THE UNIVERSITY OF
NEW SOUTH WALES

SCHOOL OF BIOLOGICAL,
EARTH AND
ENVIRONMENTAL
SCIENCES
FACULTY OF SCIENCE

28th November 2005

Dear Sir/ Madam

Re: Senate Rural and Regional Affairs and Transport References Committee Inquiry into Water Policy Initiatives

I was invited to make a submission to this inquiry. Please find the enclosed submission which also includes some copies of scientific papers, relevant to the submission, that have more detailed information.

Should you require any further information related to this submission and the inquiry, please do not hesitate to contact me.

Yours sincerely

Richard Kingsford
Professor of Environmental Science

UNSW SYDNEY NSW 2052
AUSTRALIA
Facsimile: + 61 (2) 9385 1558
Telephone: + 61 (2) 9385 3442
Email: richard.kingsford@unsw.edu.au

THE UNIVERSITY OF NEW SOUTH WALES

Senate Rural and Regional Affairs and Transport References Committee Inquiry into Water Policy Initiatives

Submission by

Professor Richard Kingsford
School of Biological, Earth and Environmental Sciences
University of New South Wales
28/11/05

Summary

Much of this submission relates to the problems of ecological and socioeconomic effects in the Murray-Darling Basin because this is where almost 70% of Australia's annual water use occurs.

Development of water property titles (terms of reference 'a')
The history of water property titles has followed one of Governments building dams and then allocating water on the basis of yield. Most of the rivers in the Murray-Darling Basin have been overallocated. The Murray-Darling Basin Cap established in 1993/94 is still not fully implemented and does not deal with floodplain harvesting. Much of the water resource development on rivers has resulted from the building of Government dams from the 1950s-1970s. More recently, there has been a significant increase in the building of off-river storages or ring tanks on the floodplains of the Murray-Darling Basin. The resulting extractions have resulted in major declines in river flows towards the terminal ends of rivers. Rivers that flow between states provide a further challenge for management.

There have been significant effects on landholders dependent on flooding for their grazing livelihoods as well as significant degradation of rivers. Many areas of floodplain eucalypts (river red gums, coolabahs and black box) are dying because they do not receive sufficient flooding. Native fish species are declining for the same reason while exotic fish species and weeds are increasing. Waterbirds have experienced declines of about 80% in some areas such as the Lowbidgee floodplain and the Macquarie Marshes.

Methods of protection for rivers and aquifers (Terms of Reference 'b')
An executive summary is provided of a more lengthy document that details opportunities and options for the protection for rivers and aquifers. These focus on the potential for establishing an Australian Heritage River system that is primarily driven by river communities and the better management of iconic sites within regulated river systems.

Farming innovation (Terms of reference 'c')
Significant opportunities exist for water use efficiencies and for highly degraded rivers such water saved could be retired back into river systems. There remains considerable scope for work on the burgeoning levee banks and structures affecting river flows in the Murray-Darling Basin because of their potential impact on downstream processes and people's livelihoods.

Monitoring drought and predicting water demand (Terms of reference 'd')
Currently droughts are exacerbated at the terminal parts of river systems because many regulated rivers no longer receive the flows that previously sustained them. This also affects floodplain landholders who rely on flows for grazing productivity. Most of the area of rivers about 85% are floodplains and of this about 95% is owned by landholders.

The implications for agriculture of predicted changes in patterns of precipitation and temperature (Terms of reference 'e')
Estimates for effects of climate change predict reduced precipitation for the Murray-Darling Basin. This will be mean that flows will be less frequent and lower for the terminal parts of rivers. This will result in reduced economic return for floodplain graziers and increased ecological degradation. In addition, salinity of rivers is likely to increase as will the frequency of blue-green algal blooms.

Main submission

This submission deals with each of the key terms of reference and provides some hardcopy references behind the science of water management and some of the issues identified. In particular much of this submission, although not all, focuses on the Murray-Darling Basin because this is where most of the river water use in Australia occurs. Many of the problems currently affecting the Murray-Darling basin are also affecting other rivers that have been regulated.

Development of water property titles (terms of reference 'a')

About 73% of all Australia annual water use comes from rivers (24,000,000 ML (Sydney Harbour holds about 500,000 ML, National Land and Water Audit 2001) and most of this water is diverted from the Murray-Darling Basin rivers (see Fig. 1). Much of this development of water has occurred relatively recently. The National Land and Water Audit found that there had been a 65% increase in surface water use between 1983-84 and 1996-1997 (National Land and Water Audit 2001).

