacting directly with people such as Professor Ian Rutherfurd, Professor Peter Davies, Dr Amy Jansen, Dr Andrew Brooks, Dr Phil Price and Dr Siwan Lovett. Due to the demand for these workshops, and as part of our 'legacy' activities, we have now placed our final workshop, held in Melbourne on the 14th of February this year, on to the web. By clicking on **www.rivers.gov.au** you can access the workshop and hear the presentations as the PowerPoint slides automatically change. By doing this we hope that people can continue to access the findings from this great Program.

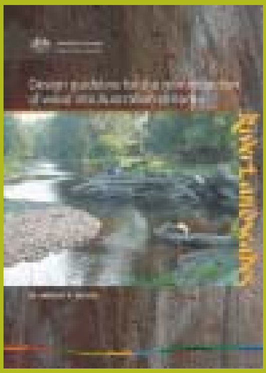


These great Rivers products are still available ...

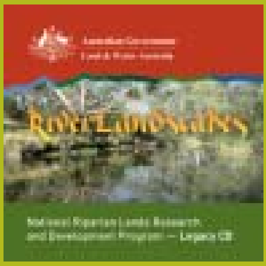


At the end of Phase 1 of the National Riparian Lands R&D Program we produced the two-volume *Riparian Land Management Technical Guidelines*. These became an important scientific reference document for anyone involved in riparian management. We have now updated these Guidelines and 'Principles for Riparian Lands Management' covers the main findings over the life of the Program. The authors of the chapters are those researchers that have been funded through the Program and include:

- Professor Stuart Bunn, Professor Peter M. Davies, Professor Ian Rutherfurd, Dr Andrew Brooks, Dr John Dowe, Dr Amy Jansen, Dr Siwan Lovett, Dr Phil Price and more!



This new guideline by Dr Andrew Brooks, provides some step by step design principles for reintroducing wood into different types of Australian rivers. Information about the research projects that have been undertaken in Australia are provided, with plenty of case study examples, practical tips, diagrams and photographs clearly explaining the different strategies available for using wood to restore rivers. To hear about the guideline visit www.rivers.gov.au and click on 'Feb 2007 No Frills workshop' where you can follow the PowerPoint presentation on this topic and hear about it direct from Andrew.



The Legacy CD-ROM brings together all the research, publications, tools and key scientific references from the 13-year National Riparian Lands R&D Program onto one easy to access product. The material is organised against eight management issues for those that want to understand a particular riparian issue and how the science that has been undertaken supports recommended practical guidelines. For users that don't want to access the information by management issue, alternatives are provided so the CD-ROM also works like a website, containing all the information from the Program.

... and all are FREE

www.rivers.gov.au provides access to all these products and information about River Contaminants workshops.

Sediment as a contaminant

Globally, sediment is probably the most common river contaminant. While sediments play a beneficial role in the functioning of river systems by providing a substrate for biological and chemical processes, excess quantities of sediments cause a range of problems. The balance between sediment and river flow is also important, and both can change with catchment development and changes in land use. In a sediment-starved river the banks and bed may erode, while excessive amounts of sediment may remain in the river as sand or gravel 'slugs'.

Coarse sediments alter river habitats by infilling pools and destroying these drought refuges, while finer particles can clog bed interstices thus degrading benthic habitat. Large-scale sediment deposition buries entire riffle-pool reaches, replaces diverse river habitats with uniform sand beds, and creates zones of wide shallow flow subject to greater temperature extremes and at risk of invasion by aquatic weeds. Fine sediments that are carried in suspension interfere with the breathing and feeding of many river animals, for example, favouring fish (such as carp) that are not visual feeders. By increasing turbidity, and hence reducing light penetration, suspended sediments also reduce submerged plant photosynthesis and alter the light regime for phytoplankton. This can favour toxic cyanobacterial species that are able to regulate their cell buoyancy and hence move into the narrow upper light zone.

Finally, many agrochemicals, heavy metals and nutrients chemically bind to sediments. Consequently, sediments provide a transport mechanism for these contaminants as well as a substrate where they can react. Thus, any complete examination of river contaminants needs to consider both the direct effects of sediment, as well as the role of sediment in transporting and transforming other contaminants. The next two summaries of chapters in the new *Contaminants* book discuss different aspects of managing sediment within a catchment context. ■

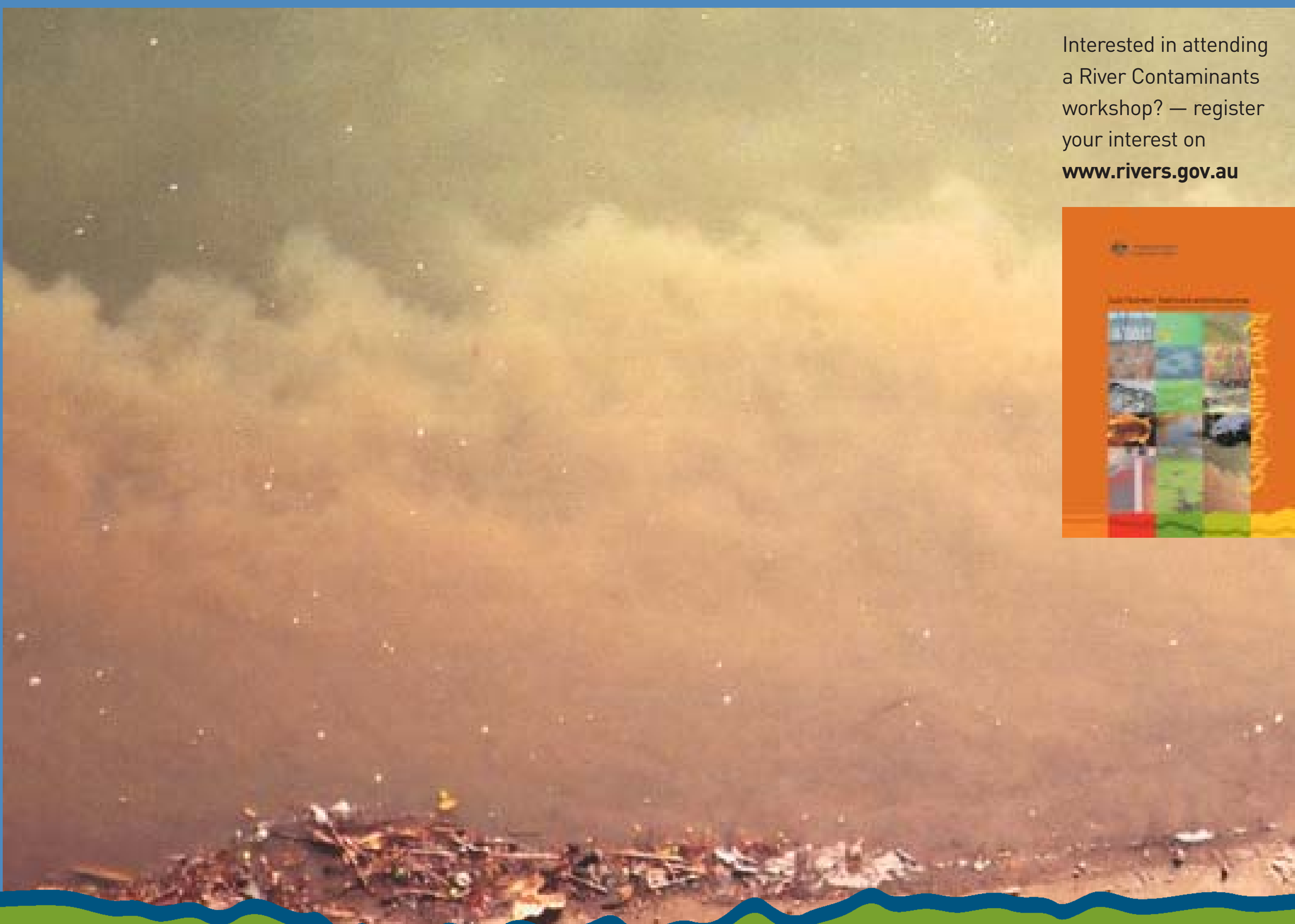


Photo Phillip Ford.

