
4 Allocating environmental water

Key points

- Allocating water to improve environmental outcomes in the Murray-Darling Basin is difficult and complex.
- Recently, too little water has been allocated to the environment. In many locations, the benefits from governments buying water for the environment could exceed the costs, if well implemented.
- Determining environmental allocations and water recovery targets that maximise community benefits is hampered by incomplete information on ecological responses to environmental watering.
- The ability to deliver water for environmental benefit at priority locations depends on hydrological connectivity, conveyance losses and the potential for water to be intercepted by other users.
- Environmental outcomes depend not only on the volume of water allocated to river systems and other environmental assets, but also on the timing and quality of allocations, as well as the implementation of land management practices.
- Setting the environmental objectives of water recovery in a way that maximises the wellbeing of the community requires prioritisation of environmental outcomes in a way that reflects people's preferences.

This chapter discusses the rationale for government involvement in acquiring water for the environment and assesses the information and criteria being used to guide the purchase of water entitlements under the Restoring the Balance (RTB) program. It looks at the challenges in setting environmental priorities as part of the buyback, including incorporating community preferences. It also identifies the spatial and temporal characteristics that influence the capacity of the water rights being recovered to deliver environmental benefits across the Basin.

4.1 Why is water use in the Basin a policy issue?

Water is diverted for a broad range of consumptive uses, including for household and agricultural uses. This includes irrigation of annual crops, permanent plantings and pasture to feed livestock. However, water can also benefit the community if it is used for the provision of environmental services — that is, if it is allowed to remain

in river channels and to flow into wetlands and estuaries. These benefits can take many forms, including enjoyment of healthy river valley ecosystems, improved water quality and water-dependent recreational activities.

The volume of water flowing through the rivers and tributaries of the Murray-Darling Basin (the Basin) has reduced significantly in recent times. The allocation of water to consumptive uses increased until the mid 1990s. This has contributed to changes in seasonal flow regimes across the Basin and a reduction in the volume and frequency of flows to many wetlands including the Lower Lakes, and through the Murray mouth. This has been exacerbated by prolonged drought (chapter 2). The average period between environmentally beneficial flooding has more than doubled for a number of floodplain forests and wetlands, with some wetlands not receiving flows for over a decade (CSIRO 2008a). These changes in river flows result in a number of environmental effects (box 4.1).

Box 4.1 Environmental effects of altered river flows

Altering river flows can result in a number of changes in environmental conditions:

Hydrology — River flow variability may change in terms of volume, seasonality and velocity. This can result in atypical drought or flooding events, the loss of lateral connectivity of rivers (to floodplains), the loss of longitudinal connectivity (between upstream and downstream reaches), or the creation of new water bodies (for example, weirs).

Habitat — Physical changes to river channels, such as disconnection from habitats can result in atypical drying of wetlands, potentially causing degradation of habitats.

Water quality — A decline in water quality over time and/or in particular locations may result in increased risk of toxic algal blooms, increased sedimentation and acidification associated with exposed soils. Water use may result in highly saline return flows to river systems.

Biota — Changes in the condition of habitats result in changes to the distribution and diversity of species of flora and fauna, changes or interruptions to fish movement pathways, potential loss of native species and increased spread of exotic pest species.

Sources: PC (2006); Robson et al. (2009).

Such environmental effects are causing deterioration in the health of the Basin's water-dependent ecosystems, including a decline in the populations and conditions of native flora and fauna and a threat to the health of environmental assets, including several sites listed under the Ramsar Convention. Changes in hydrology and water quality may also have detrimental impacts for downstream water use by irrigators and tourism operators. Multiple threats to river health exist aside from reductions in water flows, such as a loss of water connectivity due to structural

changes, changes in managing floodplains, habitat destruction and the introduction of exotic weeds and pests. However, of these threats, changes to flow regimes have the most significant effect on the ecological condition of the River Murray system (SRP 2003).

Given that there is a limited supply of water that can be sourced from the Basin, choices must be made about how much to allocate to consumptive uses, and how much should be retained as environmental flows.

The economic rationale for government intervention

The existence of market failures can provide an economic rationale for governments to intervene in the market for environmental services. Governments might intervene where property rights for the environment are not well defined. As a result, the actions of water rights holders could create environmental externalities that would not ordinarily be taken into account in decision making by private agents. This might include, for example, irrigation-induced salinity, and nutrient pollutants that adversely affect ecosystems and reduce the quality of water for downstream users. There may also be a case to preserve environmental assets that have some public good characteristics. For example, flora, fauna or scenery are environmental services that are to some degree, non-rival and non-excludable in consumption, and hence are generally underprovided by the market.