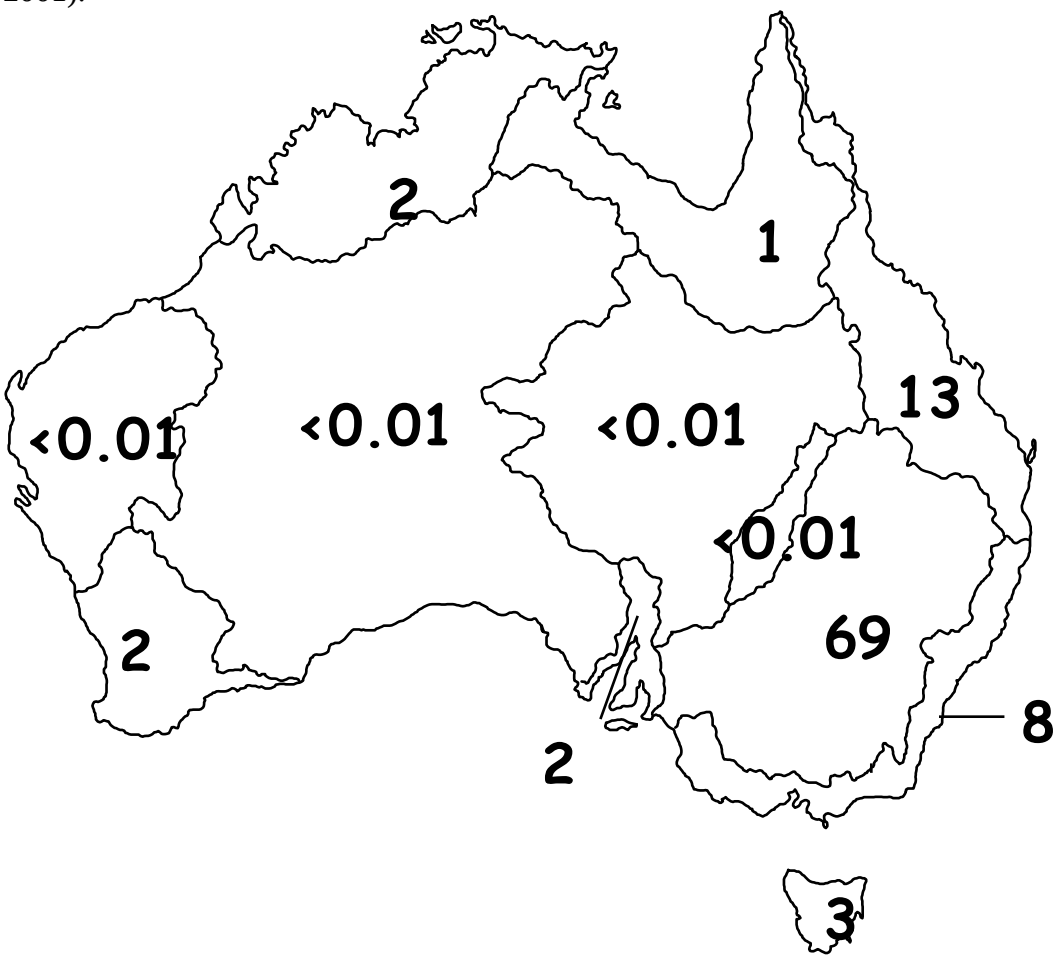

Fig. 1. Relative diversion of surface water in each of the major river basins in Australia as a percentage each year (National Land and Water Audit 2001).

Much of this development has come from the activation and granting of water licences. What is not measured in this figure is the diversion of water from the floodplain (termed floodplain harvesting) as there are few audits and relatively little metering. The amount of water diverted from Australian rivers, particularly the Murray-Darling Basin is likely to be higher and increasing, even in areas such as the Murray-Darling Basin where there is meant to be a cap in place (MDBMC 1996). To deal with each of these issues adequately, different property rights are defined below and the impact that the granting of these property rights are having on the ecology of rivers and downstream communities. Much of this impact is confined to the Murray-Darling Basin where the most impacts are being registered.

Allocated water licences

Governments generally built large dams in the catchments of rivers and then asked landholders to buy licences for the rivers. The amount of water that was to be licensed was generally based on the yield from the dam that had been built. Most of the dams in the Murray-Darling Basin were built in the 1950s-1970s (see Fig. 2).

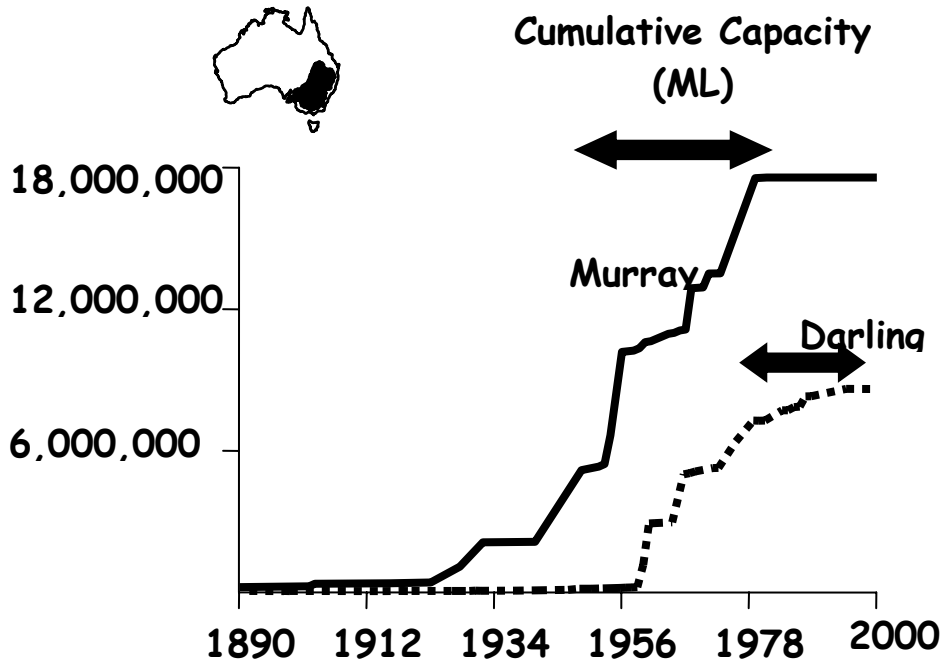

Fig. 2. Cumulative capacity (ML) of dams built in the Murray-Darling Basin, showing the major periods of water diversions for the Murray river systems and the Darling river systems.

Sometimes the amount of water available in a dam was overestimated. For example, in the Gwydir River system, 530,000 ML per year of irrigation licences were given out, exceeding the median annual flow in the Gwydir of 520,000 ML just upstream of the major wetlands (Kingsford 2000).

The capital cost of licences has also increased substantially. In the Border Rivers region, an irrigation licence could be purchased before 1981 for about $850. The same irrigation licence is now worth about $1.5 million on some rivers (Kingsford 1999a). Reliability of meeting irrigation allocations on licences each year is often not met as result of over allocation.

