Informing river management policies and programs with science

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Abstract Conventional wisdom has it that we already have enough science to address the problems causing degradation of our environment, including rivers. This is not true. However it is the case that we could be using existing knowledge better, and that we could be doing more to learn the lessons from the huge sums being spent on river restoration and management. Informing good policy and practical on-ground management with R&D outputs has proven to be is difficult, but essential.

This paper reviews some of the history of water and river management in Australia and how perceptions of rivers have evolved. It discusses the challenge of enhancing the linkages between science, policy and practice in river management. It outlines the knowledge exchange, R&D and capacity building strategies of the National Rivers Consortium – a new initiative whose founding partners are LWRRDC, the MDBC, CSIRO Land and Water and the Western Australian Waters and Rivers Commission. This strategic collaboration between policy makers, river managers and scientists brings together organisations with responsibility and expertise to improve the health and management of Australian rivers. The National Rivers Consortium is making a major investment in knowledge exchange and capacity building, based on direct personal contact and learning by doing. The Consortium is establishing a program of training activities targeting river managers and policy makers, based on the best available science and high quality information products. It will support river managers as they plan and implement river restoration and protection projects.

The paper concludes with a discussion of the key knowledge gaps that remain impediments to the better management of Australia's unique and diverse river landscapes.

Keywords Collaboration; National Rivers Consortium; policy; river management

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Changing perceptions of riverine values

In the driest, flattest, most poorly drained inhabited continent, rivers assume a special significance; ecologically, economically and socially.

Yet relative to the land, there has been a genuine paucity of writings on how Australians have interacted with their rivers over time. The "age of rivers" is still dawning in the country, with the seriousness of their degradation only becoming mainstream in the last two decades. Even today, Australian governments, scientists and communities are only just beginning to grapple with ever-increasing riverine problems. The slowness to recognise the magnitude and scale of these issues is still evident in the virtual absence of effective river management institutions and legislation. Even major topical issues like Aboriginal Land Rights almost totally ignore water rights.

Australia is effectively a newly developed country, with major settlement extending barely 200 years. However in that time, this vast continent has been significantly disturbed by massive land use change. Some of these changes have long lag times and will influence landscape and riverine processes for centuries to come. Indeed many changes to the environment will be irreversible.

Aboriginal river perspective

Few modern writers comment on pre-European use of rivers by Aborigines, and most accounts are restricted to the use of fish traps. Extensive eel and fish traps have been found on many creeks and channels in inland Victoria. Contemporary accounts from the 1840s

describe the gatherings of several hundred Aborigines at fish trapping sites which were seasonal events of social significance.

It is now understood that Aboriginal occupation over many millenia has led to an affinity with water and land that is unmatched by European settlers. Networks of waterholes and rock pools were known and maintained across even the driest parts of the continent. Water, however, was a frequent source of conflict between Aboriginals and Whites, especially in driers areas as evidenced in the quote (FRDC, 1994):

> "As a result the blacks were repeatedly driven away from the river frontages and lagoons. They were shot at or ridden down and stock-whipped….All the freshwater is surrounded by cattle."

The Aboriginal way of life was intimately linked to the biophysical environment and involved spiritual relationships centred on ancestral beings who created the form of the land and the people. The impact of Aboriginal occupation on rivers and water resources was minimal compared to the changes they caused to native flora and fauna.

Accounts of early explorers

Explorers Oxley, Sturt, Mitchell, Hume, Leichhardt, and botanists John and Allan Cunningham all repeatedly reported that watercourses ceased in reed barrier ponds (billabongs). The Darling, Macquarie, Gwydir, Namoi, Lachlan, Murrumbidgee, Goulburn and Murray died in the plains. They reported the watercourses were unlike any other and had a total absence of worn banks. Cod and other species of fish lived in the cool reed barrier ponds and were observed moving up the catchment in times of flood.

It was disturbing to the Surveyors General, returning after some years to their original routes, to find settlers and squatters had burnt reeds for their cattle and sheep and cleared areas adjacent to watercourses. The watercourses had become fast flowing and scoured deep trenches, often cutting new courses miles from the original path. The prior streams and billabongs were draining to the new lowered rivers.