However, the role of private agents in providing some environmental services should not be overlooked. Groups, such as conservation groups or private trusts, may provide some level of environmental services based on altruistic motivation. For example, in the western United States, voluntary conservation trusts have been established, with the larger trusts having acquired substantial volumes of environmental water. In 2006 the Freshwater Trust held around 390 megalitres (ML) per day of environmental flow rights (appendix C). In comparison, while some Australian charities — such as Healthy Rivers Australia — accept donations to improve environmental outcomes in the Basin, these do not play as large a role in providing environmental water as private trusts do in the United States. This might be because there are a large number of enthusiastic recreational fishers in the United States, and it is easier for them to organise charities than in Australia where environmental interests are less concentrated. It may also be because Australia has a culture of relying on governments to provide many environmental services.

The existence of market failure demonstrates that market provision is unlikely to be efficient, but it does not suggest that government intervention will necessarily improve efficiency. ‘Government failure’ may arise because politicians and public

servants lack relevant knowledge, or because their incentives are not aligned with the public interest. Whether governments should intervene on efficiency grounds is an empirical issue, and depends on the costs and benefits of the specific intervention proposed, taking both market and government failure into account.

In this instance, the Commission believes that too little water has been allocated to the environment, and that in many locations the benefits from governments buying water for the environment will exceed the costs, if well implemented.

Getting the balance right

There has been much concern in recent years about reallocating water to the environment and setting diversion limits at environmentally sustainable levels. The way in which sustainability is defined is important because it has implications for the setting of sustainable diversion limits (SDLs) under the new Basin Plan and water recovery targets (chapter 6). However, there are divergent views on how to define environmental sustainability.

The Murray-Darling Basin Commission (2008c) suggested that a river system can be considered ‘healthy’ when its character, biodiversity and functions are sustained over time, as demonstrated by its resilience in the face of environmental changes including climate change, resource exploitation or other impacts of human activity. Natural conditions might have the highest ecological integrity, but this may not be the optimum or desired condition in all cases, because a departure from natural conditions might be necessary to secure other important social and economic values.

In 1992, all levels of government in Australia adopted a National Strategy for Ecologically Sustainable Development to guide the management of Australia’s ecological and economic resources. The core objectives of this strategy were:

- to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations
- to provide for equity within and between generations
- to protect biological diversity and maintain essential ecological processes and life-support systems.

This approach recognised that ecologically sustainable development has implications for broader concerns of welfare and equity, and hence that tradeoffs between different objectives may sometimes be required. This framework is useful in deciding how sustainability should be considered within the context of allocating water to the environment. The Commission’s view is that sustainable water use is

not inconsistent with maximising the net benefits (or wellbeing) to the community. This requires consideration of all benefits and costs of different options for using water, including all relevant private and social impacts (including impacts on the environment).

The efficient allocation of water resources occurs when the marginal net benefits of water are equated across all uses, including consumptive and environmental uses. Ideally, the reallocation of water, whether through the buyback or through the Basin Plan, should have this objective in mind (box 4.2).

However, governments must make resource allocation decisions based on imperfect knowledge of the benefits and costs of different water uses. In most jurisdictions, water resource plans, prepared in accordance with the relevant state legislation, are used to meet a number of policy objectives, including provision of environmental water allocations. Such non-market allocative processes do not always effectively reveal preferences or transparently weigh up different community values of water use, a concern expressed by Murrumbidgee Irrigation (sub. 39, p. 2).

Tradeoffs between environmental and consumptive uses of water should be based on informed processes and transparent public consultation, and where possible, an assessment of the benefits and costs of competing uses of water. Further, environmental managers need to be able to choose the right combination of water and other inputs (for example, engineering works, alternative land use and weed and pest control strategies) to maximise environmental outcomes (section 4.5).

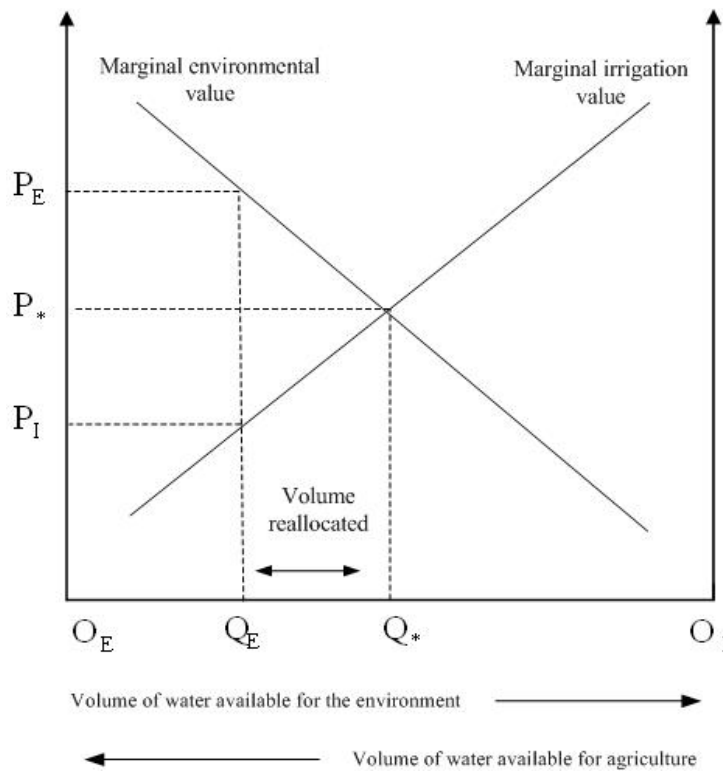
4.2 How is the Australian Government deciding on environmental priorities?