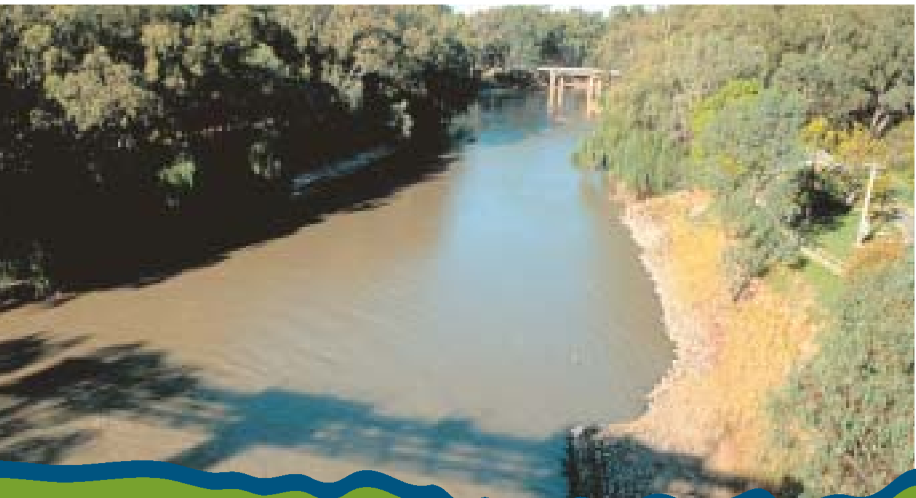
Interested in attending a River Contaminants workshop? — register your interest on **www.rivers.gov.au**

Identifying sources of sediment in river basins to help develop revegetation priorities

By Scott Wilkinson and Cris Kennedy
CSIRO Land & Water

The changes man has made to the Australian landscape since European settlement have had a significant impact on our river systems. Sediment eroded from gullies, hillslopes and river banks is transported in faster-moving river reaches, and accumulates in slower ones. In some situations this delivers much-needed nutrients, but in other cases it leads to increasing turbidity that reduces production of plankton and algae, and hence, the amount of the food and oxygen available to aquatic life. Transport of suspended fine sediments brings nutrients as well; in Australian rivers around 75% of phosphorus is transported attached to sediment particles. Sediment has a similarly important role in the transport of agricultural chemicals and heavy metals. Coarser sediment can settle along the stream bed, replacing diverse and stable riverine habitats "with flat sheets of coarse sand and gravel extending for kilometres".

Trying to redress these changes to the landscape in order to improve water quality and the health of aquatic ecosystems, is a significant challenge for our land and water managers. The National Land & Water Resources Audit found that suspended sediment loads were typically 10–50 times pre-European levels in many river systems, and that tens of thousands of kilometres of rivers were affected by sand and gravel accumulation resulting from upstream erosion. Organisations across Australia are now trying to improve management of these impacts and in some regions water quality targets have been legislated. SedNet is one tool that can assist the development of strategies to most effectively reduce sediment loads and meet those targets.



SedNet is a modelling tool developed to assess spatial patterns in the sediment sources and sediment transport at the river basin regional scale. It has enabled catchment management agencies to target areas for riparian restoration, and implement measures to reduce bank and soil erosion. The SedNet tool can be used to identify the primary sources of sediment that is carried by rivers, and to model the relative costs of different management interventions to achieve catchment sediment targets.

The SedNet software is available as a free download that uses GIS data layers to predict spatial patterns in the sediment and nutrient fluxes, and to identify the upstream sources of impacts on downstream water quality and sedimentation. It is suitable for use by environmental consultants and natural resource management agencies with GIS, catchment hydrology and erosion assessment expertise.

SedNet is a tool that can help a wide range of land and water managers to make the most informed decision when targeting land rehabilitation to reduce erosion into the river network, allowing proposed management strategies to be simulated in the model, so that the predicted outcomes of alternative management actions can be considered and costed.

SedNet is being used to develop water quality improvement strategies in a number of focus catchments, and managers report the approach has enabled them to target areas for riparian protection, bank erosion and catchment erosion activities. The tool enables them to address the source of erosion and sediment problems, rather than using a random approach throughout the catchment. This targeted approach has been accepted by catchment management authorities and their partners in land management, as well as being used to target grant proposals. SedNet has already found use in identifying strategies to reduce sediment and nutrient export to the Great Barrier Reef, Moreton Bay and the Gippsland Lakes, as well as assisting management of sediment sources to Sydney's main water supply catchment. ■

A weir on the Murrumbidgee River near Maude, NSW. Photo courtesy CSIRO Land and Water.

Budgeting and monitoring for sediment and nutrients at the catchment scale

By Myriam Bormans[1], Phillip Ford[1], Arthur Read[1] Heather Hunter[2], Rob Dehayr[2] and Christine Fellows[3]

1. CSIRO Land and Water,
2. Queensland Department of Natural Resources and Water,
3. Griffith University

Sediment and nutrient inputs into aquatic systems have considerably increased since European settlement of Australia, however, the ecological effect of these changes is still relatively unknown. Carbon (C), nitrogen (N) and phosphorus (P) exert a bottom-up control on aquatic ecosystems and in many situations the processing of these nutrients has changed dramatically as a result of catchment land use and modifications to our waterways. This, in turn, can alter the composition and biomass of primary production with follow on effects up the food chain. The cycling of C, N and P are intimately linked because N and P cycles include a significant organic component, and because the response of an ecosystem is dependent on the ratios between these elements and their forms, not just the concentration of an individual element.

While the ecological effects of sediment and nutrient inputs in Australian rivers are relatively well understood, there is limited quantitative information about the effects of human induced, land-based processes on delivery of nutrients and sediments to rivers. Environmental researchers and catchment managers alike need to understand the pathways of nutrient movement (source, transport and transformation) to be able to successfully manipulate the nutrient cycle and set priorities aimed at reducing sediment and nutrient inputs.

Nutrient and sediment budgets at the sub-catchment scale, which account for inputs, outputs and changes in materials stored in the river, have the potential to generate the knowledge required to underpin management decisions. However, the construction of such budgets is constrained by the need for extensive data sets derived from long-term monitoring. This project developed budgets derived from both observations and modelling. Use of information from modelling has the potential to reduce monitoring costs and widen the application of nutrient and sediment budgeting.

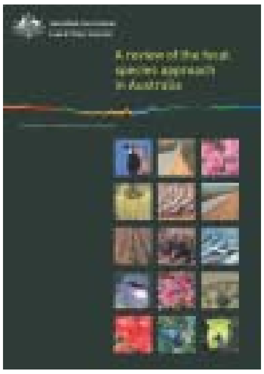
Regional nutrient (N and P) and sediment budgets for four catchments with different land uses, soils, and hydrological regimes showed wide variations in the dominant sediment source (hillslope, bank and gully erosion) between catchments. The computer models SedNet/Annual Network Nutrient Export and Hydrological Simulation Program–Fortran were applied in the Johnstone River catchment to predict annual dissolved nutrient and sediment loads. There was good agreement between the models and direct observations, increasing confidence that either of the models could provide realistic end of catchment loads.

Sediment and nutrient budgets provide a method for predicting the level of sediment and nutrient inputs to waterways over time. The four catchments studied in vastly different environments have given a picture of how sediment and nutrient generation and loss change with environmental conditions. The study also highlighted the importance of carefully designed monitoring programs which reflect the purpose for which data is being collected and identified necessary improvements to the models being used for sediment and nutrient budgeting in these catchments. ■

Above: Brisbane River. Below: Murrumbidgee River at Darlington Point. Photos courtesy of the project team.

RAPt in rivers

FOCAL SPECIES



Focal Species Approach reviewed

Land & Water Australia recently commissioned and published *A review of the focal species approach in Australia*.

The focal species approach (FSA) involves the identification of a set of species for the management of key threatening processes such as habitat loss, modification and fragmentation, predation, salinity, resource depletion, and inappropriate fire regimes. One or more focal species are identified for each threat or threatening process.

In recent times, the FSA has been widely adopted in extensive agricultural zones in southern Australia, sometimes with a limited application of the science behind the approach or without proper consideration of the strengths or weaknesses of the approach. With this in mind, the review undertook to:

- review current trends and clarify the FSA scientific debate,
- summarise and synthesise key findings from Land & Water Australia-funded research based on the focal species approach,
- identify key messages and opportunities for knowledge exchange, including the need for and targeting of case study analyses, and
- inform future strategic R&D investment in landscape design principles.

The review will be particularly useful to groups developing revegetation plans, especially those based on multi-species recovery, or to those groups who have adopted the FSA and wish to evaluate its performance or application.

