September 2001

contents

The Ten Next Steps in Water Management

by Professor Peter Cullen

Water and salinity are issues of concern to many Australians. Governments, community groups and landholders have done much to address these issues. But despite these efforts we do not seem to be getting on top of these problems. New approaches are needed if we are realistic about overcoming these problems. What are the next steps required?

Following are ten simple strategies that would improve our rivers. They will not be easy to implement, especially given the competing pressures that are causing the present degradation. They all need to be further developed, but if implemented, would start to make a difference.

- **Efficiency Dividends:** All irrigators and irrigation companies should be required to return 3% of all water used each year as an efficiency dividend to the environment. This water could then be used to provide appropriate environmental flows.
- **Clawback of Water in Over-allocated Rivers:** Any river where more than 1/3 of the median flow is extracted is likely to be seriously damaged. In such catchments, there should be an annual claw-back of water for the environment until this level is reached or, a sustainable level of extraction is determined through sound research. Compensation should only be paid where there is a genuine legal right to this water.

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The Cooperative Research Centre for Freshwater Ecology improves the condition of Australia's rivers, lakes and wetlands

CRC Australia

- **Burden of Proof:** Any proposal to extract water from any river should be accompanied by studies demonstrating the impact that the extraction will have on downstream river health. The burden of proof should be on the proponent, and it should be accepted that a minimum of five years is needed for such studies, given the variability of rainfall in Australia.
- **Monitoring of River Health:** Ongoing catchment and river health audits, based on the Land and Water Audit, reporting every five years in the State of the Environment reports should be required. States should be funded to collect appropriate data in a standardised and co-ordinated form, this data should be made publicly available on the Web. Such monitoring could be used to demonstrate the outcomes of investments under the National Action Plan and the Natural Heritage Trust.
- **Protection of Undamaged Rivers:** A National system of heritage rivers should be established under the Environment Protection Biodiversity Conservation Act to ensure the few remaining undamaged rivers are protected. Funding is required to ensure they are effectively managed and monitored as long-term benchmarks.
- **Protecting Important Wetlands:** Effective management planning and funding is required to assess and protect nationally important wetlands and their catchments, if we are to meet our international obligations. This must include providing instrumentation and detailed regular monitoring of selected sites.
- **Better Technical Advice to Governments:** Provision of an expert body to provide ongoing strategic advice to the newly established Natural Resource Management Ministerial Council, and to oversee technical aspects of the National Action Plan and the Natural Heritage Trust. This requires a group of experts and some community leaders and should not be based on State representation. This group could also act as an “intelligent purchaser” of research into land and water issues.
- **Putting the Bits Together:** Governments must recognise that rivers cannot be managed in isolation from their catchments. Riparian areas, floodplains and wetlands are integral to river health, and must be managed in an integrated way. The organisational structures should reflect this integration.
- **Regional Science:** Capital and recurrent funding should be provided to develop a number of regional freshwater ecology laboratories. Each laboratory must have scientific staff and staff to deliver the science to community groups. These laboratories will address issues such as river health, environmental flows, salinity impacts and the management of invasive species. They would also be responsible for some long-term reference sites of river condition.
- **Large-Scale Catchment Research:** Governments need to fund some large-scale ongoing catchment studies. These studies will enable us to identify and predict the ecological impacts of climate change, land use and alternative farming systems on streamflow and river health.

Australians want to see healthy rivers, not only to provide clean drinking water, but also to enjoy the recreational and intrinsic benefits that our rivers, lakes and wetlands offer. They want to protect and enjoy our unique biodiversity and they want our waterways to be managed for the benefit of all Australians.

We desperately need leadership in this area. We need to re-examine the institutional arrangements that have led to the current problems and try and develop more effective ones. We need to clarify rights, not just of those extracting water but the rights of those who live downstream. We have only just started.

Professor Peter Cullen, Chief Executive of the CRC for Freshwater Ecology. Photo: M Ashkanasy, courtesy of Melbourne Water

Cold water Pollution: Barren, Wintry Rivers in Mid-Summer

by Dr John Harris

For decades, water scientists have known that cold, dense water settles at the bottom of reservoirs and is released downstream from low-level valves. What is surprising is how long it has taken to develop awareness of the scale and ecological significance of these hypolimnetic (cold water) releases. Irrigation releases are commonly 10-12°C colder than ambient and temperatures in some rivers have not returned to natural for hundreds of kilometres downstream. Few large dams can release ambient-temperature water from the storage. Some, like Windamere or Chaffey, have multi-level offtakes but they are unwieldy and the capacity is rarely if ever used. Estimates vary, but about 2,500km of rivers are believed to be affected by coldwater pollution (CWP) in the Murray-Darling Basin alone.