Captain Cadell won the South Australia Governor's prize of 20,000 pounds in 1853 for reaching Albury and returning with wool and grain. From Swan Hill he cut a path from billabong to billabong, often travelling 6 miles to achieve one mile against the direction of flow. Cadell was granted 80,000 pounds by the NSW Government to clear a river up the Murray. He developed a steam powered saw machine for cutting trees below the water line. He went on to clear the Goulburn, Darling and other rivers between 1856 and 1863. When floods occurred new river courses were cut into the soft soil and clays miles from the prior watercourses, undercutting and dropping large stretches down several feet. He then returned to clear the river of further obstructions.

Early history of development

For the first half of the nineteenth century the European population comprised free and convict settlers living on the margins of the continent. By 1850 the non-indigenous population was approximately 400,000. Until the 1940s, over 80% of immigrants were from the United Kingdom and Ireland.

The vision for rural communities was founded on cottage farming (self-contained family farms cropping in a well ordered landscape) that would give rise to a "little England" in Australia. This ideal soon came into conflict with a very different form of farming pioneer, the pastoralists who engaged in illegal occupation of land beyond the settled fringe. These "squatters" as they were known, were early explorers and pioneers who claimed large tracts of inland grasslands for grazing runs. The squatters placed great store on the acquisition of river frontages for stock watering. In the mid-1850s a group of squatters built

a dam to divert the Wimmera River, one of the first engineering works for rural purposes.

Australian water histories frequently cite the occurrence of droughts as shifting social attitudes. The severe Victorian droughts of 1877–81 led to water being the key social and political issue of the time. The Water and Conservation District Act (1880, amended 1883) was the first to

> "conserve and distribute water not only as a means of preserving life, both animal and human, but also as a means of increasing the yield of soil, giving some security to agriculturalists in districts where rainfall is precarious".

The Irrigation Act 1886 was based on the recommendations of Alfred Deakin, regarded as the founder of Australian water law. At the head of Deakin's recommendations was the essential requirement that the State should exercise supreme control of ownership over all rivers, lakes, streams, and sources of water supply except springs rising upon private lands. This led to the formation of large statutory bodies which could utilise the hard-earned experience of the Australian climate in setting the stage for a period of extensive engineering development. Deakin's "nationalisation" of water was adopted by other states.

The 20th century

The Federation of Australia was proclaimed on 1 January 1901 and natural resources remained a State responsibility. Section 100 of the Constitution states:

> "The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or of the residents therein to the reasonable use of the waters of rivers for conservation or irrigation".

At the turn of the 20th century, the grazing farming structure was largely in place, with cattle and sheep numbers exceeding 10 million and 100 million respectively. At this time there was a growing demand for irrigation. After World War I, 39,000 returning servicemen were settled on farming land, a proportion being in irrigation lots.

In the first half of the century, water engineering works were fostered by large, powerful and well resourced state government agencies. Dam engineering and irrigation were preeminent and any adverse effects were rarely mentioned.

By the 1920s the first accurate understanding of the relationship between land clearing and land and stream salinisation was published (Wood, 1924). Soil scientists at the time were also well aware of the potential salinisation problems that faced the clearing of marginal lands. However the political imperative to expand agriculture overwhelmed these concerns and little action to manage or control clearing occurred until the 1970s. Even today Australia ranks in the top three land clearing nations in the world, despite a wealth of information on the deleterious effects.

1950s to the 1980s

The growth of infrastructure for water resource development over this period was massive. The growth occurred in all states and territories and in the agricultural sector. The national goal of development was supported with new injections of federal government funds which became possible with federal tax collection introduced in the 1940s. Throughout all water sectors the major developments were planned and implemented by state agencies.

Australia had entered a phase of development that was to lead to an era of mega-projects founded on even larger dams. The best known of these schemes are: the Snowy Mountains Scheme, the Ord River development, Hydro-electricity in Tasmania and the Burdekin Dam in Queensland.