The review can be downloaded from the Land & Water Australia website at www.lwa.gov.au or ordered free of charge from CanPrint by calling 1800 776 616 quoting product number PR071247.

ENVIRONMENTAL FLOWS

Managing environmental flows to wetlands

Water is an essential resource for Australia's future prosperity and for the well-being of its population and environment. Good management of our water resources is essential, particularly in the face of a protracted drought and uncertainty from long-term climate change.

In recognition of this, Land & Water Australia's Environmental Water Allocation R&D program partnered with the Department of the Environment and Water Resources and the National Water Commission to co-host an Australian Government feature session at the recently held 10th International River*symposium* & Environmental Flows Conference in Brisbane.

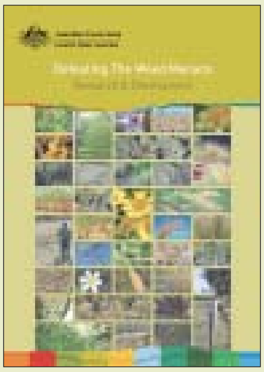
While Australia has developed a good understanding of the watering needs of coastal and inland wetlands, putting this knowledge into practice raises significant issues. The LWA session explored issues such as how to acquire water, how to deliver water so that it benefits wetlands, how to avoid harm to other water users and how to monitor the results. Panellists included researchers, water managers and policy makers who drew on experience to discuss these practical issues. A report on this LWA session titled 'Knowledge for Watering Wetlands: Scoping, impediments and challenges' will be available in late October from the website lwa.gov.au/ewa

The Department of the Environment and Water Resources featured a session titled A National Plan for Water Security — Water for the Environment, with presentations on methods of water recovery, prioritisation of use of available water, governance and related decision making arrangements.

The National Water Commission concluded the Australian Government feature with a panel session that examined the importance of maintaining rigour in both the definition and management of environmental flows.

For a review of the River*symposium* and the Australian Government feature sessions, see www.riversymposium.com

WEEDS



Research to defeat weeds

The Defeating the Weed Menace R&D component managed by Land & Water Australia has recently contracted a second round of research projects. The first round call for research contracted 14 projects under the following four research themes:

1. Developing best practice early detection, survey and eradication of potential weed species.
2. Assessing risk of different pathways of weed ingress.
3. Identifying biological control agents for priority weed species.
4. Land use change on weed incursion.

More recently, a second round call for research has contracted a further 11 research projects under the themes of:

- developing new integrated weed management strategies that incorporate an understanding of landscape scale ecological processes,
- developing efficient methods for surveying and eradicating agreed emergent weeds, and
- quantifying the impacts of weeds on sustainability and the environment (including the ecological costs of weeds) and the relative benefits and costs of different control measures.

In total, 25 research projects will have been contracted with the likelihood of further research being commissioned on priority knowledge gaps. All projects are due to conclude by mid-2008.

For further information on the Defeating the Weed Menace R&D component download these publications and visit www.lwa.gov.au/weeds or contact Judy Lambert on (02) 9948 7862, e-mail judy.lambert@lwa.gov.au

GROUNDWATER

How much groundwater is there?

A new report more closely identifying the mechanisms that link surface water (rivers) and groundwater (aquifers) has identified the serious implications double counting has for water use and water planning. *The Impact of Groundwater Use on Australia's Rivers* is the outcome of a year-long Land & Water Australia Senior Research Fellowship by Dr Richard Evans, Principal Hydrogeologist with Sinclair Knight Merz.

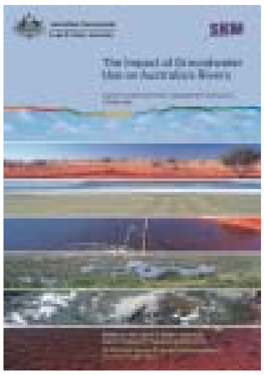
"Groundwater and surface water are often closely linked. However, at times, we have over-estimated our total water resource by treating them as different; we have sometimes allocated the same resource twice," Dr Evans said.

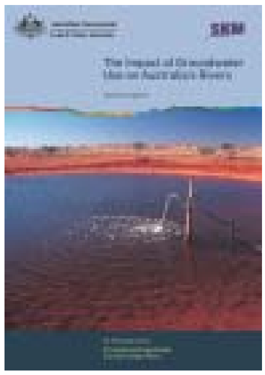
The relationship between groundwater pumping and stream flow is complex, with a range of time lags depending on local and regional factors. Between the start of pumping and the impact on the stream, the lag can be days, years or centuries.

Land & Water Australia Executive Director Dr Michael Robinson said this report is an important contribution to the current focus on our precious water resources.

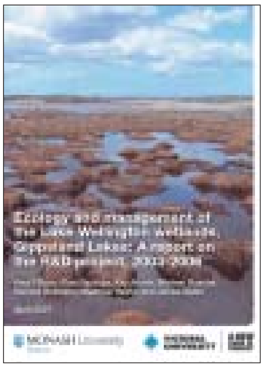
The internationally peer-reviewed technical report is available electronically or in hard copy through Land & Water Australia's website at www.lwa.gov.au as a full report or a summary version.

These reports can be ordered from CanPrint by calling 1800 776 616 quoting product numbers PR071282 (main report, on left) and PR071283 (technical report, on right).





Ecology and management of the Lake Wellington wetlands, Gippsland Lakes: A report on the R&D project, 2003–2006

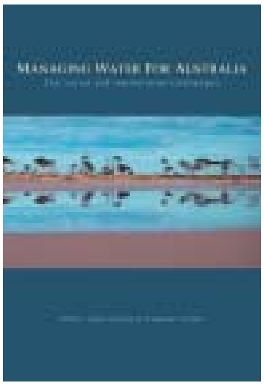


By Paul Boon, Elisa Raulings, Kay Morris, Michael Roache, Randall Robinson, Matthew Hatton and Jacqui Salter

This handbook has been produced from the results of a four-year R&D project undertaken on the wetlands that fringe Lake Wellington in the Gippsland Lakes of south-eastern Victoria. The information contained in the handbook is intended to assist in improving public knowledge, building capacity in the broader community, and prompting discussion about the management of wetlands.

Limited hard copies are available by contacting Dr Paul Boon at Victoria University on paul.boon@vu.edu.au or by viewing the publications page on Land & Water Australia's Environmental Water Allocation program website at lwa.gov.au/ewa

Managing Water for Australia: The Social and Institutional Challenges



Edited by Karen Hussey and Stephen Dovers

Australian water policy and management are undergoing rapid and immense change in response to drought, technological advances, climate change and demographic and economic shifts. The National Water Initiative and the 2007 Australian Government water policy statements propose a fundamental shift in how Australians will use and manage water in the future. The implementation of the national water policy presents many challenges — the creation of water rights and markets, comprehensive water planning, new legislative settings, community participation in water management, linking urban and rural water management, and more. *Managing Water for Australia* brings together leading social sciences researchers and practitioners to identify the major challenges in achieving sustainable water management, to consolidate current knowledge, and to explore knowledge gaps in and opportunities for furthering water reform.

Copies are available from CSIRO Publishing for $45.95 through www.publish.csiro.au or contacting 1300 788 000.

River*symposium* 2007—call for action

All water users: government, business, scientists and the general community, need to take urgent action if we are to save our dying rivers, according to participants at the 10th International River*symposium* & Environmental Flows conference. The conference ended with an agreement that we have most of the science needed to get on with the job, but the challenge now is gaining agreement from society, particularly governments, for implementation. A call for action ended the conference and you can add your vote if you would like to get involved.

Brisbane Declaration — call for action

- Exchange scientific and engineering expertise.
- Incorporate environmental flows in climate change adaptation strategies.
- Incorporate environmental flows in design and operation of water infrastructure.
- Integrate environmental flows in water planning and management.
- Develop and enforce environmental flows in laws and programs.
- Engage community and stakeholders in consultation on, and implementation of, environmental flows.
- Realign incentives for implementation through innovative payment and market arrangements.

Individuals and institutions can endorse the Brisbane Declaration by sending an e-mail to River*symposium* Program Coordinator Dr Selina Ward s.ward@cms.uq.edu

Interactions between contaminants

While understanding and managing river contamination by single substances might be relatively straightforward, very little is known about the synergistic or antagonistic effects of different contaminants. Different contaminants may chemically interact during transport or once deposited, and the ecological responses to 'cocktails' of chemicals are likely to be wide-ranging and complex. The interactions between contaminants, the net ecological responses, and the links back to catchment and river management options are relatively unexplored in catchment-scale research.