This section focuses on water recovery under RTB. The Australian Government is also setting sustainable diversion limits through the Basin Plan, which will determine the volume of water available for the environment in the long run (chapter 6). Key environmental resource allocation decisions that must be made under RTB include:

- How much water should be recovered?
- Where that water should be sourced?

The related question of ‘what type of water rights should be acquired to meet environmental needs?’ is addressed in chapter 7.

Box 4.2 Gains from transferring water to environmental use



The figure represents a simplified model of water allocation between environmental and irrigation uses and could represent the whole basin or a particular catchment. At the initial level of water allocations Q_E , the amount of water entitlements allocated to irrigators is $O_I Q_E$, while the amount of entitlements allocated for environmental use (either left in rivers or used to water environmental assets) is $O_E Q_E$. Before any transfer of water between uses occurs, the marginal value of water for environmental use at P_E is higher than the marginal value of water for irrigation use at P_I .

In this example, gains would result from transferring water entitlements until the point where the environmental share increases to $O_E Q_*$. At this allocation, the price P_* is the marginal value of water for both uses and the optimal allocation of water resources has been achieved between environmental and irrigation uses.

In practice, the shapes of these curves are rarely known with certainty, with the marginal environmental value curve being especially difficult to estimate. This increases the risk of reallocating either too much or too little water to the environment (relative to the efficient allocation).

Assessment process

The Department of the Environment, Water, Heritage and the Arts (DEWHA) uses interim water recovery targets in each catchment, which will apply until sustainable

diversion limits are announced. DEWHA's targets are intended to ensure that water acquisitions address overall system health as well as the health of key environmental assets, and that the resulting portfolio of environmental entitlements is consistent with what it anticipates will be required under the Basin Plan.

The interim water recovery targets are based on scientific assessment of the 'environmental watering needs' of Basin catchments (table 4.1). In conducting this analysis, DEWHA draws on:

- the Sustainable Rivers Audit, which assesses the health of riverine ecosystems (box 4.3)
- the Sustainable Yields Project, which examines existing water availability, and risks to water availability, such as climate change
- various studies that estimate the watering needs of particular catchments or environmental assets.

Once 'environmental water needs' have been estimated, DEWHA takes into account the volume of water that will likely be provided to the environment through water sharing plans and other environmental water recovery projects, such as the Sustainable Rural Water Use and Infrastructure Program and The Living Murray.

In establishing interim water recovery targets, DEWHA consults with the Murray-Darling Basin Authority, which has confirmed (according to DEWHA) that the approach DEWHA is taking in determining catchment purchase priorities 'is broadly consistent with the approach the Authority is taking to developing the Basin Plan' (sub. DR85, p. 10). DEWHA also discusses water recovery targets with the Commonwealth Environmental Water Holder (CEWH) to ensure that purchases are directed to the greatest environmental need.

Finally, DEWHA considers the impact of delivery constraints, such as:

- the management arrangements and infrastructure required to deliver and use the water entitlement for environmental benefit
- whether the entitlement is able to provide water when it is needed
- possible water losses through seepage, evaporation and extraction by other licensed users
- the relevant state legislation and water sharing plan which govern the use of the water entitlement and provide security over the property right (sub. 56).

Table 4.1 Scientific assessments of river health and water availability in the Murray-Darling Basin

<i>Catchment</i>	<i>MDBC Sustainable Rivers Audit Health Rating^a</i>	<i>Historical average surface water availability^b</i>	<i>Diversions based on current development and historical climate</i>	<i>Forecast decline in surface water availability by 2030^c</i>
		GL/year	%	%
Northern Basin				
Paroo	Good	445	0	3
Border Rivers	Moderate	1 208	34	10
Condamine-Balonne	Moderate	1 363	53	8
Moonie	Moderate	98	34	11
Barwon-Darling	Poor	2 088	11	11
Gwydir	Poor	782	41	10
Namoi	Poor	965	37	5
Warrego	Poor	420	12	6
Macquarie-Castlereagh	Very poor	1 567	24	7
Southern Basin				
Ovens	Poor	1 776	1	13
Murray	Poor - very poor	11 162	36	14
Eastern Mount Lofty Ranges	na	120	5	18
Campaspe	Very poor	275	36	16
Goulburn-Broken	Very poor	3 233	50	14
Lachlan	Very poor	1 139	28	11
Loddon-Avoca	Very poor	285	32	18
Murrumbidgee	Very poor	4 270	53	9
Wimmera	Very poor	219	55	21

^a SRA ratings are composite measures of a range of indicators of river health (box. 4.3) ^b Based on the climate from mid-1895 to mid-2006 and the current level of water resource development. ^c Based on a median scenario of future climate change and likely future water resource development (including expected growth in farm dam capacity, commercial forestry plantations and groundwater extraction). **na** not available.