Emergence of environmental values

The Tasmanian dams issue is a symbolic turning point in Australian history (and to some extent internationally) in galvanising the environmental movement. The first signs of conflict arose with the proposals to construct the first stage of the Gordon River power development. This involved flooding Lake Pedder which had been designated a National Park a few years earlier. The "Save Lake Pedder" campaign resulted in the first large co-ordinated environmental demonstrations seen in Australia.

Whilst the dam went ahead and the lake was flooded, the campaign spawned the United Tasmanian Group, the first environmental political party in the world. The subsequent battle over the proposed damming of the Franklin River was resolved in 1983 in the High Court with a majority 4:3 decision in favour of the Commonwealth over the Tasmanian state government to stop the dam. This decision broadened the Commonwealth's constitutional powers to make decisions over the environment, that were previously the sole responsibility of the States.

Since that time dam building has been in serious decline, with only two significant dams constructed in the 1990s. Whilst the dam building debate will continue, new major infrastructure developments are now required to meet both economic and environmental criteria before proceeding.

In the early 1990s the Australian community was confronted with the world's largest ever algal bloom. The blue-green bloom in late 1991 extended 1100 km up the Darling River. This national "disaster" heightened awareness of our declining river health and spawned a number of government programs to combat the problem.

From this complex history of water and river management in Australia, today's perceptions and values of rivers has emerged and is evolving. Different parts of Australia are at different stages of development and can be "positioned" in the eras described above. Some degree of polarisation now exists between northern Australia, which is still rapidly developing its water resources and has many unimpacted rivers, and the south whose rivers are highly developed, often over-allocated and highly degraded but is seeking rehabilitation solutions.

Lessons from history – some learnt, some ignored

There is abundant evidence that many Australian rivers are in poor condition, and their condition and ecological status continues to deteriorate. There is an increasing level of interest and high community aspiration in river management, but action is limited by major knowledge gaps, by a lack of tried and tested methods known to be effective, and by a lack of community capacity and confidence to act.

Some of the lessons listed in Table 1 appear to be self-evident with the knowledge we have today. Yet our management of rivers on the whole suggests that many of these lessons have yet to permeate legislation, institutional structures and on-ground management.

Future directions in river management

Where will river management be in ten years time? This is an important question for the Land and Water Resources Research and Development Corporation. Research involves long lead times. It takes time to conceive and develop effective programs and projects, to find partners who share common objectives, to commission new work. The research itself typically takes three to five years to complete. It then takes further time to disseminate results, change peoples' perceptions about the environment, and promote the adoption of new ways of doing things.

The allocation and management of water within Australia will come to dominate the debate on the environment across Australia within the next 10 years. The debate will have two major elements:

Table 1 Lessons to be learnt about Australian watercourses

Australian streams are unique	Australian streams are different from others in the world in terms of geomorphology, ecology, sedimentology and vegetation. The flow regimes of our inland rivers are amongst the most highly variable in the world and the ecosystems had adapted to these extremes.
Streams are not in equilibrium	Australian streams as we see them today are rarely in a state of equilibrium but are recovering from the previous natural catastrophic events or responding to longer-term human-induced landscape changes.
Channel expansion is common	Historical and geomorphological studies show that there have been major stream changes due to European settlement. Bed degradation and the resulting width expansion is very widespread, especially in eastern Australia.
Stock damage to rivers is common	A major cause of accelerated erosion is livestock access to channels and stream banks. These animals destabilise banks through disturbing soils and trampling and destroying stabilising vegetation.
Channels and gullies are the major sources of sediment	Most sediment in rivers comes from the river beds, banks and feeder gullies. Surface erosion is generally a less significant source.
Rivers are strongly influenced by catchment land use	River behaviour can be strongly governed by catchment processes. Salinisation is a clear example where replacement of perennial, deep-rooted vegetation by annual crops has disturbed the hydrological balance, resulting in rising groundwater tables and leaching of salts to streams.
River regulation has severely affected ecology	Dams, weirs and other in-stream structures, as well as river pumping, change the river flow regime and can severely affect ecosystems adapted to natural flows. The regulation also favours algal blooms and some exotic species.
River salinisation is a long term incipient problem	Land and river salinisation respond to land clearing at scales of time from tens to thousands of years, depending largely on rainfall. The agricultural development of Australia has set in place changes that will affect many generations into the future.
Increasing algal blooms are a symptom of decreasing river health	The frequency and intensity of algal blooms have increased substantially in Australia as a result of the increased availability of nutrients (from erosion, agriculture and urban effluent disposal) and decreased and regulated flows. Algal blooms cost the community well in excess of $200M annually.
Farm chemicals pose significant risks to river health	Fish kills from pesticide oversprays and runoff, and sub-lethal effects of pesticides on macroinvertebrates and other organisms are well documented.
Invasive pests can severely impact rivers	Introduction of alien species into the riverine environment can have devastating consequences.
Holistic approaches to river, riparian areas and floodplains are required	Over 95% of rivers in Australia have significant floodplains but the linkages between floodplains and rivers, including the watering of floodplain vegetation in floods, and movement of nutrients and biota into and out of billabongs has been largely ignored in the past. Planning mechanisms in Australia fall well short of best practice that would require a holistic, integrated, ecosystem approach.
Downstream river, estuarine and coastal waters can be impacted by upstream activities	One of the inevitable consequences of poor land and water practice is downstream impacts. Wetlands, riparian vegetation, estuaries, coastal lagoons and the streams themselves can be highly vulnerable to changes in flow, sediments, nutrients, salinity and applied chemicals.
Institutions are poorly organised for effective river management	The major natural resource government agencies are generally not structured around the holistic needs of rivers per se. Where river agencies or sections of agencies have been established, they seldom have the legislative backing or the holistic responsibility to effectively manage for all riverine values.
Legislation provides a poor framework for managing rivers	Recent reviews of river legislation in Australia (eg. LWRRDC, 2000) have shown significant shortcomings.
Community involvement and action is essential for sustainable rivers	The size of the Australian continent, length of its rivers and magnitude of degradation requires a whole of community response to achieve sustainable rivers. All sectors of the community must be involved: political, industries, agencies, landowners and the general public.

- The allocation of scarce waters between various users and the increasing competition that this will generate– urban/irrigation/industrial/environment
- The high expectations of the community for improved management of rivers, wetlands, estuaries and catchments

LWRRDC strategic plan

The new LWRRDC Strategic Plan 2001–2006 includes a major focus on managing river landscapes. LWRRDC has increased the resources allocated to river programs and has established, along with partner organisations, the National Rivers Consortium. The Strategic Plan also tackles the challenge of enhancing linkages between science, policy and practice in river management.

Conventional wisdom has it that we already have enough science to address the problems causing degradation of our environment, including rivers. This is not true. However it is the case that we could be using existing knowledge better, and that we could be doing more to learn the lessons from the huge sums being spent on river restoration and management. Informing good policy and practical on-ground management with R&D outputs is difficult, but essential.

Recently LWRRDC has focussed much of its research on improving river management, because it is here that significant gains are able to be realised with targeted investments of the limited resources available.

What are the key knowledge gaps impeding better management of Australia's unique and diverse river landscapes, and how is LWRRDC proposing to address these gaps? A discussion of the major initiatives being implemented by LWRRDC is outlined below.

National Rivers Consortium

The National Rivers Consortium was founded on the belief that while there is currently a high level of individual activity on Australian riverine issues, there is no effective framework at the national level for assembling the best available information and knowledge on rivers, and for delivering ongoing improvements in their long term management.

Founding partners to the Consortium include the Land and Water Resources R&D Corporation, Murray-Darling Basin Commission, WA Water and Rivers Commission and CSIRO Division of Land and Water. The program partners are currently broadening the membership of the Consortium, including State, Commonwealth and Local Government agencies with policy responsibilities for river management, catchment authorities, and non-government and community organisations with a commitment to improving river management.