Threatened species such as this trout cod, Maccullochella macquariensis *are particularly vulnerable to cold water pollution.*
Photo: G Schmida

In aquatic biology, biochemical reactions that drive the fundamental processes of respiration, growth and movement are controlled by the temperature of the surrounding water. Hence feeding, reproduction, migration and survival are all temperature-dependent.

Tolerance of cold temperatures is common among invasive freshwater species.

Aquatic biota evolved to become adapted to natural temperature regimes, often within quite limited tolerance limits of a few degrees. Plainly, suppression of summer water temperatures by 10-12°C can profoundly affect aquatic animals and plants, so that they may disappear from CWP-affected rivers. Data on the spawning requirements of native fish, for instance, show that suitable temperatures are rare or absent below most large dams. In the Mitta Mitta River, for example, coldwater pollution from Dartmouth Dam led to local extinction of the threatened species, trout cod and Macquarie perch, as well as other native fish and invertebrates.

Tolerance of cold temperatures is common among invasive freshwater species. Fish like carp, goldfish, trout and redfin perch cope well with chilly hypolimnetic releases and they are favoured by coldwater conditions. These alien species commonly dominate fish communities downstream of large dams, where native fish are usually diminished or rare.

Conversely, winter water temperatures below dams are likely to exceed natural levels. Seasonal variation is inhibited, as large masses of stored water take longer to heat or cool, and the duration of warm water is reduced. Furthermore, substantial lag periods are introduced into the thermal regime below dams, with summer peaks arriving a month or more later in the season, and autumnal falls in temperature similarly delayed. These changes may alter the timing of biological events such as migration and spawning in fish, or metamorphosis in insects, which are influenced by temperature as well as day-length, stream flow and other factors. De-coupling these environmental signals has unknown consequences.

Cold water releases from Dartmouth Dam led to the local extinction of several fish and invertebrate species in the Mitta Mitta River.
Photo: John Hawking

The CRC for Freshwater Ecology, with NSW Fisheries and the Department of Land and Water Conservation (DLWC), has established an experimental facility on the Macquarie River below Burrendong Dam. Its aims were to determine the effects of CWP on native fish and to guide changes to water-release practices. Experiments in the replicate, temperature-controlled channels tested the effects of CWP on juvenile silver perch, golden perch and Murray cod. Depending on species, the growth, survival, distribution and activity of juvenile native fish were affected by CWP. Silver perch grew substantially more in ambient-temperature water, had much higher survival and exhibited a strong preference for warm water. Murray cod showed similar thermal preference. This experimental facility remains available for continued research on the consequences of CWP for aquatic biota and would be excellent for graduate research projects.

Other research is continuing in the CRC for Freshwater Ecology. The Victorian Department of Natural Resources and Environment is studying the effects of CWP on biota in the southern Murray-Darling Basin, particularly the impacts on survival and development of native fish eggs and larvae. The project is also studying temperature preferences of native fish and identifying habitat areas most in need of thermal mitigation. The NSW DLWC has a project monitoring temperature changes associated with dams in the Macquarie River.

In June a Thermal Pollution Workshop was hosted at Lake Hume by the Inland Rivers Network and the World-Wide Fund for Nature. After research papers and plenary discussions, the two-day workshop released a statement calling on governments to address CWP, and issued 27 specific recommendations to deal with the problem. Recommendations included listing thermal pollution as a threatening process under the relevant legislation, measuring and mapping its geographic extent, expanding knowledge of ecological impacts and responses to restored thermal regimes, reviews of licensing arrangements, and including thermal mitigation as an integral part of river-rehabilitation programs.

Fortunately, achievable technical solutions are emerging. Last year a scoping project between the CRC for Freshwater Ecology and CSIRO reported a series of engineering options for releasing water from warmer, epilimnial (surface) layers of storages, using existing outlet structures. These options included cost-effective devices like surface pumps, draft tube mixers (a more effective form of surface pump) and submerged curtains capable of increasing discharge temperatures by 4-10°C. The submerged curtain may result in warmer water (20-23°C) during spring and summer, as water is only discharged from the top 6m of the reservoir. CWP has now joined the growing list of issues demanding attention in comprehensive river-rehabilitation programs.