The largest gaps in our understanding are those related to the interactions between contaminants, both in terms of how they interact physically and chemically in transport or in storage, and in terms of the complex responses of aquatic biota to mixtures of contaminants. While relatively simple experiments can provide information about the tolerances and responses of individual organisms to particular contaminants, or even combinations of contaminants, scaling these results up to predict ecosystem level response is extremely difficult. The combination of detailed experimental work with medium-scale field test and large-scale system modelling is likely to be the best way to advance our understanding.

The following three summaries of chapters in the just-released *Salt, Nutrient, Sediment and Interactions* book examine this problem from different perspectives. Chapter 9 by Darren Ryder and Sue Vink studies the interactions between flow and contaminants at a range of scales, and comments about implications for management of environmental flows. In chapter 10, Barry Hart and colleagues consider the role of Ecological Risk Assessments in helping managers and communities make difficult decisions under conditions of uncertainty and incomplete data, with two practical examples; it emphasises the importance of monitoring to evaluate and improve decision-making. Chapter 11 discusses work undertaken by Lachlan Newham, Susan Cuddy and others on the role of models in helping to scale up from processes to catchment-scale targets, again with examples drawn from NRCP research. Following these summaries is an article about other work funded by Land & Water Australia that is also examining contaminant interactions within a catchment. ■

Wyangala Dam, NSW. Photo courtesy Lachlan Newham.

Interested in attending a River Contaminants workshop? — register your interest on **www.rivers.gov.au**

Managing regulated flows
and contaminant cycles in floodplain rivers

By Darren Ryder[1] and Sue Vink[2]

1. University of New England,
2. University of Queensland

Understanding ecosystem processes such as nutrient cycling, primary production and respiration (metabolism), and their integrated response to present day contaminant and flow regimes, is critical for the management of regulated rivers to improve river health and sustain industries and populations reliant on water resources. Identifying the sources and sinks of contaminants such as nutrients, salts and sediment at multiple spatial scales (e.g. catchment, sub-catchment, reach, habitat) is important for all river systems where environmental flow regimes are developed with the aim of improving river health. This information also allows for the identification and prioritisation of restoration initiatives such as riparian and corridor plantings in catchments identified as contributing disproportionately high loads of contaminants.

Using the processes and protocols developed through this research, priority areas for river and landscape management can be identified. For example, unregulated tributaries in the upper reaches of catchments can hold significant stores of salts and nutrients within the stream channel that are readily mobilised during small rainfall events. This can have localised detrimental effects on river function.

Understanding the cycling of contaminants throughout the year is an important component of managing the health of regulated river systems. The first irrigation flows for the season can have elevated contaminant loads from scouring of contaminants stored within the channel under preceding low flow conditions. The use of environmental flow releases that precede water used for irrigation will help dilute and transport this material out of the system rather than deliver it to irrigation areas

Research has also shown that catchment run-off events can have a different chemical character and, consequently, a quite different ecological significance to releases from dams. Managers therefore need to consider if topping up small runoff events with low-nutrient water from large dams (without entraining material from the floodplain) will meet the goals for these environmental water releases.

The work reported in this chapter has developed a framework for understanding contaminant cycles in rivers that can be tested in regulated systems throughout Australia and the world. The framework relies on an understanding of where the contaminants are in the landscape (from catchment to habitat scales) and how each of these interact with flow regime. Armed with this knowledge, we can better tackle the sustainable use of water resources for industry, society and the environment. ■

Right: Biofilms on snags are often hotspots for primary production as well as a source and sink for riverine contaminants depending on flow conditions. Below: Large dams play an important role in regulating the transport of nutrients, carbon and biota in rivers. Photos courtesy of the project team.

Risk-based approaches for managing contaminants in catchments

By Barry Hart[1], Carmel Pollino[1], Andrea White[1], Michael Grace[1], Mark Burgman[2], David Fox[2], Jan Carey[2], Yung En Chee[2], Brent Henderson[3] and Elisabeth Bui[3]

1. Monash University,
2. University of Melbourne,
3. CSIRO

Natural resource managers currently have few quantitative tools to assist them in identifying which of their environmental assets are at greatest risk from degradation and then to decide upon the best options for managing these risks. Risk-based approaches are increasingly being used in natural resource management. An Ecological Risk Assessment (ERA) framework initially developed for the Australian irrigation industry is available and applicable for assessing risks to all natural resources.

*Freshwater catfish (*Tandanus tandanus*). Photo Gunther Schmida, courtesy Murray-Darling Basin Commission.*

A major difficulty with the ERA process is to obtain a quantitative analysis of the key risks when there is a large degree of uncertainty — the case for many situations. Bayesian Network modelling is a relatively new technique that shows great promise in this area. By listing and linking the major factors and processes that are thought to influence the desired outcome, and ascribing probabilities to them, it is possible to 'sensitivity test' to determine which are the most significant to measure, monitor or manage.

As part of this NRCP research, examples are provided of the development and use of Bayesian Network models to quantify the ecological risks to a) a *Eucalyptus camphora* wetland, and b) freshwater catfish in the lower Wimmera River (environmental flows). Such Bayesian Network models will eventually be used to link catchment contaminant reduction targets (e.g. end-of-valley targets for nutrients, salinity and sediment) with the ecological benefits in receiving water bodies.

New guidelines for monitoring and assessment programs associated with Ecological Risk Assessments are now available as a result of the work undertaken through this project. ■

New products: Knowledge for Regional NRM

Land & Water Australia's Knowledge for Regional NRM Programme is developing products and services to make it easier for Australia's 56 regional NRM bodies to find, use and share knowledge and information. Two products are now available.

The Regional Knowledge Resource Kit (RKRK) is an interactive online resource for learning about managing information and knowledge for regional NRM. It includes a stage-by-stage guide to preparing a Regional Knowledge Strategy and reference resources covering a wide range of information and knowledge management topics. The RKRK is now online at www.rkrk.net.au

The NRM Toolbar is an internet tool designed for easy finding and sharing of digital resources. It includes a customised search engine connecting to NRM-specific Australian websites. The first version of the NRM Toolbar is now available at www.nrmtoolbar.net.au

The role of modelling in catchment management

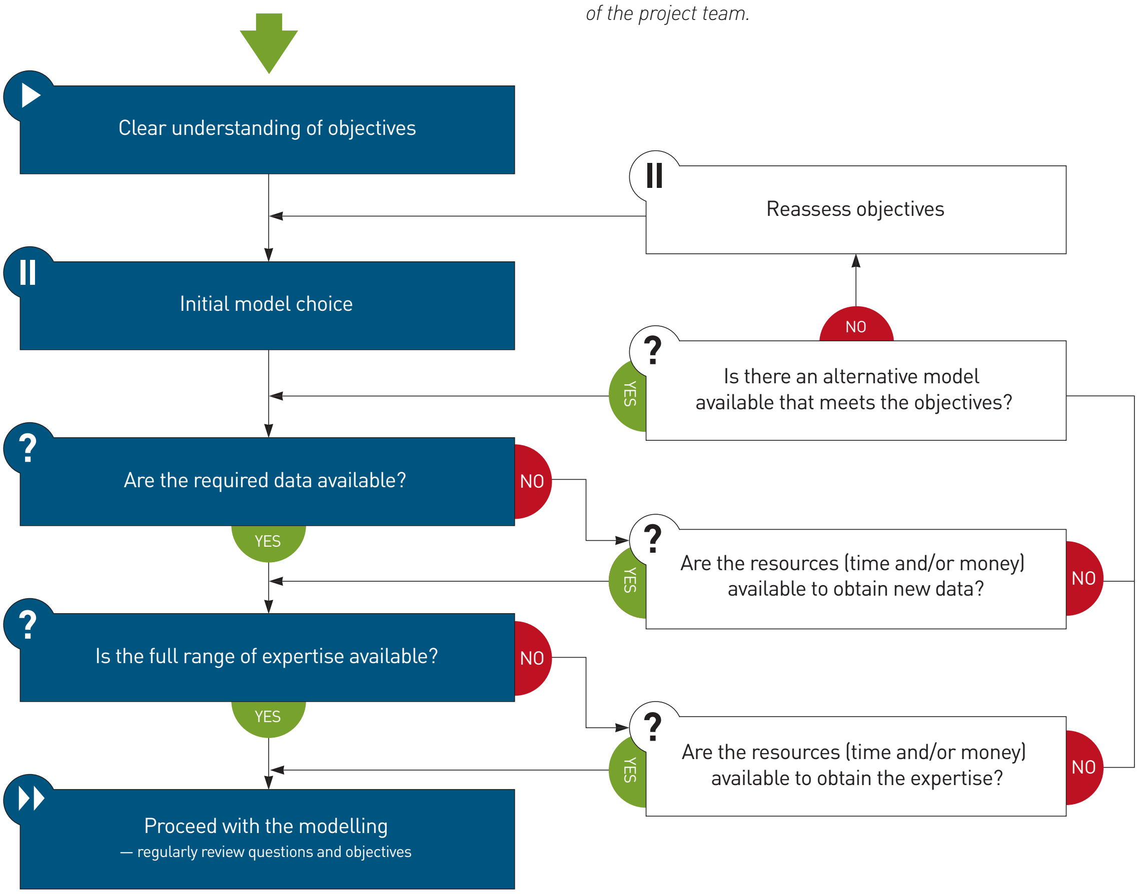
By Lachlan Newham[1], Susan Cuddy[2], J. Christopher Rutherford[3], Anthony Jakeman[1]