Sources: CSIRO (2008a); MDBC (2008c); Productivity Commission estimates.

Entitlement types that have been assessed to be of high risk include those that involve overland flow licences that are remote from a large volume channel, and small volume channels, particularly when separated from a high value environmental asset by a dam. The issue mainly concerns NSW unregulated rivers and supplemented and unsupplemented rivers in Queensland.

This process generates a list of water recovery targets and priority catchments. In the 2008-09 tenders the following list of priorities was assigned to catchments in the Basin:

- higher priority catchments — Southern connected Murray System, Lower Condamine Balonne, Gwydir and Macquarie
- moderate priority catchments — Border Rivers, Barwon (Upper Darling), Lachlan, Upper Condamine and Namoi
- lower priority catchments — Moonie, Paroo/Warrego and Castlereagh.

Box 4.3 Murray-Darling Basin Commission Sustainable Rivers Audit

The Sustainable River Audit (SRA) is an assessment of the health of river ecosystems in the Basin, involving systematic collection and analysis of biophysical data from locations in 23 designated valleys. Environmental indicators, grouped as themes, are used to assess the condition of key ecosystem components, and condition assessments are combined to indicate ecosystem health.

Condition assessments are made relative to a reference condition that is a measure of conditions as they would be in the absence of significant human intervention. The reference condition represents the river ecosystem in good health, but is not necessarily a target for management. Depending on how much the condition of ecosystem components differs from the reference condition, ecosystem health is rated on a five-point scale, ranging from good to extremely poor.

In the SRA Report for 2004–07 (the first of a series of three-yearly reports), three themes were utilised — fish, macroinvertebrates and hydrology. These themes were chosen for their significance in river ecosystems, their sensitivities to interventions and their linkages to other features of river ecology. Of the 23 river valley ecosystems studied, only the Paroo Valley was in good health. The Border River and Condamine Valleys were judged to be in moderate health. Seven other valleys were in poor health and 13 in very poor health. In nine of the valleys, the proportion of alien fish outweighed native fish species, and most valleys showed reduced macroinvertebrate diversity. A high proportion of sites identified as being in poor hydrological condition were on the main channels of the Basin’s principal rivers, particularly in lowland zones. As hydrological assessments accounted for the effects of climatic conditions, the results reflect long-term water resource development impacts on flow regimes, rather than the effects of prevailing drought.

The next report, due in 2011, will include two additional themes: vegetation and physical form. Future reports will also describe trends, showing how river ecosystem health changes from one SRA to the next, and over longer periods of time.

Source: MDBC (2008c).

A catchment’s priority is reviewed as water purchases approach water recovery targets. For example, as a result of the substantial purchases already made in the Gwydir, it has been reclassified as a lower priority catchment, and DEWHA has

decided to ‘cease making any further purchases in the Gwydir catchment for the time being’ (sub. DR85, p. 9).

While DEWHA is using water recovery targets, it does not believe that it would be appropriate to release this information. These transparency issues are discussed in chapter 8.

How will Restoring the Balance water be used?

The CEWH’s environmental watering priorities are guided by the objectives of:

- avoiding the loss of threatened species
- avoiding irretrievable damage or catastrophic events
- providing drought refuges to allow recolonisation following drought.

While the CEWH uses different criteria to RTB for setting environmental watering priorities, the CEWH will be required to allocate water in accordance with the Basin Plan and DEWHA will prioritise further water purchases in accordance with the Plan. Hence, once the Basin Plan is implemented, the environmental watering objectives should converge.

So far, environmental watering using the Commonwealth’s water holdings (as well as water recovered by other programs including The Living Murray Initiative and Riverbank) has largely targeted the protection of ‘iconic’ sites. Many of these are identified under the Ramsar Convention on Wetlands of International Importance (box 4.4). However, the Ramsar sites are just a small proportion of the 30 000 wetlands in the Basin (CSIRO 2008a).

Analysis of the Restoring the Balance assessment process

Some of the ways used by DEWHA to determine environmental watering priorities are sound, given the constraints involved. In particular, it makes sense for it to continue to consult with the Murray-Darling Basin Authority to reduce the risk of ‘overshooting’ the sustainable diversion limits, and to work with the CEWH to ensure the portfolio of water products matches the CEWH’s environmental watering objectives.