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Further reading

Sherman, B. *Scoping options for mitigating cold water discharges from dams.* CSIRO Land and Water, Report 00/21 May 2000.

Measuring Carbon Inputs to the Murray River

by Dr David Williams

Carbon is the main chemical building block of life. Rivers receive organic carbon from various sources including, aquatic plants, biofilms (algae, bacteria and fungi), groundwater and plant litter. The riverbank (and floodplain) is a natural source of carbon as it contains vast quantities of organic material in the form of leaf and woody litter. Because carbon is a valuable food source in aquatic foodwebs, quantifying the amount of litter produced by different plants allows us to predict carbon inputs and thus the potential impact of changes in riverbank vegetation on riverine foodwebs.

Floodplains are considered to be a primary source of carbon for rivers and, under normal flow regimes, some of this carbon is washed into the river during flooding in the form of leaf litter and as dissolved carbon. This allochthonous carbon, that is, carbon derived from outside the stream, is considered in some river function models to be one of the most important sources of energy for aquatic foodwebs. However, only recently has any attempt been made to quantify the amount of litter contributed by different plants.

As part of the Cooperative Research Centre for Freshwater Ecology's Lowland Rivers Project, a research team headed by Dr David Williams is developing reach-scale estimates of riparian carbon production for sections of the Murray, and other rivers. Three study sites were sampled to establish the quantity and seasonality of carbon inputs to the stream. The sites, at Albury, Hattah, and Barmah, had very different riparian vegetation patterns, reflecting both the extent of historic forest clearance, current flows and land management, in particular, the extent of grazing by domestic stock.

The riverbank is a natural source of carbon

Considerable variation in forest production was found along the reaches, even at Barmah where river red gum was the dominant species. This variation relates to aspect, (which affects the amount of direct sunlight in the canopy), bank height, soil conditions and possibly the extent of recent treefall. Another key result was the establishment of a relationship between litterfall rates on the bank and the total amount of litter

Aerial view of Hattah reach, showing floodplain forest and shrublands and a red gum lined Murray River. Photo: Courtesy MDBC

Mature red gums line the Murray River at Hattah reach.
Photo: David Williams

likely to enter the channel. For example, for 30 m high red gums at Albury, there was about 12 times as much litter falling into the stream per metre of each bank, as was falling onto one square metre on the bank. Hence for tree-lined channels wider than about 50 m, tree litter input would be about 24 times that on the bank.

The amount of litter entering the stream at the reach scale, depended on the extent and composition of the riparian zone vegetation, with willows depositing more than twice as much litter per unit area of their canopy, as did red gums. Interestingly, peak periods of input by the different species were spread over the year; eucalypts in summer, willows in autumn, *Typha* (cumbungi) in winter and *Phragmites* (common reeds) in spring. Given the differing bioavailability of their litter, this complex pattern of organic matter entry to the channel may have implications for instream biota.

This study has a number of implications for management: it allows us to predict carbon inputs from the immediate riparian zone for lowland river reaches given different vegetation patterns. For example, complete replacement of red gums by willows at these Murray River sites would entail a 4-8 fold increase in total litter input. Another example might be where emergent macrophytes and stock are present, the removal of stock would result in a 2-5 fold increase in carbon inputs from these plants.

The other overall implications for management of streams, that arise from these findings, are that estimates of litter inputs from riparian forests to lowland rivers can be made given some baseline values and a knowledge of the riparian vegetation at reach scales. In addition, the relative importance of various species to the seasonal and annual input can, and needs to be considered. These assessments can also be applied in monitoring riparian restoration sites and in further refinement of riparian habitat assessment protocols.

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Modelling riverbank vegetation

Lisa Evans, PhD Student

As rivers carve their way through a landscape, the plant communities that evolve with them are unique. Lisa Evans, a PhD student with the CRC for Freshwater Ecology has been studying the impacts of flooding and water velocities on riverbank vegetation.

The riparian zone (or riverbank) is a diverse and integral part of a river's ecology. It is the zone of transition between terrestrial and riverine environments and is a product of hydrology, landform, climate and available biota. The plant communities living within the riparian zone are as fundamental to a river as the water flowing through it. Riparian vegetation plays a vital role in stabilising riverbanks and moderating the erosive forces of water, among other functions.