1. Australian National University, 2. CSIRO Land and Water, 3. National Institute of Water and Atmospheric Research, New Zealand

Models are increasingly being used to support catchment management, especially to set targets and to develop management strategies aimed at meeting those targets. Careful consideration is needed to identify the appropriate role of modelling in the context of target setting for catchment management.

The process of model development and implementation needs to be well planned and carried out with consideration of guidelines of good modelling practice to ensure reliability in outputs, transparency in decision making and continued use and development of modelling capacity. Modelling is a potentially key element in the adaptive management cycle and effort needs to be invested in incorporating improved feedback into the cycle, particularly through well targeted monitoring and assessment of the efficacy of remediation measures. Chapter 11 of the new *Contaminants* book discusses the use of models and provides some examples of where they have assisted target setting processes. ■

Stream flow gauging site, Gudgenby River, ACT. Photo courtesy of the project team.



Key questions in choosing a model for practical application.

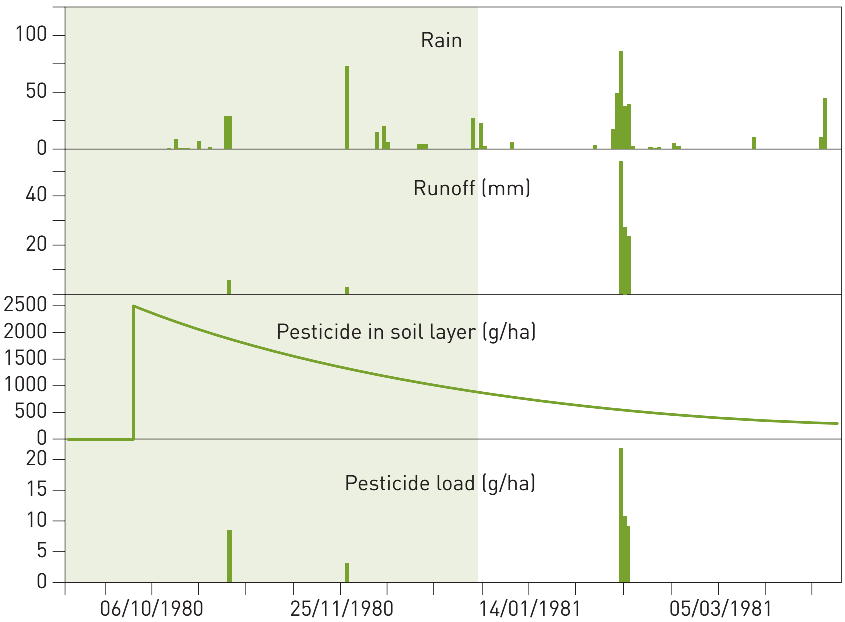
Improving water quality from grain farming catchments — from scientific understanding to delivering at the farm and catchment gate

By David Freebairn, Dan Rattray, Norm Gurner

The grains industry is increasingly being inspected for its environmental credentials. Monitoring and research studies have shown that flows from agricultural catchments often contain sediment, nutrients and herbicides. While high sediment loads are clear for all to see, awareness of chemicals in runoff water is low.

A number of projects funded by the Grains Research and Development Corporation (GRDC) and Land & Water Australia (LWA) have contributed to an improved understanding of the dynamics of sediment and dissolved chemicals within agricultural landscapes. Nested catchments in southern Queensland provided the venue for exploring the role of management, scale and hydrology on pollutant movement, and the impact of management in reducing loads and concentrations. Detailed studies under more controlled conditions used rainfall simulators, while a water balance model (Howleaky?) was modified to integrate findings from the various studies and provide a tool for exploring "what if" scenarios. Howleaky?, a water balance model which explicitly considers tillage, crop type and agri-chemical applications was developed to integrate data from different studies and also to facilitate a wider range of users to access this analytic capacity. Its graphical interface aims to demystify the "nerd' element of computer models, allowing the user to more easily look inside the model. Howleaky? provides estimates of runoff, erosion, pesticide and phosphorus losses from any specified soil type and management. Daily water balance accounting allows us to explore likely outcomes for a wide range of soil types and landuses, and is anchored in reality using field measurements from the many studies. One challenge in dealing with environmental issues is building awareness in the target group without being alarmist or confronting. Australian farmers have always been quick to adapt to new challenges when they are aware of the issues and have viable options presented to them. In order to improve awareness and support decision making on the farm, a paper based assessment checklist has been developed to explore risks of chemical

***Figure 1**. Output from a daily water balance model (Howleaky?) used to analyse risks associated with different herbicide management options. Note that the high runoff is needed when soil concentrations of chemical are high to move high loads.*



Dan Rattray collecting a water sample in Hodgson Creek catchment on the eastern Darling Downs.

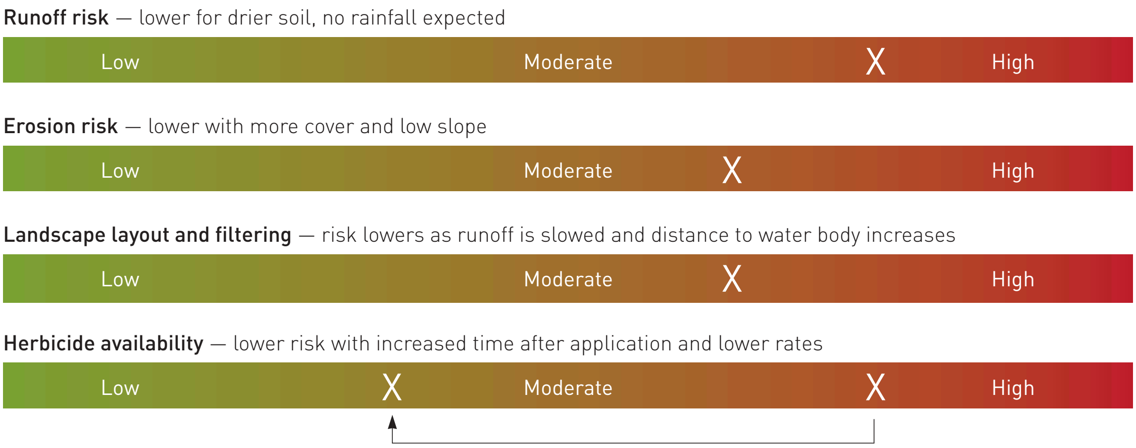


***Figure 2**. Example of the Pesticide in Catchment (PIC) checklist. High runoff and erosion risk and high chemical load make this a risky situation as the paddock is near a stream. A split application of a residual herbicide lowers the risk of chemical loss.*

losses on any paddock. If a high risk situation is identified, then either tactical or strategic changes can be made.

Progress requires providing a suite of positive management options once the issue is understood. A Best Management Practice manual supports suggested improvements. This approach has proven effective in engaging farmers who are quite dependent on residual herbicides in their production systems.

The range of approaches used in these studies (catchment studies for ground truth, process studies to fill in gaps, models to integrate and provision of decision support and information tools) now give the grain industry tools to better use valuable chemicals in a safer manner. In most cases, the use of residual chemicals is crucial to maintaining high soil cover so essential to reducing erosion and preventing high sediment loads getting into streams.