Many river catchments in the Murray-Darling are acknowledged to be overallocated, resulting in the Murray-Darling Basin Cap. Even though there was agreement to implement the Murray-Darling Basin Cap at 1993/94 levels, this did not apply to Queensland. So even today more than ten years after this significant policy initiative to deal with overallocated systems was implemented, there are no caps on the Condamine-Balonne, Moonie, Border Rivers, Warrego. There are intentions through the water planning processes in Queensland to arrive at these figures but currently, these rely on the implementation of the resource operations plan. NSW has made similar intentions for the Barwon-Darling River system and yet there is still no clear cap on extraction in place. Also note (see below), there is little assessment audit or constraints on floodplain harvesting.

Water sharing plans in southern states have virtually granted property rights to water in perpetuity that were not given before. While allocated shares may be overturned in the future if there is sufficient science, in reality major changes to allocations will be extremely difficult without compensation.

Management of rivers is also particularly difficult when it comes to rivers that flow between States (Kingsford *et al*. 1998). The issue is to some extent dealt with by the Murray-Darling Basin Commission but remains challenging, mainly because different states have water legislation that is different. Policies that are implemented under such legislation also are different. Terminology provides another layer of complexity as the same time of water extracted can be given different names.

Off allocation, supplementary water, water harvesting

Most of Australia's legislation for river was derived from English legislation where rivers are considerably different. So until relatively recently most of Australia's legislation, policy and management left out floodplains, the vast majority of a river. In NSW, floodplains equate to about 88% of a rivers area and more than 95% of this is owned by landholders who will be affected by changes in river flows.

Access to water flowing over the banks has been routinely provided to the irrigation industry whenever there was a flood. This has resulted in a significant increase in the number of off-river storages for the pumping of rivers. In the Gwydir River catchment, these have increased from little to about 400,000 ML today (see Fig. 3). In Queensland, such water had no charge further encouraging its development. Much of this water is not metered and unaccounted for.

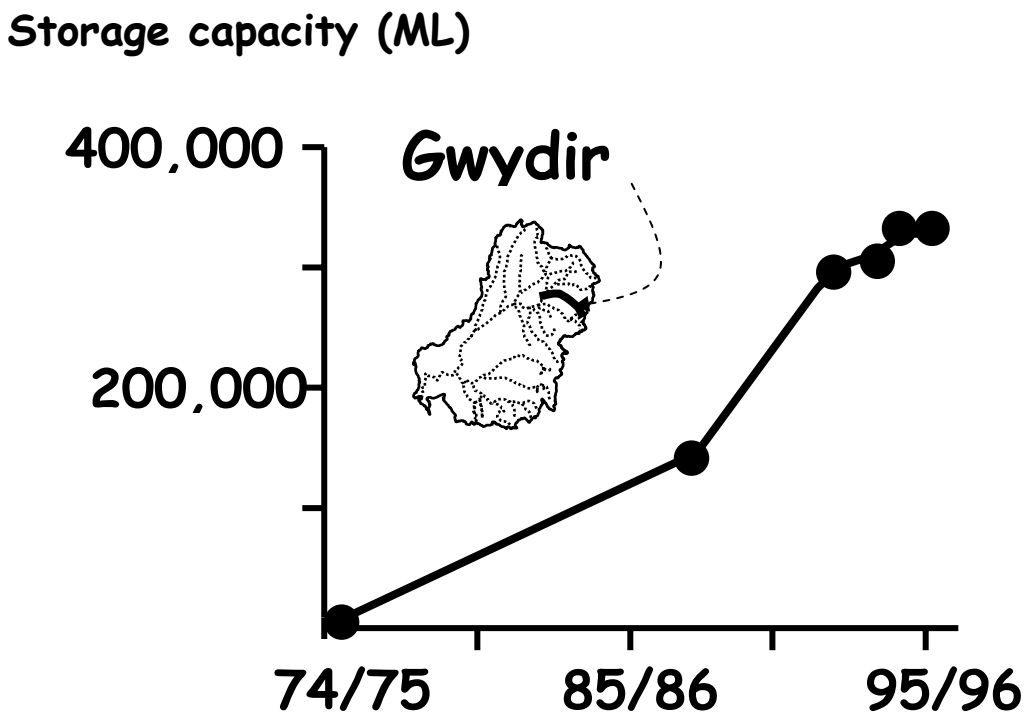

Fig. 3 Growth in off-river storages in the Gwydir River catchment. In 2005, the storage capacity is believed to be about 400,000 ML. Sydney Harbour holds about 500,000 ML.

In some floodplains, small distributary or effluent creeks are turned into off-river storages resulting in the supply of water straight into storages. Other catchments have drains across the floodplain that allow water to fall into them when it flows across and can then be pumped into storages. Such structures have considerably reduced flows downstream. On the Condamine-Balonne, this has been taken to other level with people 'bunding' off the floodplain so water can be captured.

The most significant development of a river has occurred on the Condamine Balonne where the number of off-river storages and ability to divert water has increased exponentially (Fig. 4). Most of the regulation in this catchment is related to the development of off-river storages.