Box 4.4 Ramsar wetlands

The Convention on Wetlands of International Importance (signed in Ramsar, Iran 1971, known as the Ramsar Convention) aims to halt the worldwide loss of wetlands and to conserve those that remain. A diverse range of natural and human-made habitats are classified as wetlands under the Ramsar convention, including rivers, swamps, marshes, lakes and other bodies of water.

Under the Ramsar criteria, a wetland should be considered to be of international importance if it:

- is a representative, rare or unique wetland
- is important for conserving biological diversity (it supports vulnerable, endangered, or critically endangered species or threatened ecological communities by providing refuge during adverse conditions)
- supports significant populations of waterbirds and indigenous fish.

As a Contracting Party to the Ramsar Convention, Australia has committed to taking steps to protect the ecological character of listed sites, and is required to meet obligations in terms of reporting, management, planning and provision of supporting information on Ramsar wetlands. These obligations are implemented at the national level through the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) and associated regulations, policies and funding programs. Currently there are 65 Australian Wetlands of International Importance listed under Ramsar. Sixteen of these are in the Murray-Darling Basin.

Australian Ramsar wetlands in the Murray-Darling Basin

<i>Wetland name</i>	<i>Location</i>	<i>Area (ha)</i>
Fivebough and Tuckerbil Swamps	NSW	689
Gwydir Wetlands	NSW	823
Narran Lake Nature Reserve	NSW	5 531
NSW Central Murray State Forests	NSW	84 028
Paroo River Wetlands	NSW	138 304
The Macquarie Marshes	NSW	18 726
Barmah Forest	Victoria	28 515
Gunbower Forest	Victoria	19 931
Hattah-Kulkyne Lakes	Victoria	955
Kerang Wetlands	Victoria	9 419
Lake Albacutya	Victoria	5 731
Currawinya Lakes	Queensland	151 300
Coorong and Lakes Alexandrina and Albert	South Australia	140 500
Banrock Station Wetland Complex	South Australia	1 375
Riverland	South Australia	30 600
Ginni Flats Wetland Complex	ACT	343

Sources: BMT WBM (2007); DEWHA (2009d).

It is also reasonable to draw on existing scientific studies. However, the value of these studies in allocating environmental water is often limited. For example, while the sustainable rivers audit assesses the health of a riverine ecosystem, it does not estimate the ecological response to environmental water. There is no reason why a less healthy ecosystem should always receive more water. It could be that the poor condition of an ecosystem is due to an introduced fish. The strategies for dealing with this may require management of the flows (for example, to encourage native fish spawning), rather than applying more or less water. In this instance, the additional environmental water might have little impact on the health of the ecosystem and the water might be better used elsewhere.

Ecological response assessments are potentially more valuable. In 2003, a scientific reference panel concluded that an additional environmental allocation of 1500 GL per year — combined with improvements in structural, operational and water quality management (for example use of regulators and weir pool raising) — would provide considerable ‘whole-of-river and local ecological habitat benefits’ (SRP 2003). This involved using the Murray Flow Assessment Tool to assess ecological responses of habitat condition under different flow scenarios for various locations along the River Murray, both in-channel and on the surrounding floodplains and wetlands. The panel considered that any recovery in river health would be likely to occur over many decades.

However, even with the best scientific knowledge, this approach could be seriously flawed. Understanding ecological responses to environmental watering is necessary, but without valuing the ecological responses and the costs of achieving those responses, virtually nothing can be said about whether an environmental watering will increase the wellbeing of the Australian community (section 4.6). Participants have expressed a range of views on DEWHA’s purchase criteria (box 4.5).

4.3 Challenges in setting environmental priorities

There are many factors to consider in setting environmental priorities across the Basin to inform decisions about recovering water. This includes an understanding of the relationship between changes in environmental flows and ecological responses.

Box 4.5 Participant views on the Restoring the Balance purchase criteria

Irrigators are very concerned at the impact of a 'no regrets' policy and the fact that the government has set no volumetric target for its buyback other than a dollar figure. It would appear that the government has not identified exactly what the environmental needs are, what volume or water product it therefore needs to purchase, and what the likely impact of those purchases might be on remaining irrigation communities ... The NIC sees significant risk to the Commonwealth and to irrigators in the 'no regrets' policy through the potential to overshoot purchases, particularly in individual valleys, if not across the entire Basin ... an interim purchasing strategy ought to be developed that identifies a bandwidth for key environmental assets. (NIC, sub. 24, p. 2)

The CEWH is developing a framework for prioritising the use of the Commonwealth's water which will aim to protect ecological processes as well as ecological assets ... So far no similar framework for prioritising where water should be acquired to meet the watering objectives is being developed. The 'strategic approach' used by RTB in 2008-09 was broad enough to include all Victorian water shares, irrespective of location or reliability. (Environment Victoria, sub. 23, p. 1)