PhD student Lisa Evans, under the supervision of Dr David Williams and Associate Professor Martin Thoms, is completing her studies on the effects of riverine processes on plants within the riparian zone of upland rivers.

Such research in Australia has generally focused on lowland floodplain vegetation. This is one of the first studies conducted on the woody vegetation of the narrow riparian zones of Australia's upland rivers. Uniquely, the study also addresses velocity effects on woody plants. Upland rivers generally experience shorter flood periods with greater velocities than lowland rivers.

The study has shown that current velocity and length of flooding affect species differentially, and these differences depend on the plants proximity to the stream. Interestingly, higher water velocities did not suppress subsequent growth as much as low velocities. The study has also shown that riparian vegetation composition can be predicted reasonably well based on factors such as flooding, geomorphic landform, soil and climate.

The vegetation data collected will be used to develop a predictive model using the mathematical methods developed by the CRC for Freshwater Ecology AusRivAS model.

"The incorporation of this information into the AusRivas model allows the species likely to occur at a site to be predicted even if there is no native vegetation present, making it a valuable tool for stream managers to use when a stretch of river is to be rehabilitated" said Lisa.

"The findings also indicate how altered flooding and drying regimes will affect the composition of plants in the riparian zone. If flows are altered and flooding became a rare event, it would allow less flood-resistant species to gain a foothold in an area that they were previously excluded from. Conversely, if flooding were to become more frequent and prolonged, those rarer species that are less flood tolerant would disappear from the riparian zone."

This research is of particular relevance Landcare and catchment management groups, river managers and anyone involved in the rehabilitation of degraded riparian zones. With the addition of new baseline environmental data, the model developed during this study can be applied to other rivers.

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Casuarinas are well adapted to regular wet and dry cycles.
Murrumbidgee River in high flow, ACT.
Photo: Lisa Evans

Reinstating Variability to Regulated Systems

by Dr Michelle Bald

Originally built to provide year round navigation for cargo and passenger steamers, and later co-opted for irrigation, the locks and weirs built along the Murray River have impacted on river system health. Manipulating the water level in weirs to resemble more natural flow conditions may assist scientists quantify some of the impacts of river regulation.

The regulation of river systems through the construction of locks and weirs is thought to contribute to the loss of biodiversity and ecosystem integrity. Water levels in highly regulated weir pools remain much the same throughout the year. This is in direct contrast to the variable waterlevels to which our native plants and animals have adapted. As a result, many fish, invertebrates and plants have been deprived of their essential habitat, food or breeding cues, leading to population declines and competition for resources from various pest species.

Reinstating variability in the water level of weir pools may be of great benefit to the ecology of river systems; but is it really that simple?

The Lower Basin Laboratory in Mildura is currently investigating the ecological benefits of a trial weir pool drawdown (lowering of the water level). The project, funded by the Murray Darling Basin Commission, is led by Dr Bernard McCarthy. The weir pool at Euston on the Murray River (weir and lock 15) has been selected as the site for the trial, and plans are under way for the draw-down to begin after Easter 2002. It is proposed to drop the weir pool in stages, at an average rate of 7 to 8cm/day to 2m below full supply level by June or July. The weir pool level will then be raised in stages over subsequent months to reach full supply level before high irrigation demand in October/November.

The monitoring program will focus on parameters of water quality and chemistry (both "in river" plus groundwater) and biological parameters such as primary production, biomass and composition of planktonic and attached algae. Changes in fish, macro-invertebrates and vegetation will also be monitored. Social and economic impacts, such as inconvenience to irrigators, general public perceptions and the potential loss of tourist dollars will also be assessed during the trial.

One major concern of weir pool drawdowns, such as the trial at Euston, is the potential groundwater movements and possible saline intrusions (seepage) into the river resulting from the lower water level and decreased hydraulic pressure. These intrusions of highly saline groundwater are no doubt a natural occurrence at times of low river level. However, elevated groundwater tables, caused by increased irrigation, land clearing and the weir pool itself, mean that these highly saline waters may be more likely to make their way into the river than would have previously occurred. Our reliance on high water quality throughout the year (in order to support domestic and agricultural demands) has also decreased our tolerance for episodes of high salinity.

decreased our tolerance for episodes of high salinity

Bernard McCarthy and Iain Ellis collecting dissolved oxygen data in the Mildura weir pool.
Photo: Michelle Bald.