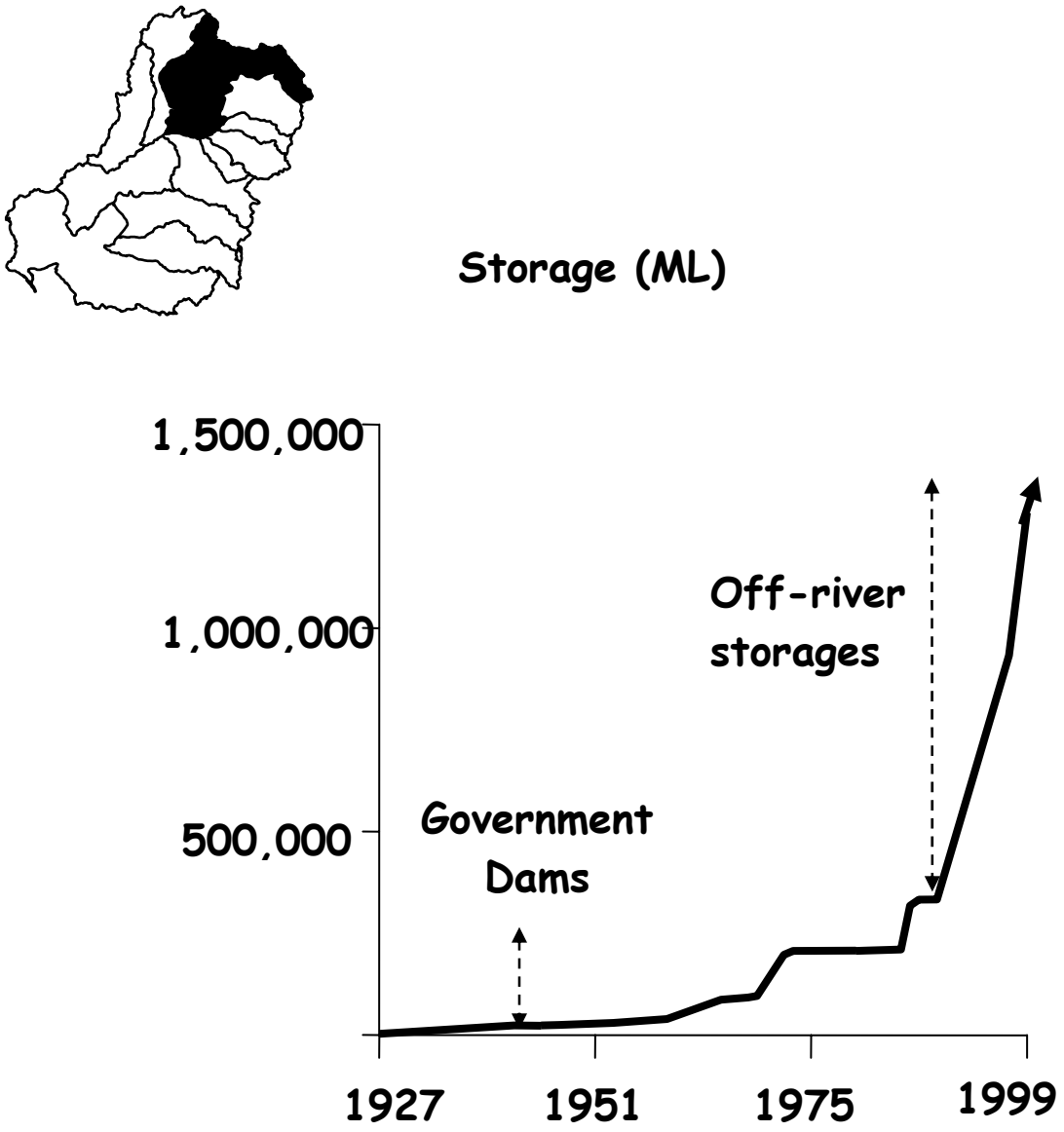

Fig. 4. Cumulative storage capacity of dams in the Condamine-Balonne catchment of the Murray-Darling Basin, showing the cumulative capacity of Government built dams relative private off-river storages.

Downstream effects of water property titles

A number of scientific papers are enclosed in this submission that demonstrate the long-term effects of development on downstream wetlands and floodplains. Most of the floodplains and wetlands in the Murray-Darling Basin at the terminal end of rivers are in ecological crisis (Fig. 4). The red gums are dying; native fish populations are declining; frogs, reptiles and waterbirds are all declining. For example, there have been significant declines in waterbird numbers in the Macquarie Marshes over a period of more than 20 years (Fig. 5).

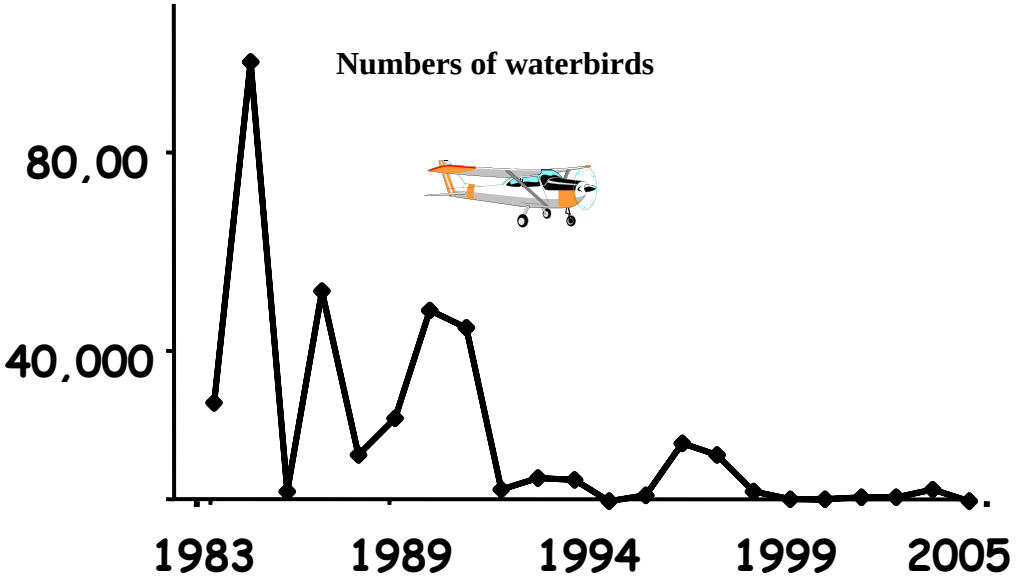

Fig. 5. Total numbers of waterbirds counted during annual aerial surveys of the northern part of the Macquarie Marshes.

Exotic fish species and weeds are generally favoured by these changes to Australia's rivers. These are all indicative of severe changes in the ecology of rivers. Specific examples are provided in the attached scientific papers. Most of the protected areas on rivers are included in this list (e.g. Macquarie Marshes, Coorong, Chowilla). These areas clearly demonstrate that Governments cannot guarantee the future protection of such areas without water protection (see below).