Gwydir Valley Irrigators Association can support "no regrets" purchases in principle, but the problem is the government has not published any "no regrets" targets, or even the basis that it has used to set targets internally ... Without that information, and the justification for the targets set, it is really impossible to determine when "no regrets" ceases to be the case. (GVIA, sub. 29, p. 4)

The potential to invest in different catchments, differences in the opportunity costs of water purchases and non-uniform environmental outcomes may support a more targeted approach as experience is gained. As such, the 'no regrets' presumption should be the subject of on-going review ... (NSW Government, sub. 51, p. 4)

In broad terms, environmental water allocations have two main uses. The first is to preserve or improve the health of rivers and streams by maintaining hydrological flows that provide for desirable levels of river health. This can be achieved by controlling the volume, variability and velocity of flows to flush sediment and prevent algal bloom outbreaks, acidification and turbidity. The second is to water environmental assets, such as floodplains and riverine and estuarine wetlands. These measures will help to preserve the biodiversity of species, including:

- the condition of species of native flora: for example, river red gum forests, wetlands and black box vegetation
- populations of various species of native fauna (fish, birds and macroinvertebrates) by preserving feeding patterns of migratory birds and fish movement pathways, and providing critical water refuges for species during drought periods.

There are many competing environmental uses of water in the Basin, creating challenges for allocating a given amount of water. This may potentially result in too

few resources being devoted to the achievement of too many environmental projects, some of widely different merits (Pannell 2008a). Indeed, environmental managers may attempt to rescue too many environmental assets with the effect of actually saving few. Setting environmental objectives in a way that maximises the benefits of water recovery may require some prioritisation of environmental outcomes and specific assets. This may involve consideration of:

- which assets face the greatest threat or experience the highest levels of degradation relative to others
- whether the threat or degradation will be reduced significantly as a result of environmental watering (based on ecological responses to environmental flows discussed further in this section) and whether this could be achieved at reasonable cost
- the degree to which other inputs might be required to produce desired outcomes
- which environmental assets the community considers most valuable (relative to consumptive uses of water) in terms of:
 - conservation value — sites that are necessary to provide critical drought refuges for rare or endangered species
 - social and cultural values — those that provide recreational benefits or have significance for Indigenous communities (community preferences are discussed in section 4.6).
- the potential for complementary watering actions that deliver multiple environmental outcomes in interconnected systems of the Basin. For example, opportunities to divert water to some wetlands will result in substantial return flows to rivers with downstream environmental benefits or additional water for downstream irrigators.

Ecological responses to flows and environmental tradeoffs

Making environmental allocation decisions in a way that maximises benefits cannot be achieved without understanding relationships between environmental flows and ecological outcomes. The responses of ecosystems and their component plant and animal species, depend on the volume and timing of flows. In naturally variable systems like the Murray-Darling Basin, promoting wet and dry cycles may be beneficial for biological diversity.

Measuring the ecological responses to flows can be difficult given that river systems have a large range of environmental attributes that interact in complex ways. There have been some attempts to estimate the ecological responses to

different flow regimes for some parts of the Basin, including the FLOWs method used for determining environmental water requirements in Victoria (SKM 2002) and the Murray Flow Assessment Tool (SRP 2003).