Effective river restoration is a multi-disciplinary task. Although a range of scientific and research organisations are involved in river restoration, none are able to provide all the knowledge and skills necessary for effective river rehabilitation. The National Rivers Consortium will better assemble the full range of skills, expertise and capacity of major organisations involved in river restoration in Australia, connect the various types of activities (policy, science, practical management) and speed up progress toward community goals for river condition and management.

The Council of Australian Governments (comprising the Prime Minister and the Premiers and Chief Ministers of all States and Territories) has agreed a comprehensive national reform agenda for water. The National Rivers Consortium will assist in delivering on that agenda.

The National Rivers Consortium recognises that knowledge exchange and capacity building are integral to successful research and development. The Consortium is making a

major investment in knowledge exchange and capacity building activities, to accelerate the efforts of those involved in river management to better manage Australia's rivers.

The National Rivers Consortium operates on the basis of the following important underlying principles:

- effective river protection, restoration and enhancement results from managing whole systems rather than fixing individual aspects of problems in isolation
- management of natural river systems is a long term commitment requiring adaptive processes, and based on a recognition that rivers are dynamic
- protection of high value river reaches currently in good condition is often a higher priority than the restoration of degraded rivers
- informed communities confident that river restoration methods work, are critical to successful river projects, which must be participative from the outset
- effective interaction between researchers, policy developers, decision makers and practitioners depends on effective relationships between people
- effective relationships between people are built on commonality of interest, objectives, credibility and respect
- researchers need to be exposed to practical day to day river management issues. Managers need to be exposed to the knowledge and skills of researchers
- applied research is emphasised whilst the need for pure research is valued.

The Consortium has recently initiated a number of projects based on the following priorities:

- protecting rivers with retained natural values
- restoring degraded rivers
- training river managers based on the best available science and high quality information products
- turning research into practical river management solutions
- regional catchment projects.

Environmental water allocations

The allocation of sufficient water for a fully functional river environment remains a significant issue in the face of ongoing water resource development. Isolated high profile environmental allocations of water have been secured in the Murray-Darling Basin for the Barmah-Millewa Forests, Kerang Lakes and Macquarie Marshes.

These allocations are not sufficient to retain all of the original natural values of these important wetlands, however the allocations do represent significant advances in water allocation for the environment. One of our major challenges is to effectively manage those entitlements. In the future all water users will need to demonstrate that they are efficient and effective at managing their entitlements, or they will come under pressure to make that water available to other users.

The Murray-Darling Basin Commission has also recently announced that it will conduct a "Sustainable Rivers Audit" which will help in the planning of a wide range of management programs, including environmental flows for the Murray as a whole.

For other parts of Australia where systems are still largely unregulated, the community is asking for the means to predict the ecological impacts of new water resource developments. In inland Australia new irrigation developments have been proposed for rivers in the arid zone, such as the Cooper Creek and Paroo River. LWRRDC has funded work in these systems so that the community can weigh up the ecological as well as the economic costs and benefits of water resource developments.

While LWRRDC has funded isolated projects on environmental flows it has also identified this issue as being high on the agenda of new program development.

Salinity

Increasing river salinity was one of the earliest observed impacts of clearing the bush. The first detailed account is from a railway engineer (Wood, 1924) who observed local railway water supplies going saline a few years after the clearing of native vegetation. His concept of a rising groundwater table brought about by the change in the hydrological balance following vegetation clearing was validated much later through detailed research in the 1970s, by which time stream salinities were rising rapidly in many areas.

Irrigation and dryland salinity are now recognised as one of our most intractable threats to agricultural and environmental systems. We have scant information on the effects of saline waters on biological systems and the plants and animals that inhabit rivers and wetlands. We will need to greatly increase our scientific knowledge of the effects of salinity if we are going to develop effective management strategies.

Riparian management

Independent evaluation of the recently completed LWRRDC Riparian Lands Program found it to be of exceptional quality and rigour. It has made a significant contribution to the understanding of riparian zone function and there are large economic benefits from the program to be captured in the future as management practices for rivers improve.