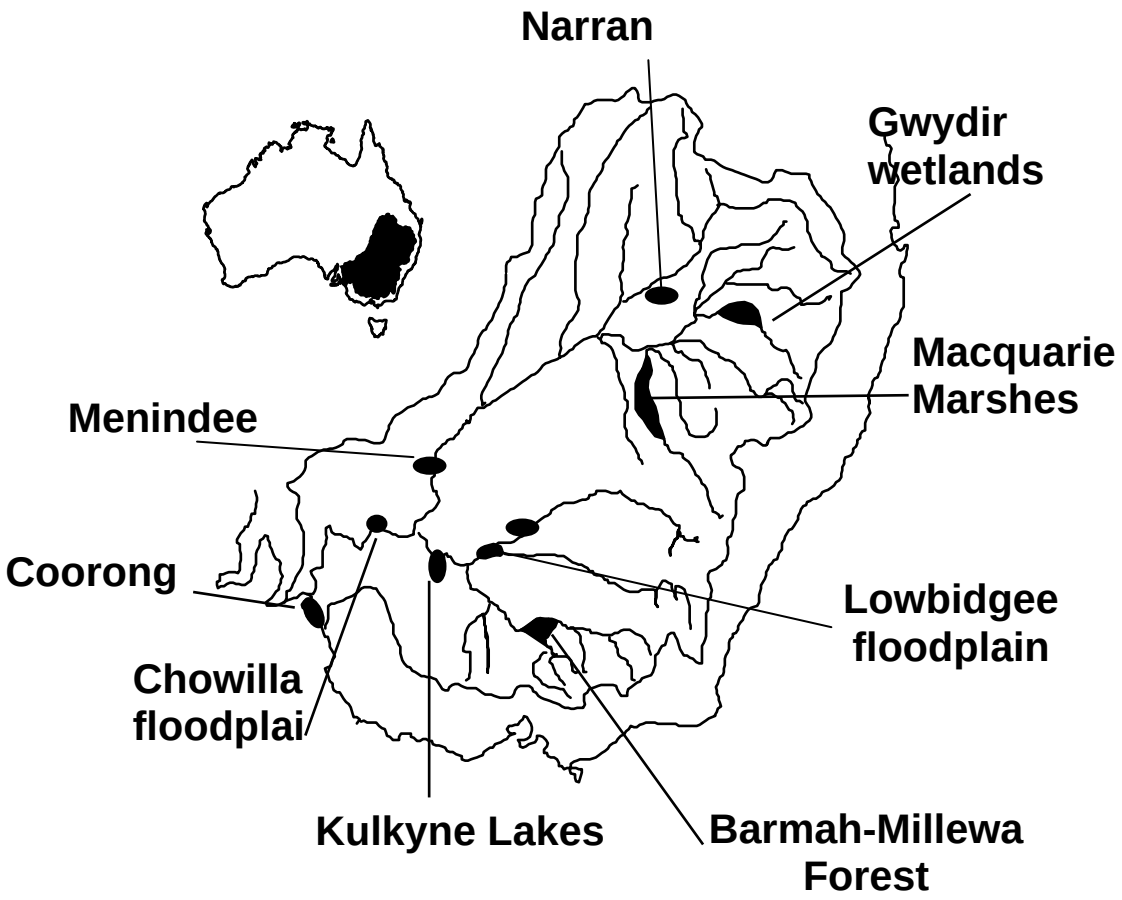

Fig. 6. Major wetlands and floodplain in severe decline as a result of water resource development upstream. Parts of each are protected but continue to degrade.

In all major rivers in the Murray-Darling Basin, river flows at the end of the rivers have significantly declined as a result of extractions upstream. A typical example of this decline is shown by the amount of water reaching the NSW border from Qld in the Condamine-Balonne River system and this does not measure any of the reductions that have occurred in floodplain flows (Fig. 6).

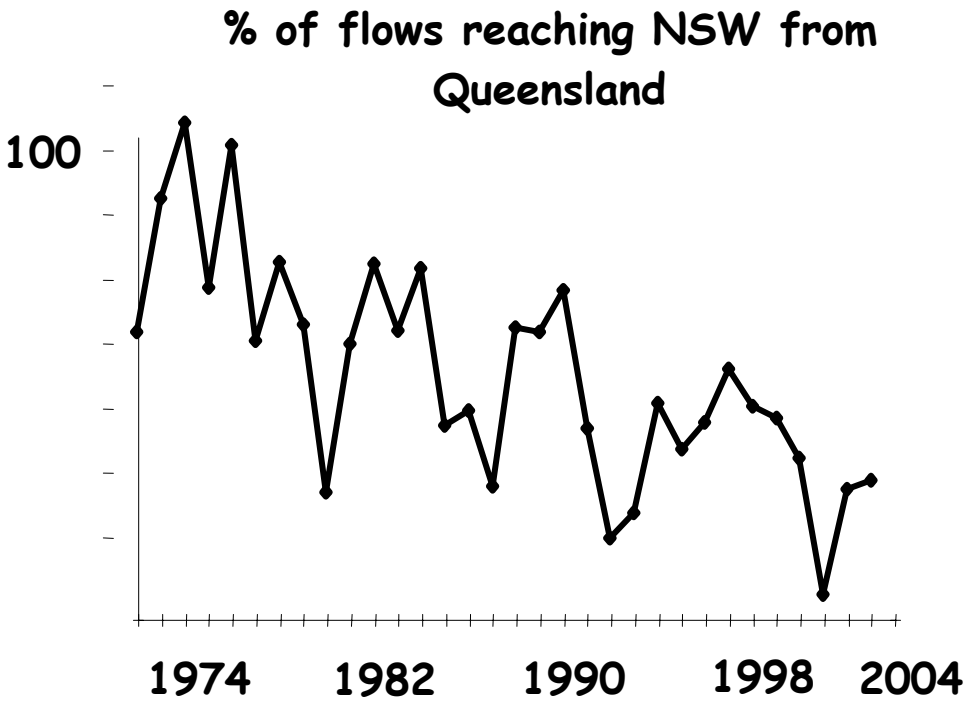

Fig. 7. Relative decline as a percentage in river flows in the amount of water reaching NSW in the Condamine-Balonne River system.