The Mildura wharf during the recent drawdown event.
Photo: Bernard McCarthy.

A short-term (nine day) drawdown of the Mildura weir pool in May 2001 for weir maintenance, not only provided an opportunity to refine our sampling techniques but also allowed us to investigate the impact of a drawdown on salinity and other water quality parameters.

Monitoring around Mildura showed that groundwater levels in some bores dropped rapidly in response to the drawdown, indicating groundwater movement into the river. Salinity levels within the Mildura weir pool also responded rapidly to the drawdown. Electrical Conductivity (EC, an indicator of salinity) increased from around 200 to approximately 500 EC with peak salinities recorded a few days after refilling of the weir pool had commenced. Turbidity and total suspended solids also increased significantly during the draw-down, but returned to pre-drawdown conditions almost immediately upon refilling.

Even though river salinity levels increased in response to the Mildura drawdown event, a number of factors need to be considered before a similar prediction can be made for the Euston trial. Water levels at Euston will be lowered more slowly, and to a lesser extent than those of the recent Mildura weir pool drawdown and the Euston trial may coincide with periods of high flow, potentially diluting any salt inputs. Examination of EC data and hydrographs from the past 30 years also suggest that significant increases in salinity in response to weir pool drawdowns (similar conditions as in these trials) are common at Mildura but generally insignificant at Euston. Therefore, it is anticipated that salinity changes in response to the Euston trial will be less dramatic than those observed in the recent Mildura event.

Information gathered from the Euston trial will enable us to explore the trade-offs between potential social and economic costs, and the ecological benefits associated with manipulated weir pool drawdowns. It may also assist us in achieving more sustainable management of our regulated river systems.

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FASTS Science Meets Parliament 2001

"Science Meets Parliament" Day provides an opportunity for scientists and technologists to meet with politicians and discuss the importance of science to the future of Australia.

One hundred and forty five Parliamentarians and one hundred and eighty scientists attended the event, which was held on the 21st and 22nd August. On day one, the scientists were briefed on the most effective way to approach interviews with politicians. Speakers included Senator Natasha Stott Despoja, Professor Peter Cullen and Dr. Robin Batterham (Chief Scientist).

The event was organised by the Federation of Australian Scientific and Technological Societies (FASTS). Professor Peter Cullen, President of FASTS and the Prime Ministers "Environmentalist of the Year" stated that "parliamentarians are expected to face an incredible array of issues, from salinity, genetically modified organisms and engineering, to nuclear waste and medical research. Our 'Science meets Parliament' Day brings the experts into Parliament House for a day to discuss their science with politicians.

"There is a growing awareness among politicians that science is fundamental to many of the issues they need to address," he said.

In his presidential address Professor Cullen discussed the issue of the national investment in science, research and higher education. This was followed on the Wednesday with a press conference at Parliament House where he outlined FASTS policies for the November election.

Four key issues were put forward as fundamental to improving our scientific base:

1. **Commercialisation and innovation:** Improving awareness among politicians about how science creates employment, businesses and wealth.
2. **Education and community awareness:** The number of science teachers with a science qualification is alarmingly low, and there is a downward trend in the number of students entering science education. This has implications for how we improve community awareness of science.
3. **The University sector:** Again, enrolments in University science courses and Government funding for Universities has declined sharply. There has been an increase in the student teacher ratios of 50% in the last ten years.
4. **Science in government:** There must be better scientific expertise in government departments. FASTS supports the establishment of Science Fellows to work in parliament House, to see parliamentarians work and to inject science knowledge into the political process.

Prior to Science Meets Parliament, FASTS asked parliamentarians to nominate topics that they would like to discuss with scientists. Water and salinity rated as the most important science issues for Australian Parliamentarians. For scientists, the most nominated issue was education and training in schools, universities and throughout industry.

FASTS President Professor Peter Cullen said that science is crucial to many issues where Members of Parliament have to make decisions

"The science community has a responsibility to contribute to the national process of decision-making," he said. "It's up to us to provide information and advice, and we need to understand politicians and the political process better if our advice is to be heeded and acted upon.

"We need to get closer to the political process, and that's what this day is about," he said.

