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Supplementary material

Eight river principles for navigating the science–policy interface

Melissa Parsons[A], *Martin C. Thoms*[A,C] *and Joseph E. Flotemersch*[B]

[A]Riverine Landscapes Research Laboratory, Geography and Planning, University of New England, Armidale, NSW 2351, Australia.

[B]National Exposure Research Laboratory, US Environmental Protection Agency, 26 W. Martin Luther King Drive, Cincinnati, OH 45268, USA.

[C]Corresponding author. Email: martin.thoms@une.edu.au

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Table S1. Supporting information for the evaluation of the eight principles of river science in the objectives of the *Water Act* 2007 and the content of the draft Basin Plan

Principle	Is the principle conveyed under the objectives of the *Water Act* 2007?	Is the principle conveyed in the content of the draft Basin Plan?	How could the principle enhance the objectives of the *Water Act* 2007 or content of the draft Basin Plan?
1 Rivers are social–ecological systems	Partly visible • Objective (d) states that subject to ecological values, the Act should maximise net economic returns to the community from the use and management of Basin water resources. • Objective (c) relates to the use of the basin's water resources in a way that optimises economic, social and environmental outcomes.	Not visible • Water allocations were designed to maintain ecological systems and critical human water needs. The effects of water allocation on broader social systems were only addressed following adverse reaction to the draft plan during public consultation. • Initial separation of ecological and social components did not allow feedbacks and relationships between ecological and social systems to be built into the plan. • Adaptability and transformability as social behaviours that encourage ecosystem sustainability could not be promoted or integrated into the plan. • The designation of the current state of the basin as undesirable came from the ecological component.	• Treating the ecological and social components of the Basin as a social–ecological system acknowledges that consumptive uses and ecological values are tightly related. Adaptability and transformability of actors – a social phenomenon – needs to be nurtured in the policy as the cornerstone of ecological sustainability. • Determination of the state of the Basin's rivers as desirable or undesirable. Ecological functioning in some parts of the Basin may have already moved into an irreversible, alternative state.
2 River ecosystems provide valuable ecosystem services	Visible • Objective (d) states that the Act will protect, restore and provide for the ecological values and ecosystem services of the Basin. • After this, the term ecosystem services only occurs once more in the Act, where an environmental asset is considered an ecosystem service.	Partly visible • The focus was on water as a provisioning service. • Environmental assets were considered equivalent to ecosystem services, covering regulating, cultural and supporting services. It was assumed that maintenance of assets would then support the maintenance of provisioning services.	• Analysis of the costs and benefits of optimising for or protecting combinations of ecosystem services in the Basin provides information that the actors in a social-ecological system can use to help determine their futures.

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		• There was limited analysis of the tradeoffs among ecosystem services required to deliver policy objectives in a social–ecological system.	
3 Tools should support policy development	Partly visible • Objective (h) enshrines the collection, collation and analysis of water resource information as part of the Act.	Partly visible • Sophisticated hydrological models were developed for determining surface and groundwater sustainable diversion limits. These allocation models were linked to ecological responses where data were available. However, the hydrological–ecological models were not readily suited to answering policy questions about the effects of different scenarios of water allocation on the social parts of a social–ecological system.	• Integrated models that link water allocation to social and economic outcomes would provide a tool for predicting the effects of policy options under different scenarios now and into the future.
4 Knowledge of river ecosystems will always be incomplete	Partly visible • Objective (h) relates to collection of water resource information.	Visible • There was due acknowledgement of the gaps in information on Australia's river ecosystem structure and function, and ecological responses to environmental flows. • The best available science framework was used to work with available knowledge. • There are provisions for updating knowledge into the Basin Plan at regular intervals.	• A research and development programme targeted specifically to the objectives of the Act may assist in gathering policy relevant information before the next Plan review.
5 Social-ecological systems require interdisciplinary perspectives	Partly visible • Objective (c) relates to the use of the basin's water resources in a way that optimises economic, social and environmental outcomes.	Not visible • There was limited interdisciplinary expertise within the department responsible for developing the plan. Consequently, focus was on technical solutions from the disciplines of hydrology, engineering and ecology, with limited and late analysis of the social, economic and political effects of the Basin Plan.	• Although difficult to achieve in practice, analysis of the effects of different water allocation scenarios could be coordinated across different departments with specific disciplinary expertise.
6 Science is one of many inputs to be considered	Not visible • The range of values present among users of basin water is not acknowledged in the objectives of the Act.	Not visible • The focus on the environment necessitated reliance on hydrological and ecological science to develop the plan. Science initially played the role of independent knowledge provider.	• Although unlikely to be a high level objective of any policy, acknowledgement of the stakeholder space, and harnessing of all views and values, is important in the development of policy content.

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		• Despite the multi-faceted values associated with the use of water in the Murray–Darling Basin other stakeholders such as community groups, farmers, local government and irrigators only moved into the decision space after the release of the draft Basin Plan, and once allocations had been determined on the basis of science. • When reaction to the plan by stakeholders was adverse, science and scientists moved from the role of independent knowledge provider to an environmental advocacy role within the multi-stakeholder decision space.	
7 Heterogeneity and variability are characteristic of river ecosystems	Not visible • The role of variability and heterogeneity as key drivers of the character of the Basin's river ecosystems was not acknowledged in the objectives of the Act.	Visible • There was acknowledgement of Australia's inherent flow variability as a key limitation on the use of water resources in the Murray–Darling Basin. • Division of the basin into 19 regions acknowledged the inherent spatial heterogeneity of rivers within the basin. However, the inherent spatial heterogeneity of social components was not considered, nor heterogeneity in the feedbacks between the social and ecological parts of the basin.	• The inherent heterogeneity and variability in the availability of water is likely the key factor for achieving environmental outcomes. Understanding how this heterogeneity and variability plays out in a social–ecological system such as the Murray–Darling Basin is important for achieving the objectives of the Act and implementing the content of the Plan in the national interest.
8 Scale awareness is essential in river ecosystems	Partly visible • The scale of reference for all objectives was the entire Murray–Darling Basin.	Not visible • The assumption in the Basin Plan was that targeting a sub-set of 18 key ecological assets would provide suitable flow regimes for all 2402 ecological assets in the basin. There was an attempt to ensure that important ecosystem functions were included within the environmental flow regimes defined for the 18 key	• Although a difficult task to operationalise, improved environmental outcomes may be achieved with consideration of the scaled nature of river ecosystems where flows are targeted at different spatial and temporal scaled social–ecological processes.

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		ecological assets. However, functions were not placed within the context of the nested hierarchical nature of river processes and their relationship at different scales to social–ecological systems. Flows were measured at the end of system, de-emphasising any within-system hydrological character that is important for maintaining biodiversity and the integrity of social–ecological systems within the basin. • Annual and long-term watering plans are required.	