In addition to the environment, development of rivers has affected downstream landholders reliant on beneficial flooding by significant amounts. Up to about 50% of these people's flooded country has been affected sometimes translating to a 50% reduction in their income (Kingsford 1999b).

Methods of protection for rivers and aquifers (Terms of Reference 'b')

The following extract is the executive summary from the following document and provides details of the most effective methods for adequate protection of rivers and aquifers.

Protecting Australia's rivers, wetlands and estuaries of high conservation value

R.T. Kingsford, H. Dunn, D. Love, J. Nevill, J. Stein and J. Tait (2005)

Executive summary

Australia has a rich variety of different rivers, wetlands and estuaries that support a significant amount of its biodiversity and industry. Important social values of Australia's Indigenous and European culture are also intimately linked to the integrity of our rivers. Despite this, compared with terrestrial conservation (e.g. national parks and reserves, and regional forest agreements), there has generally been a lessor focus on conservation of these ecosystems in Australia.
This report presents a conceptual framework for the protection of riversd, river reaches andestuaries of high conservation value. It was developed in conjunction with State and Territory agenciesduring 2003 and 2004 and provides an important foundation for developing future approaches to the conservation of these key areas.
Many of Australia's rivers, wetlands and estuaries are affected by river regulation, catchment

disturbance and pest species, and opportunities to effectively conserve riverine biodiversity and landscapes are limited.. There are opportunities to protect Australia's most important aquatic areas so that future generations do not have to pay the high costs of rehabilitation (e.g. as has happened for the River Murray). This may begin with a comprehensive national framework that identifies and protects rivers, wetlands and estuaries that have high, national conservation value. States and Territories are primarily responsible for their protection, but a national framework could support consistent identification and strategic investment in the protection of nationally important aquatic ecosystems.

All Australian governments have invested in programs and projects aimed at protecting rivers, wetlands and estuaries. There is national recognition of the importance of this issue across all jurisdictions. In 1994, the Council of Australian Governments (CoAG) agreed that the environment was a legitimate user of water. In 2004, CoAG agreed to the National Water Initiative (NWI), which will chart the future responsibilities and progress towards sustainable management of the nation's rivers and aquifers. Provisions in the associated intergovernmental agreement commit most governments to identify, protect and manage high-conservation-value rivers and aquifers and their dependent ecosystems.
To effect protection of high-conservation-value rivers and their dependent ecosystems, national conservation goals are essential. They may be used also to determine short-term and specific goals developed from a national vision statement for rivers. This recognises that it is not possible to single out high-conservation-value rivers or their dependent ecosystems and expect to protect only these and achieve conservation of their values. River conservation requires a network approach that recognises that many processes and organisms may use all parts of rivers and even different rivers during their lives. A protection framework focused on only high-conservation-value rivers will not work.

Rivers and dependent ecosystems with nationally high conservation values are a subset of the country's aquatic ecosystems. Conservation value is a relative measure, established through a comparison of all rivers and dependent ecosystems. This discussion paper focuses on ecological conservation values, but recognises that rivers also have considerable cultural, economic and ecosystem service values.

There are two key questions for this framework.

- *What rivers, floodplains, wetlands and estuaries are of high conservation value?*
- *How can these be protected?*

Elements of a national framework

A national framework of river protection could be built around three main elements:

1 nationally consistent collection of information on rivers, wetlands and estuaries, which will entail agreement on spatial scale and classification and evaluation systems for identification of rivers and dependent ecosystems of high conservation value

2 protection schemes that operate at different scales such as :
   – a 'whole-of-river' approach that could include establishment of an 'Australian Heritage Rivers' system
   – protection of high-conservation-value rivers, river segments and dependent ecosystems (floodplains, wetlands, estuaries) in a national, State, regional and local context (using current legislative and policy tools; i.e. environmental flows, protected areas, natural resource planning and management, and incentives)

3. operational and institutional arrangements— coordinated programs involving jurisdictions in implementation of a national framework.

Nationally consistent collection of information

All rivers, wetlands and estuaries have conservation values, but we need methods to identify which of them have the highest national conservation value to assist decision makers to determine priorities.. To do this, we must first have a method that can operate at various and agreed spatial scales. To achieve a relative comparison of conservation value, consistent and agreed approaches to classification and evaluation are needed to work across all rivers, wetlands, floodplains and estuaries. The following conservation criteria could be utilised to assess high-conservation-value rivers and their dependent ecosystems.

The river or dependent ecosystem:

- is largely unaffected by the direct influence of land and water resource development
- is a good, representative example of its type or class
- is the habitat of rare or threatened species or communities, or the location of rare or threatened geomorphic or geological feature(s)
- demonstrates unusual diversity and/or abundance of features, habitats, communities or species
- provides evidence of the course or pattern of the evolution of Australia's landscape or biota
  OR
- performs important functions within the landscape.

Spatial framework
An agreed spatial framework is essential for undertaking national assessments.

Recommendations

a. *Use current drainage divisions, river basins and river segments for initial implementation of this framework. These map layers, and the sub-catchments and catchments they support, should be publicly available.*

b. *River ecosystem data should be labelled according to resolvable hierarchical scales, allowing for future evaluation and reassessment of classifications.*

c. *Develop a new hierarchical spatial framework for managing aquatic systems and rivers, based on topography and drainage networks and without the problems of current spatial layers.*

Classification and evaluation systems
Collation of all available attribute data for the criteria, and gap-filling where necessary, at the finest spatial scale possible (i.e. river segment), is important to make a national assessment of rivers, wetlands, floodplains and estuaries.