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SideStream

NABS 2001

Several staff members from the CRC for Freshwater Ecology were among the 800 scientists attending the North American Benthological Society Conference annual general meeting, held in La Crosse, Wisconsin, 4th to 7th June. Presentations by the Australian AUSRIVAS team on aspects of predictive models, including new methods, simulated data sets and the effects of sampling on outputs were included in one of the many sessions on biological assessment. Richard Norris presented a summary of the Assessment of River Condition, part of the National Land and Water Resources Audit in a US Environmental Protection Authority sponsored session on assessment. Panel discussions focussed on what had been achieved in the audit and how it might be applied to the US, and Canada in particular. Recent developments suggest that the predictive model approach is making major inroads and has the potential to become widely used.

Publications

Three new publications are now available on the CRCFE website, www.freshwater.canberra.edu.au:

River Health Forum, Dalby, Queensland. Summary Report, June 2001. CRC for Freshwater Ecology.

*The Chaffey Dam Story, Final Report for the CRCFE Projects B.202 and B. 203.*B. Sherman, P. Ford, P. Hatton, J. Whittington, D. Green, D. Baldwin, R. Oliver, R. Shiel, J. van Berkel, R. Beckett, L. Grey, B. Maher.

Outcomes of the NRHP Urban Sub-Program. Report of a workshop held at Environment Australia, Canberra, 21st February 2001. P. Cottingham, J. Anderson, P. Breen, J. John, J. Langford, J. Moverley, N. O'Connor, J. Parslow, G. Rooney, C. Walsh, M. Whelan.

The following technical report is now available by contacting the CRCFE on 02 6201 5371, via email: lregan@enterprise.canberra.edu au, or via our website.

Large Scale Ecological Studies and their Importance for Freshwater Resource Management: Report of a forum held at Bayview Conference Centre, Monash University, 15th December 2000. Technical report no. 4/2001. by P. Cottingham, S. Carpenter, R. Hilborn, J. Kitchell and C. Stow.

The following publication is available in electronic format. *Catalogue of Australian Mayflies.* Hubbard, M.D., Suter, P.J. and Campbell, I.C., at: http://www.famu.org/mayfly/australia/ausintro.html

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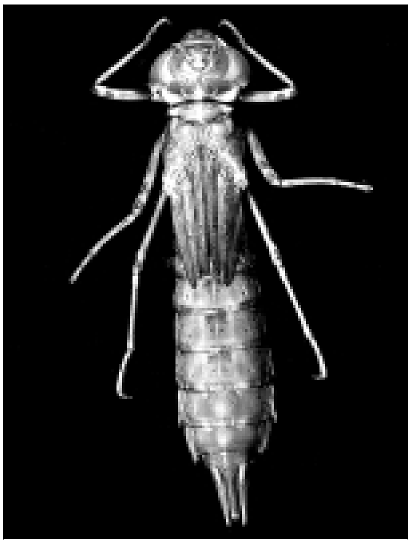

Photo: Karlie Hawking

The creature feature for this issue is the dragonfly (immature):

Class:	Insecta
Order:	Odonata
Suborder:	Anisoptera
Family:	Aeshnidae
Genus:	*Hemianax*
Species:	*papuensis*

Popular with fishers and commonly known as mudeyes, H. papuensis is one of Australia's most abundant dragonflies. It is found throughout Australia, the Cocos Keeling Islands, Java, Sumba, New Guinea and New Zealand. The carnivorous larvae are active predators of a range of water borne insects. They inhabit still and sluggish waters (eggs are laid in the plant tissue of aquatic plants). Adults may reach 49 mm in length and are often seen clinging to streamside plants.

CRCFE web site:
http://freshwater.canberra.edu.au

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The CRCFE is a collaborative venture between:

- ACTEW Corporation
- CSIRO Land and Water
- Department of Land and Water Conservation, NSW
- Department of Natural Resources and Environment, Victoria
- Environment ACT
- Environment Protection Authority, NSW
- Environment Protection Authority, Victoria
- Goulburn-Murray Rural Water Authority
- Griffith University
- La Trobe University
- Lower Murray Water
- Melbourne Water
- Monash University
- Murray-Darling Basin Commission
- Natural Resources and Mines, Queensland
- Sunraysia Rural Water Authority
- Sydney Catchment Authority
- University of Adelaide
- University of Canberra

Comments, ideas and contributions are welcome and can be made to:

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