The Program has a strong practical focus, with the research and development activities undertaken designed to assist those attempting to rehabilitate and better manage riparian lands. The Program has generated significant new knowledge including the following.

- Vegetation roots are effective at reinforcing and stabilising streambanks. The weight of trees is a minor influence in bank mass failure, with trees being more important in reducing soil wetness and in resisting cracking and rotational failures.
- A 6 metre wide grass strip can trap up to 95% of sediment, nitrogen and phosphorus entering from upslope agriculture.
- The shade provided by riparian vegetation is the controlling influence preventing growth of nuisance aquatic plants, including blue-green algae, even in the presence of advanced nutrient levels. Shade equivalent to around 70% of that of an intact canopy is required to prevent growth by nuisance aquatic plants.
- Native riparian vegetation is important in providing essential in-stream habitat, for example in the form of large woody debris, root armouring of banks, undercapped banks, etc. Declining habitat and declining food, both a consequence of overclearing/poor management of riparian lands, are major causes of loss of native fish and other aquatic species.
- Uncontrolled stock access to streams is highly deleterious through:
  - major source of sediment input to streams from stock tracks;
  - massive nutrient inputs in urine and dung;
  - trampling and pugging of banks, leading to increased scour and erosion;
  - overgrazing of riparian vegetation, leading to weed invasion and loss of bank stability; and
  - passage of disease organisms to other stock downstream.
- It is possible, through strategic management of stock and grazing pressure, to both improve productivity and recoup fencing/watering costs while improving environmental management.
- Quantitative data comparing economic and social costs and benefits of riparian rehabilitation and management are being collected at nine sites around Australia.
- Practical methods have been tested, demonstrated and publicised for:
  - riparian fencing (flood resistant);
  - stock management through water point distribution;

– off-river watering;
– electric fencing;
– replanting and reseeding;
– bank stabilisation techniques;
– riffle construction;
– bed armouring; and
– problem analysis and project design.

The LWRRDC Riparian Lands Program is about to enter into its second phase. Projects are being developed from the perspective of what research is needed to address management issues, with those issues being identified by river and catchment managers. Twelve priority issues have been selected.

1. Developing a conceptual model to show the importance and key components of riparian management at a catchment scale.
2. The influence of riparian management on flood hazard at a catchment scale.
3. Stabilising streambanks and trapping of sediment and nutrients.
4. Improving water quality and maintaining aquatic ecosystem health.
5. Reintroduction and maintenance of large, woody debris for habitat and energy source (including bed, bank and grade control).
6. Preventing or reducing pollution due to nitrogen and associated carbon sources.
7. Regeneration and maintenance of healthy riparian vegetation (including weed management).
8. Valuing riparian ecosystem services to improve decision making.
9. Determining appropriate riparian width for different management objectives.
10. Management of domestic stock and feral animals.
11. Development of simple but effective techniques for monitoring and evaluation of riparian management and vegetation condition.
12. Overcoming constraints to implementation of sound riparian management.

Supporting institutions

Stable institutions, well resourced and with a clear mandate are essential for long term river management. LWRRDC is supporting improved institutional capacity to restore and protect rivers, and is active in the following areas.

Putting a price on river degradation. Rivers are public goods, however, the environmental costs imposed on rivers have not been borne by the users. The continuing inability to describe environmental impacts in real economic terms has been an insurmountable barrier to establishing a financial incentive to minimise these costs and to invest in rehabilitation work.

Advocates for rivers. Compared to other natural assets such as forests, there have been no nationally organised industry or lobby groups that act as powerful advocates for river health. With organisations such as the National Rivers Consortium and the Inland Rivers Network this situation is changing.

Who manages rivers? River management responsibility is typically split between multiple agencies at the State and local government level, with a lack of clearly defined roles and responsibilities. There is an increasing devolution of responsibility to local and regional authorities. Stable institutions with a clear role and responsibility for promoting good river management are essential to long term improvements in river health. Limited budgets and reduced government commitment to investment in public good activities has significant consequences for our ability to restore and rehabilitate degraded rivers.