Further details can be found at http://www.grdc.com.au/growers/res_summ/dnr00002/index.htm)

This research program has been supported by funding from the Grains Research and Development Corporation, Land & Water Australia and the Queensland Department of Natural Resources and Water. ■

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Chemicals and sexual chemistry in Australian riverine environments

By Rai Kookana, Anu Kumar, G.G. Ying, Marianne Woods and Ali Shareef

In recent years, it has become increasingly evident that exposure to certain chemicals can interfere with the normal functioning of endocrine, reproductive and immune systems in wildlife. Such chemicals are generally referred to as endocrine disrupting chemicals or EDCs. EDCs are a very diverse group of chemicals, including natural and synthetic hormones, some pesticides, pharmaceuticals, flame retardants, cosmetic ingredients, plasticisers and natural products such as plant-derived estrogens. These substances may alter the function of hormonal systems by mimicking the effects of natural hormones, blocking their normal action, or by interfering with the synthesis and/or excretion of hormones. Evidence on the effects of exposure to endocrine disrupting chemicals on wildlife is substantial, including some reports from Australia (Figure 1).

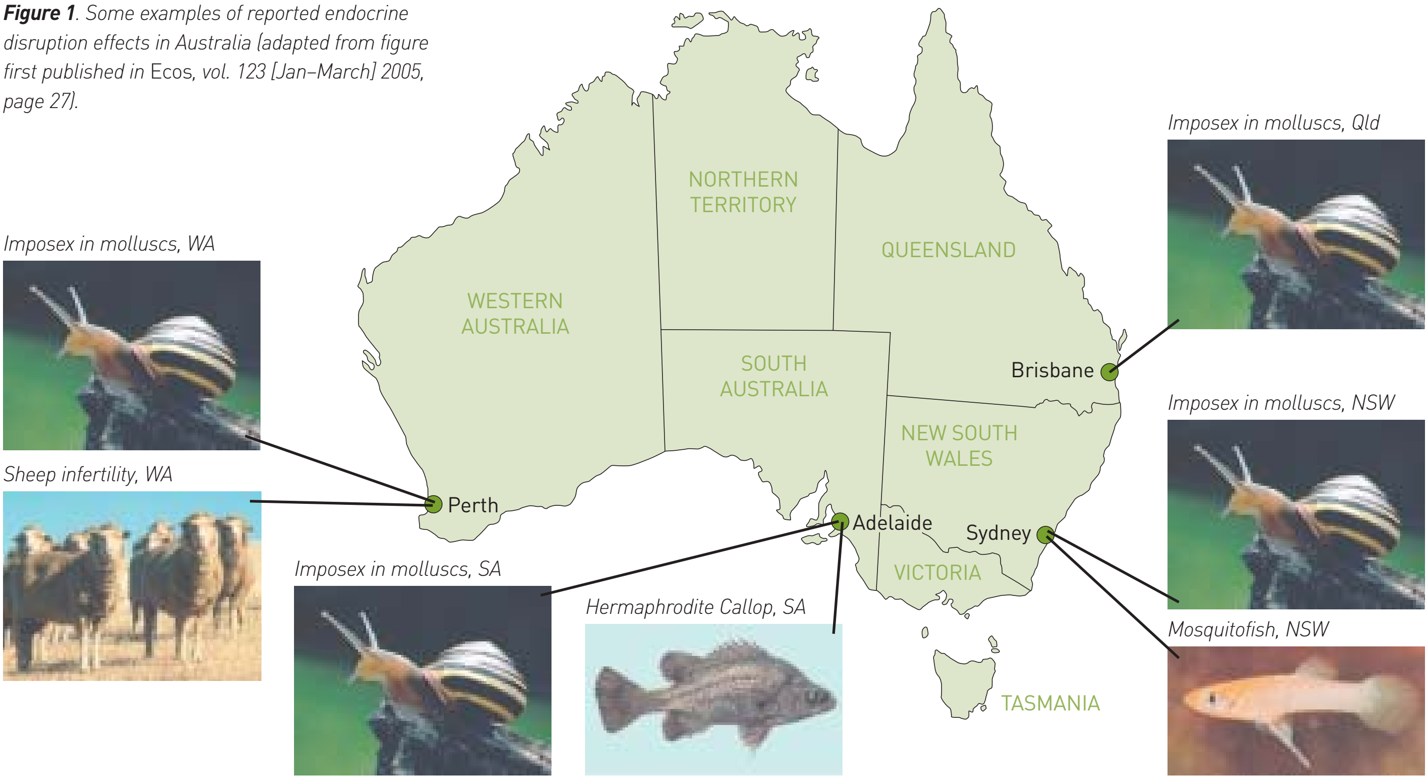
Endocrine disruption effects reported so far in Australia include:

- abnormal reproductive and developmental functions in offspring of women who took DES (diethylstilbestrol) and thalidomide drugs for preventing miscarriages and morning sickness,
- imposex (females with male sex organs) of molluscs in harbours caused by TBT (tributyltin) in antifouling paints,
- decreased fertility of sheep in Western Australia caused by phyto-estrogen in pasture grasses, and
- decreased breeding success of the peregrine falcon in South Australia being associated with high organochlorine residues from pesticide use.

Discharge of treated wastewater or effluent from sewage treatment plants is one of the common sources of EDCs in the environment. However, their sources are many and varied; e.g. from industrial, agricultural and mining industries (Figure 2). The lack of sound scientific data on levels and exposures to EDCs in the Australian environment is the principal knowledge gap in characterising risk.

Land & Water Australia and CSIRO jointly initiated a three year project to develop a better understanding of the potential risks of EDCs in the Australian riverine environment. The study shows that levels of certain EDCs, such as hormones and alkylphenols, are detectable in our riverine environments, especially in some rural streams with low flow, at concentrations that have been reported overseas to have an adverse effect on aquatic organisms, even when the compounds are considered individually. The additive effect of low doses of EDCs may have a more serious effect on aquatic organisms. Despite short half-lives, the compounds may accumulate in aquatic systems under continuous discharge of effluents

Figure 1. Some examples of reported endocrine disruption effects in Australia (adapted from figure first published in Ecos*, vol. 123 [Jan–March] 2005, page 27).*



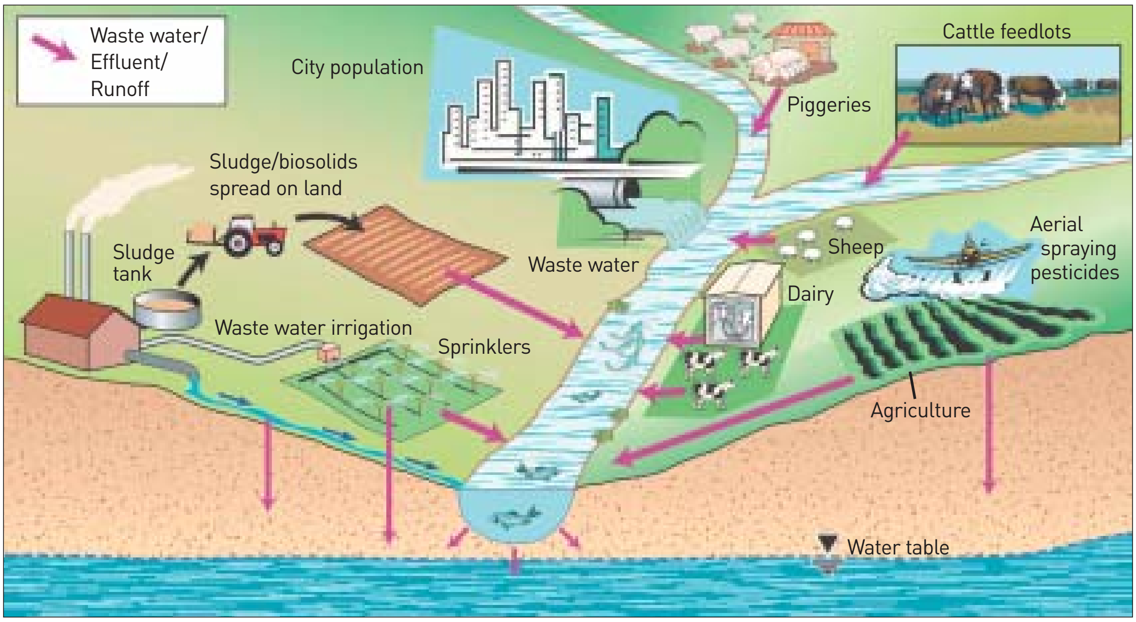


***Figure 2**. Common pathways through which the EDCs can potentially enter the riverine environment in Australia.*

For further information

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as the compounds may not undergo sufficient biodegradation before being replenished.