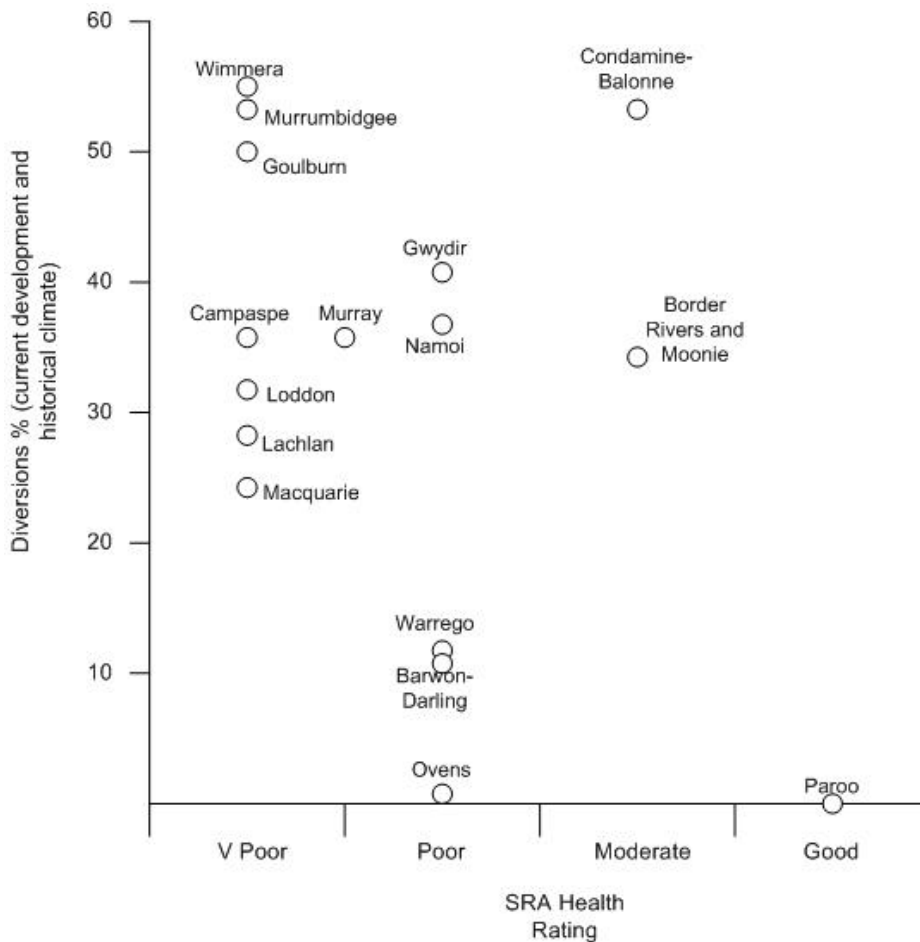
Studies that link flow volumes to quantifiable ecological responses have tended to focus on indicators of habitat condition for various species (Horne et al. 2009). Such indicators can show how habitat condition changes with additional water and hence can be used to construct environmental response curves.

Ecological responses can be examined at the level of environmental assets or entire catchments. The complexities of catchment ecological responses can be seen from scientific assessments of river health and water availability (box 4.6). The analysis shows that the amount of water diverted (as simulated by the CSIRO) from a catchment is not, by itself, a sufficient indication of river health across the Basin.

Ecological response functions are the first step towards building marginal benefit functions. The second step is to estimate willingness to pay for environmental outcomes. The environmental marginal benefits that result from increasing quantities of environmental water allocation (the demand curve) will vary between different sites. For example, some wetlands may only experience ecological responses from the application of water beyond a large volume threshold (figure 4.1 (a)). Others may respond to initial watering but with diminishing marginal benefits as additional water is applied (figure 4.1 (d)). The shape of the environmental benefit curves will significantly affect tradeoffs between environmental assets and also between environmental and consumptive use.

In some cases concentrating water recovery efforts to target particular environmental assets will be to the detriment of others. A triage approach to prioritising environmental assets has been considered as part of managing ecosystems during drought (Gorddard et al. 2009). Under this approach, environmental assets would be identified according to different categories: those in relatively good condition; those that have suffered degradation and will respond positively to watering; and those that are so degraded that recovery would not be feasible or practical given the high costs involved.

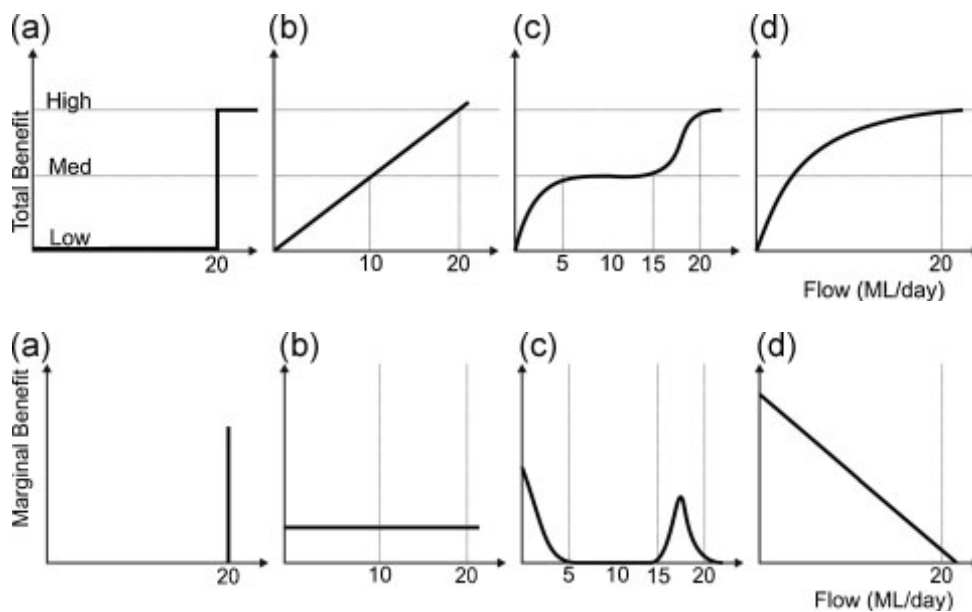
Box 4.6 Ecological responses at the catchment level



The MDBC and CSIRO assessments of river health and water availability suggest that, in general, high environmental allocations are neither sufficient nor necessary for river health. The Ovens catchment has a ‘poor’ health rating along with diversions of one per cent, demonstrating that high environmental allocations have not been sufficient to generate reasonable river health in that catchment. The Condamine-Balonne catchment has the second highest health rating of any catchment, ‘moderate’, while sustaining the second highest level of diversions at 53 per cent. This demonstrates that high diversions are not necessarily associated with poor river health in that catchment, at least not when river health is measured as it was in the SRA study. More comprehensive measures of river health may show a different outcome.