Protecting high conservation value rivers. We have extensive systems of national parks and conservation reserves, but have not given sufficient attention to protecting high value river systems. Most reservation strategies have little or no consideration of catchment boundaries. Practices and guidelines to identify and conserve rivers are not well developed.

Legislative frameworks for rivers. A well functioning legislative framework is essential for good river management that encompasses water flows, water quality, riparian management and catchment management. Criteria for best practice river management legislation have been developed from Australian and international experience that include:

- setting measurable river management standards
- establishing a duty of care for land and resource managers
- developing a statutory definition of "river" encompassing the whole water cycle
- establishing a single multi-functional agency for river management and rehabilitation
- providing statutory powers for river management agencies
- preparing statutory based river management plans

Eutrophication

The frequency and severity of algal blooms in Australia's rivers, lakes, reservoirs and estuaries are an indicator of the severity of aquatic degradation. In 1991/92 Australia set a world record for the longest riverine algal bloom, covering some 1100 km in the Darling River, western New South Wales.

The principal nuisance algae are the blue-greens, which frequently lead to closure of drinking water supplies. In rivers, the common sites for algal blooms are river pools created by weirs and barrages. Increased frequency and intensity of blooms is associated with nutrient enrichment and reduced river flows from water extraction.

The LWRRDC National Eutrophication Management Program has been developing practical solutions to the problem, with some important achievements as outlined below.

- Cost of algal blooms to Australia – the cost of freshwater algal blooms to Australia has been conservatively estimated to be between $180 and $240 million annually, in a recent LWRRDC report.
- Managing storages to minimise risk of algal outbreaks – A detailed study of data from Burrinjuck Dam has shown that the nutrients that fuel algal blooms are most likely to come from the bottom sediments rather than directly from inflowing waters. Researchers and storage managers have used this information to develop management guidelines for the dam.
- Influence of flow on blooms – research has shown that algal blooms that form in weir-pools arise primarily because of the stratification of the water. Blue-green algae (Cyanobacteria) can move up and down in the water column providing a competitive advantage where they move between nutrient enriched, anoxic bottom waters and the light zone in the top waters. Researchers have developed flow management techniques to break the stratification.
- Sources of phosphorus in the landscape – research using radio-isotopic tracers showed that for a typical catchment in northern NSW fertilisers were a negligible contributor to the phosphorus attached to sediment particles in rivers. Most of the phosphorus comes from natural stores in soils and is liberated by soil erosion. However in irrigated pastures areas such as the Shepparton district of northern Victoria or the sandy soils of Western Australia there is a significant contribution to the phosphorus load from applied fertilisers. These results are being turned into practical management guidelines.

The priority now is to disseminate the results of this important work, to work further with managers to develop management solutions and to change management practices.

Managing in-stream structures

Over 447 large dams have been built across Australia for a variety of purposes, including urban water supply, hydro-electric power, irrigation and flood mitigation. In addition there are many thousands of smaller weirs, barrages and floodgates that modify the flow of water in rivers, estuaries and wetlands. In the Murray-Darling Basin alone 3,600 structures have been listed as impediments to fish movement.

Major impacts of these structures include obstruction of fish movement and loss of fish habitat, increasing susceptibility of algal blooms and promotion of environments more conducive to invasive species such as carp.

There is a growing recognition of the need to better manage weirs and dams to achieve improved river environment outcomes. In some cases there will be a compelling case for their removal. There is a growing trend overseas in the selective removal of weirs and rehabilitation of river environments. One of the major drivers is the economic cost of replacement of these structures as they fall into disrepair, given that they often no longer fulfil the function for which they were built.

Work will be needed in Australia on the science to better managing of flows at weirs and the science of rehabilitation of river environments. The most difficult issues in weir removal will be gaining policy, political and community support. These will far outweigh the technical problems and we need to develop planning processes to support our river management objectives.

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