Recommendations

a. *Devlop agreed approaches for assessing criteria and use of attributes for rivers, river reaches and dependent ecosystems.*

b. *Develop agreed national classifications of rivers and dependent ecosystems, with agreed objectives, to support evaluation and assessment.*

c. *Apply a nationally agreed set of evaluation criteria and significance thresholds, compatible with Ramsar and National Heritage, with nationally available data, aggregated to the smallest resolvable scales of assessment (i.e. river segments and their sub- catchments). This could be done to assess all river segments to identify nationally important rivers, wetlands (greater than 200 ha) and large estuaries. This initial assessment could be reported at a range of scales, informing a national assessment but also State and regional assessments.*

d. Establish long-term collection and storage of nationally consistent data on rivers and their dependent ecosystems that allows for comparison across the country.

Protection scheme

Once identified, the challenge is to ensure protection of rivers, wetlands and estuaries at different scales and contexts. We propose consideration of a protection scheme with two approaches: establishment of an Australian Heritage Rivers system in conjunction with better use of existing protection mechanisms. There are generally sufficient mechanisms available within jurisdictions for protection of aquatic ecosystems, but implementation of a mulit-scale system would improve effectiveness at a catchment level.

Australian Heritage Rivers system

Potential candidate rivers could be identified that are of high conservation value, generally at a large scale (i.e. river basin, tributary river), using the methods identified above. While identification of candidates could be a national process, nominations for listing as Australian Heritage Rivers could also come from communities. Designation as an Australian Heritage River could signify sustainable use rather than a moratorium on development. There could also be parallel development of a process that identifies and assesses cultural values.

Recommendations

a. Identify potential candidate river basins as Australian Heritage Rivers. This process could be done immediately, using current data, but nomination and designation would not occur without community support.

b. Identify institutional arrangements that would deliver an Australian Heritage River system, including current models, and whether there is a need for legislation. Essential steps in the arrangements would be nomination, designation, consultation and administration. The Canadian Heritage Rivers System is a model worth considering.

c. Largely unmodified river basins designated as Australian Heritage Rivers could be priority areas for funding river management plans that protect ecological values, prevent environmental problems, encourage uses compatible with protection of ecological values and promote understanding of ecological values and processes.

Protecting nationally important rivers, river segments, floodplains, wetlands and estuaries using current mechanisms

There are many tools within jurisdictional, legislative and policy frameworks for protecting nationally important high-conservation-value rivers, wetlands and estuaries. These can be grouped under four, main, interrelated mechanisms: environmental flow management; protected area acquisition and management; natural resource management; and incentives. These preferably operate within a catchment planning and management framework that logically follows the rivers and recognises their connectivity.

Priorities for protection could be defined by working from quantitative national conservation targets for rivers, wetlands and estuaries. Actual protection may be effected through jurisdictional policies and management, and the regional bodies responsible for catchment management. The following recommendations for environmental flow management, protected areas, natural resource management and planning, and incentives scould apply to rivers, river segments, floodplains, wetlands and estuaries identified as having high national conservation value.

Recommendations—environmental flow management

a. Environmental flows for long-term sustainability of rivers and their dependent ecosystems need to be identified at catchment scales.

b. Environmental flows should be managed within an adaptive management framework that ensures the best environmental outcomes.

c. Targets for flow restoration may need to be developed with a focus on better management of flows and access to additional flows if required (e.g. improving water-use efficiency, purchase of water).

Recommendations—protected areas

a. Aquatic ecosystems should be considered for future acquisition of protected areas (e.g. national parks, nature reserves, conservation areas, or aquatic reserves), or nominations of important wetland areas (e.g. National Heritage, World Heritage and Ramsar sites). This may also include Indigenous protected areas.

b. Policies and management practices and documents for protected areas with rivers and dependent ecosystems should include how management or policies will meet long-term ecological outcomes of sustainability (e.g. upstream environmental flows, pest control strategies and impacts of catchment disturbance).

c. These ecosystems could be the focus for the development of cooperative protective management arrangements with landholders (e.g. voluntary conservation agreements and other protected area programs).

d. They could be considered for heritage listing under the National Heritage List of the Environment Protection and Biodiversity Conservation Act 1999.

e. They could be listed under relevant threatened-species legislation as endangered or threatened ecological communities if they satisfy appropriate criteria.

Recommendations—natural resource management and planning

a. Statutory resource and land-use plans, including river- management plans, should assess and control potentially deleterious impacts on these ecosystems at catchment scales.

b. Environmental objectives in water plans should adequately acknowledge high-conservation-value rivers and their dependent ecosystems and water regimes that maintain their ecological values.

c. River-management planning of these areas needs to explicitly incorporate rivers and their dependent ecosystems within management plans, recognising catchment processes and hydrological connections.

d. For those aquatic ecosystems that cross management borders, river planning should incorporate all of a catchment, taking account of different jurisdictional water legislation.

e. Water-quality policies and management should link to planning, assessment and controls that protect identified aquatic ecosystems.

f. Introduction of exotic species (plants or animals) should be controlled in these aquatic ecosystems and their catchments.

g. River management planning should involve communities early and involve effective community consultation and communication.

j. Planning should be culturally sensitive (e.g. respect Indigenous decision-making and governance processes) and involve traditional owners for identified ecosystems.

i. For improved management, research and development should focus on threats that affect conservation values of high-conservation-value rivers, reaches and dependent ecosystems.

Recommendations—incentives

a. These ecosystems need to be identified and included in Australian Government, State and regional investment

frameworks.

b. *These aquatic ecosystems could receive priority in monitoring and assessment of ecological values (e.g. Rivercare, Water Watch, auditing).*

c. *These ecosystems could be a focus for tax and rate- relief programs and new incentive schemes for landholders committed to protecting these areas.*

Making it happen

Implementation of the national framework would require cooperation between jurisdictions and the Australian Government. To that end, it could be best progressed under the aegis of the Natural Resource Management Ministerial Council and the National Water Initiative.