The study also indicated that animal operations (diary, feedlots, poultry farms) may be a significant source of EDCs in the riverine environment, even greater than domestic sewage due to higher levels of hormones excreted and less sophisticated effluent treatment in some cases. However, the current study could only test a limited number of samples. Furthermore, dairy effluents are generally dispersed on land through irrigation and not discharged directly into the riverine environment. However, considering the detections of EDCs in dairy production regions, the runoff from fields receiving dairy, beef cattle, pigs and poultry effluents needs to investigated.

The EDCs that may be present in reclaimed wastewater or treated effluent used for irrigation are not likely to accumulate in aerobic soil environments. Owing to their hydrophobic nature, most of these chemicals, especially the alkylphenols and estrogens are expected to sorb onto the organic matter in surface soil, and degrade under aerobic conditions. Therefore, application of treated effluent on land for irrigation is expected to provide a good opportunity for soil micro-organisms to attenuate the EDCs and should be encouraged, provided it is safe to do so for other reasons.

The authors are thankful to colleagues from Environmental Protection Agencies of Queensland and South Australia (in particular Dr Munro Mortimer and Dr Peter Goonan) as well as water utilities across Australia for help in this project. ■

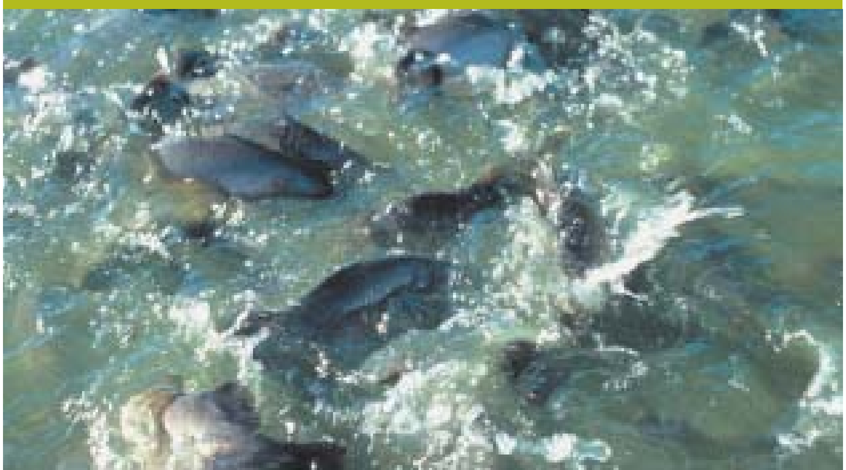
Are EDCs an issue for Australian aquatic systems?

The 2nd Australian Symposium on "Ecological Risk Assessment and Management of Endocrine Disrupting Chemicals (EDCs), Pharmaceuticals and Personal Care Products (PPCPs) in the Australasian Environment" will be held on 21–22 November 2007 at the CSIRO Discovery Centre, Black Mountain, Canberra.

The meeting, entitled "What's in our water: The significance of trace organic compounds", will showcase the latest Australian and international research and facilitate discussion on trace organic chemicals such as EDCs, PPCPs in Australian environment.

Four international speakers will provide an international perspective on EDCs and PPCPs at the meeting, organised by CSIRO, Land & Water Australia and the Australasian Society for Ecotoxicology.

Further information is available at: **http://www.clw.csiro.au/conferences/ourwater/**



There's movement on the Darling

By Mark Southwell

The integrity and resilience of riverine landscapes depend, in part, on exchanges of materials between the many different components that make these important ecosystems. Models of river ecosystem behaviour stress the importance of exchanges in the longitudinal direction (River Continuum Concept) and lateral direction (the Flood Pulse Concept). During flooding and over bank flows there is the active exchange of water, sediment and associated nutrients as well as biota between the main river channel and their surrounding floodplain landscape. Floodplains often display a patchy character in terms of vegetation distributions and this has been thought to be related to the patchiness of flooding and the distribution of nutrients. Flooding maintains the spatial heterogeneity of resources in riverine landscapes in time and space. Identifying the spatial pattern of resources in riverine landscapes and the processes contributing to this is important in understanding the behaviour of these variable systems and in their effective management.

This PhD study focused on investigating the exchange of sediment and nutrients between the main river channel and various floodplain surfaces along the Barwon Darling River in central New South Wales. In particular it has studied the role of inset-floodplains which are discontinuous floodplain surfaces, located within the larger incised channel trough of the Barwon Darling. These floodplain surfaces are located at a range of elevations above the river bed of the Barwon Darling and have been shown to be relatively important in the overall integrity of this dryland river ecosystem. Inset floodplain surfaces store relatively large amounts of organic matter which becomes available to the river ecosystem during smaller 'flow pulses'. For this study, 48 inset-floodplain surfaces were investigated along two reaches of the Barwon Darling River, one below the township of Walgett and one upstream of the township of Bourke in central New South Wales. There were two parts to the study. The first investigated the spatial distribution of the sediment texture and associated nutrients on the inset-floodplain surfaces and the influence of larger scale geomorphic constraints and smaller scale controls on these distributions. This regional study showed there was a patchy distribution of sediment texture and nutrient concentrations on the inset-floodplains of the Barwon Darling River. Sediment textural patterns appear to be a result of a combination of factors including decreasing energy gradients with increasing floodplain elevation, variable sediment supply during flow events and local sediment supply. Nutrient patterns closely follow those observed in sediment texture, with the added influence of inset-floodplain elevation. Thus a mosaic of sediment texture and nutrient concentrations was found across the inset floodplains of the Barwon Darling River rather than any clear gradient of texture and concentrations. In other words there are hot spots of relatively elevated nutrient concentrations.

This photo shows several inset-floodplains at different elevations along the Bourke study reach of the Barwon Darling River. Photo Mark Southwell.

The second part of the study attempted to quantify the exchange of sediment and nutrients to and from the inset-floodplain surfaces and assess the influence of this exchange on the spatial distribution of sediment and nutrients over time. To do this several flow events were monitored in both 2002 and 2005, with pre- and post-flow sediment samples taken and also sediment traps and erosion pins deployed to quantify deposition and erosion during flooding. The response of inset-floodplains to flooding is complex with both deposition and erosion of material occurring on the various floodplain

Above: A low level inset-floodplain on the Bourke reach of the Barwon Darling River, showing two sediment mats used to collect sediment deposited during inundation. Photo Mark Southwell.
Below: Relatively large inset-floodplain on the Walgett reach of the Barwon Darling River during an in channel flow event. Photo Anthony Senior.

surfaces during the flood events. This appears to be associated with the timing of flows along with the variable supply of sediment in time and space. Exchanges of sediment resulted in 36% of the inset floodplain surfaces changing their sediment character, and the addition of a new textural patch type suggesting the sediment textural mosaic is dynamic over time. Similarly, nutrient concentrations changed on 46% of the floodplain thus changing this mosaic. Overall, inset-floodplains predominantly acted as nutrient sinks, with geomorphic location of individual surfaces, sediment texture, and the occurrence of flooding all influencing the character of the change in nutrients.

The results of this study indicate that the exchange of sediment and nutrients between floodplains and the river channel varies in both space and time. The key influences on this exchange appear to be valley location, surface elevation, and spatial and temporal variations in sediment supply. These influences have combined to create a patch mosaic of sediment texture and nutrients that is dynamic over time. Thus while some inset-floodplains may be landscape hotspots in terms of their nutrient content and productivity, this may not remain the case over time. This is an important finding for the management of riverine landscapes because it suggests that flows of a similar size may not produce the same response in terms of the exchange of nutrients and sediment in this landscape. Current management of riverine landscapes has tended to focus on riparian zones — those patches close to the main channel or those that have a direct contact with the main channel. The results of this study suggest that effective management of riverine landscapes must also recognise those land units that are important for the transfer of material between the floodplain and the main river channel. These may not be just the immediate riparian area. Identification of hotspots is critical as will be the management prioritisation of these areas and the flows that wet and connect them. ■

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The impacts of pesticide mixtures
on aquatic ecosystems

By Catherine Choung

Intensive agricultural practices can contribute pesticides into surface waters with contamination occurring as a result of spray drift, wind erosion, volatilisation and surface runoff. Irrigated agriculture in regions such as the Coleambally Irrigation Area (CIA), a major rice production region in south-western NSW, can be particularly difficult to manage as excess water containing various pesticide residues in irrigation tail water, surface water from irrigated crops, and water from subsurface tile drains, can run off into waterways. Ideally, most of the water is collected in irrigation drains and then reused in downstream farms. However, in heavy rainfall events drainage water can reach local creeks and rivers as a result of drains overflowing, with a further risk of environmental contamination through seepage/leakage from the walls of rice bays.