Farming innovation (Terms of reference 'c')

There is significant opportunity for water use efficiencies. Off-river storages have up to 40-50% of the water can be lost to evaporation. Many channels also lose much of their water to evaporation. Given the state of our rivers in the Murray-Darling Basin, it is essential that any funds provided by tax payers to assist with water use efficiencies result in the retirement of as much water as possible to the rivers.

Considerable work needs to be done to audit and assess the effects of levee banks on floodplains and downstream flows. Policies and management need to be implemented to avoid the increasing problems of fragmentation of floodplains on the rivers of the Murray-Darling Basin.

Monitoring drought and predicting water demand (Terms of reference 'd')

Australia has the most variable rivers in the world (Puckridge *et al*. 1998). Flows are related to unpredictable weather patterns. Much of Australian history has concentrated on drought proofing the country by building dams and regulating water mainly for irrigated agriculture. This has resulted in considerable degradation problems (outlined above). Droughts are now much longer in the lower half of major regulated rivers. Some parts of rivers no longer receive floods because there is insufficient water for inundation. Such changes will continue to increase with water resource development and further building of off-river storage on the floodplain.

It is worth noting that many landholders in central Australia that rely on the floods of Cooper Creek, the Paroo River and the Georgina-Diamantina Rivers are able live with the natural variation of rivers and their droughts and floods. They specifically stock and destock in relation to the variations in conditions largely driven by river flows.

The implications for agriculture of predicted changes in patterns of precipitation and temperature (Terms of reference 'e')

Current degradation of rivers as a result of river development including abstraction is already having significant effects on landholders livelihoods in relation to grazing. Most estimates for climate change predict less precipitation in the Murray-Darling Basin rivers. This will mean that there will be less water for irrigation and significantly less water inundating the floodplains of the major rivers. This will decrease the economic return for floodplain areas that generally have more

than double the productivity of areas in arid and semi-arid parts of Australia (about 70% of the continent). Those rivers receiving less flow will have increases in salinity and frequency of blue-green algal blooms which will continue to exacerbate the problems of river degradation.

References cited in submission

Kingsford, R.T. (1999a) Managing the water of the Border Rivers in Australia: irrigation, Government and the wetland environment. *Wetlands Ecology and Management* **7**, 25-35.

Kingsford, R.T. (1999b) Social and economic costs and benefits of taking water from our rivers: the Macquarie Marshes as a test case. *In "Preserving Rural Australia: Issues and solutions". Robertson, A.I. and Watts, R.J. (Eds). CSIRO Publishing, Melbourne* 125-143.

Kingsford, R.T., Boulton, A.J. and Puckridge, J.T. (1998) Challenges in managing dryland rivers crossing political boundaries: lessons from Cooper Creek and the Paroo River, central Australia. *Aquatic Conservation: Marine and Freshwater Ecosystems* **8**, 361-378.

Kingsford, R.T. (2000) Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia. *Austral. Ecology* **25**, 109-127.

MDBMC (Murray-Darling Basin Ministerial Council) (1996) Setting the Cap. Report of the Independent Audit Group. *Murray-Darling Basin Ministerial Council, Canberra* 64pp

National Land and Water Resources Audit (2001) *Australian Water Resources Assessment 2000,* edn. Canberra: Commonwealth of Australia.

Puckridge, J.T., Sheldon, F., Walker, K.F. and Boulton, A.J. (1998) Flow variability and the ecology of arid zone rivers. *Marine and Freshwater Research* **49**, 55-72.

Hardcopies of relevant scientific papers published by the author – enclosed with submission

Kingsford, R.T. and Thomas, R.F. (1995) The Macquarie Marshes in arid Australia and their waterbirds: a 50 year history of decline. *Environmental Management* **19**, 867-878.

Kingsford, R.T., Boulton, A.J. and Puckridge, J.T. (1998) Challenges in managing dryland rivers crossing political boundaries: lessons from Cooper Creek and the Paroo River, central Australia. *Aquatic Conservation: Marine and Freshwater Ecosystems* **8**, 361-378.

Kingsford, R.T. and Johnson, W.J. (1998) The impact of water diversions on colonially nesting waterbirds in the Macquarie Marshes in arid Australia. *Colonial Waterbirds* **21**, 159-170.

Kingsford, R.T. (1999a) Managing the water of the Border Rivers in Australia: irrigation, Government and the wetland environment. *Wetlands Ecology and Management* **7**, 25-35.

Kingsford, R.T. (1999b) Social and economic costs and benefits of taking water from our rivers: the Macquarie Marshes as a test case. *In "Preserving Rural Australia: Issues and solutions". Robertson, A.I. and Watts, R.J. (Eds). CSIRO Publishing, Melbourne* 125-143.

Kingsford, R.T. (2000) Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia. *Austral. Ecology* **25**, 109-127.

Kingsford, R.T. (2003) Social, institutional and economic drivers for water resource development - case study of the Murrumbidgee River, Australia. *Aquatic Ecosystem Health and Management* **6**, 69-79.

Kingsford, R.T., Brandis, K., Thomas, R.F., Crighton, P., Knowles, E. and Gale, E. (2004) Distribution and conservation of wetlands in New South Wales, Australia. *Marine and Freshwater Research* **55**, 17-31.

Kingsford, R.T. and Thomas, R.F. (2004) Destruction of wetlands and waterbird populations by dams and irrigation on the Murrumbidgee River in arid Australia. *Environmental Management* **34**, 383-396.

Lemly, A.D., Kingsford, R.T. and Thompson, J.R. (2000) Irrigated agriculture and wildlife conservation: conflict on a global scale. *Environmental Management* **25**, 485-512.