Residues of herbicides (e.g. atrazine) are of high concern in irrigation areas such as the CIA, not only because of potential impacts on aquatic ecosystems, but because of its potential to harm crops if water is reused for irrigation. In addition, irrigated agricultural areas often support high levels of biodiversity, and vulnerable biota such as water birds and frogs (such as the endangered Southern Bell frog) may also be adversely affected. A further complicating factor is that because there is a range of crops grown in agricultural districts, this means receiving waters can be contaminated by a cocktail of different pesticides. Many studies have reported the contamination of surface waters near intensive agricultural areas by multiple pesticide compounds, with this resulting in the potential for toxicological interactions to take place between the different pesticide compounds and/or metabolites. It had been thought that chemicals with the same mode of toxic action (e.g. two organophosphorus insecticides) will result in simple additive toxicity, whereas chemicals with different modes of action (e.g. an insecticide and a herbicide) will result in antagonistic or additive toxicity. However, recent research has shown that the herbicide atrazine, in binary combination with various organophosphorus insecticides, resulted in greater than additive toxic effects (i.e. synergistic) on various invertebrate species.

Despite the relevance of examining the potential impacts of pesticides that commonly co-occur as mixtures in the environment, such studies are still very limited. More information is needed because pesticide residues in receiving waters which may not be at sufficient concentrations to be considered 'ecologically harmful', can potentially result in substantially higher toxicity when mixed with each other. This means that existing water quality guidelines designed to protect aquatic biota/ecosystems derived from examining the effects of single pesticide exposure (acute and chronic), may not adequately protect aquatic ecosystems when present in mixtures. Of particular concern are pesticide combinations that have greater then additive (i.e. synergistic) toxicity, as potential impacts predicted from individual pesticide would greatly underestimate the overall toxicity.

The aims of my work are to assess the impacts of commonly co-occurring agricultural pesticides when present as mixtures on freshwater aquatic ecosystems. More specifically, the research will help characterise the underlying

A drain typical of those in intensive irrigated agricultural districts. Photo Roger Charlton.

Impacts of pesticide mixtures

chemical interactions (antagonistic, additive or synergistic) amongst different pesticide compounds and help explain the observed effects on aquatic biota in receiving surface waters. The pesticide compounds that will be examined include terbufos and thiobencarb, which are commonly used for corn and rice production respectively. The toxicological assessment of pesticide compounds, terbufos sulfoxide and terbufos sulfone (metabolites of terbufos) will also be analysed. Atrazine, which is also used in corn production and has been shown to act as a synergist with other organophosphorus pesticides (enhance their toxicity) will also be included in the assessment. Little is known of the toxicological effects associated with these metabolites despite their similar toxicity to the parent compound. Their greater persistence and mobility in the environment compared to the parent compound, further justifies their inclusion in this study.

My project will include laboratory experiments on a range of aquatic organisms occupying various trophic levels — algae, zooplanton, macroinvertebrates and frog larvae, followed by outdoor mesocosm/semi-field experimental ponds and caging experiments to assess the impacts of these pesticide mixtures under more environmentally realistic conditions. The use of experimental mesocosms in the research also provides an opportunity to explore and document the behaviour and fate of terbufos sulfone and sulfoxide in aquatic environments for which information is still lacking. The field assessment of macroinvertebrates and tadpole diversity in the CIA will function as a complementary third tier of the assessment that will help ascertain if effects observed in the laboratory and semi-field experiments are translated to effects in the environment. If interactions between the pesticides are found to occur under field conditions, then it can help us to derive safe/acceptable limits of these pesticides when they are present as mixtures. Our overall aim is to help to protect the long-term sustainability of both agricultural production and the health of aquatic ecosystems in irrigation districts. ■

For further information

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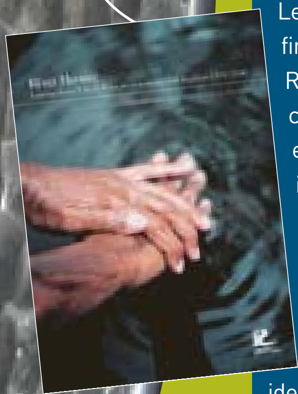
The Thiess River*prizes* were announced at a special gala ceremony on Tuesday 4 September during the 10th International River*symposium* & Environmental Flows Conference held in Brisbane, Australia.

The International Thiess River*prize* is a partnership between the International Riverfoundation and River*festival*, an annual 10 day celebration of Brisbane's river, people, culture and environment. The prize money is funded by the International Riverfoundation and the awards are managed by River*festival*. More information can be found at www.riversymposium.com

River Heroes released



The International Riverfoundation (IRF) announced the release of 'River Heroes: Lessons from Thiess River*prize* winners and finalists 1999–2006' during the International River*symposium* & Environmental Flows conference. This IRF report is about the extraordinary efforts of people to save rivers in Australia and around the world. It features 13 case studies of Thiess River*prize* winners and finalists and tells the stories about how they applied specific management practices to restore and protect their river systems in Australia and overseas. The report offers ideas for how we can mobilise an even greater change to save rivers. It is downloadable from IRF's website **www.riverfoundation.org.au** and hard copies can be obtained by contacting IRF's office at (07) 3221 1778 or e-mail **silvia@riverfoundation.org.au**

Congratulations to the winners of the 2007 Thiess River*prize*

Austrian Danube River project wins International Thiess River*prize*

A groundbreaking Austrian river management project has won the prestigious AUD$300,000 International Thiess River*prize* — the world's largest prize in its field. The Danube River project, initiated by the International Commission for the Protection of the Danube River (ICPDR), was awarded the Australian-based prize for its collaborative approach to improve water quality in Europe's second longest river. ICPDR Executive Secretary Mr Philip Weller said the prize is recognition of the work undertaken during the past 15 years to overcome political and economical obstacles.

"Hundreds of people throughout the Danube River Basin were actively involved in the ICPDR project which made the Danube River Basin a cleaner and healthier place. We are honoured by this recognition which means a great deal to the ICPDR family. The ICPDR project has aimed to combat the terrible environmental problems in the Danube River including toxic waste pollution and destructive farming practices brought about by the 45-year long Soviet era. Our overarching goal is to witness the rational use of water within the Danube Basin and minimise negative consequences of the 2780 km Danube on the Black Sea", Mr Weller said.

"The ICPDR will use the prize money to deliver a presentation at the International Water Association World Water Congress in Vienna in 2008. We will show other water managers the type of activities and results we experienced ... which will hopefully help them in their efforts. The prize money will enable us to achieve our goals by ensuring communication and activities between Danube countries, stakeholder groups and NGOs remain cooperative and constructive well into the future", Mr Weller continued.

NSW Murray Wetlands project wins National Thiess River*prize*

A river management project initiated by the NSW Murray Wetlands Working Group (MWWG) has won the prestigious $100,000 National Thiess River*prize*. NSW Murray Wetlands Working Group Chair Mr Howard Jones said the project demonstrated how regional communities can achieve success in managing waterways and catchments.

"Since the NSW Murray Wetlands Working Group was established in 1992, it has successfully delivered 75,000 megalitres of water to more than 200 wetlands over 71,000 hectares in the Murray and Lower Murray-Darling catchments. The group developed a number of grant schemes to provide individual landowners, community groups and government agencies with financial assistance to manage and rehabilitate natural wetlands. On-ground works included fencing, revegetation and minor earthworks to rehabilitate privately owned and public wetlands", Mr Jones said.

The group will use the prize money to continue managing and improving wetlands through on-ground works, education, community engagement and monitoring.

Above: *National Thiess Riverprize winners — NSW Murray Wetlands Working Group with a delighted Howard Jones holding trophy.*
Top: *Winners of the International Thiess Riverprize — International Commission for the Protection of the Danube River (ICPDR), Austria.*
Both photos courtesy of Atmosphere Photography.

RIVER AND RIPARIAN LANDS MANAGEMENT NEWSLETTER

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