Sources: CSIRO (2008a); MDBC (2008c).

Figure 4.1 Examples of possible environmental response curves



Source: Horne et al. (2009).

An environmental asset that has suffered little or no degradation at the present time could be subject to significant threats in the future if watering actions are not taken immediately. The benefits of environmental watering may be maximised by concentrating resources on preserving these assets while ceasing or reducing the application of water to others. In some cases partial recovery of environmental assets to an earlier state, rather than full recovery, might be a realistic goal, given factors such as high costs of water delivery, the need to adapt to climate change and social values (Pannell 2008c). Sometimes it might be efficient to focus water on refuge sites and not water all of the asset. For example, environmental managers might build structures that allow only part of a wetland to be watered.

The problems in the Coorong and Lower Lakes highlight the complex choices that must be made about managing changes in the condition of environmental assets and environmental trade-offs (box 4.7).

There can be other types of tradeoffs between environmental objectives as part of environmental water delivery decisions. For example, the pulsing of large flows quickly to enhance natural floods may provide a wetland with a much needed flooding but can have adverse effects such as the release of cold water flows that threaten fish survival. It could also cause rapid rises and falls in river height that may erode river beds or channels and destroy biota and plants, leading to reductions in food for native fish (Robson et al. 2009).

Box 4.7 The Coorong, Lower Lakes and Murray mouth

The Coorong, Lower Lakes and the Murray mouth region comprise one of Australia's largest wetland systems. Lakes Alexandrina and Albert are large connected freshwater lakes that comprise the Lower Lakes. The River Murray flows into Lake Alexandrina, which in turn is separated from the Coorong by a series of barrages constructed in the 1930s. Flows from Lake Alexandrina to the Coorong can be controlled by opening gates in the barrages. The region is listed as a Ramsar wetland and is designated an 'icon site' under The Living Murray program.

Consumptive water use in the Murray-Darling Basin has reduced average annual stream flow at the Murray mouth by over 60 per cent between 1895 and 2006. In addition, it has increased the proportion of time for which flow at the Murray mouth ceases and doubled the average period between the flood events that are required to flush the Murray mouth. This has resulted in a build-up of silt in the Murray mouth. Unprecedented low water levels in Lake Alexandrina (and its tributaries) and Lake Albert have uncovered large areas of previously saturated acid sulphate soils, which, when exposed to air, result in acidification. Changes in water quality and flows have contributed to vegetation toxicity and a decline in fish and waterbird species, with adverse impacts not only on the environment but also on agricultural production and recreational activities.

A range of actions have been implemented in response to the current situation including dredging to keep the mouth open, revegetation trials to address acid sulphate soils and pumping fresh water between the lakes. The Commonwealth and SA Governments are considering a range of options for long-term management of the region, with the Commonwealth providing funding support under the Murray Futures program. These options include providing more fresh flows to the Lakes, keeping the Murray mouth open by connecting the Coorong to the sea and managing specific threats such as salinisation. The SA Government has proposed, as a last resort, the construction of a temporary weir near Wellington to secure water supplies for Adelaide under drought conditions. This is expected to contribute to reduced flows to the Lower Lakes and declining water quality.

A Senate inquiry in 2008 found that the situation in the Coorong and Lower Lakes is not unique as there are many sites across the Basin suffering severe environmental degradation, and future decisions to allocate scarce environmental water need to take into account environmental and other tradeoffs.

Sources: Brookes et al. (2009); CSIRO (2008a); DEH (2009); SCRRAT (2008).

Although environmental managers might seek to prioritise some environmental outcomes, it is important to recognise that parts of the Basin are a series of interdependent, connections and processes. As stated by Environment Victoria:

An understanding of the connectivity of the river system should be at the base of any plan to prioritize water purchase or environmental watering. There is a tendency to see rivers as a series of disconnected assets or drought refuges, particularly under a drying climate when water is in short supply. If a river system is to survive and thrive, it is essential that it retains both lateral and longitudinal connectivity. In other words, it

needs enough water for fish and other animals to migrate along it, and to retain connection to its floodplains, which serve as the larders of the river system. To do this, it is essential to provide all components of the scientifically recommended flow regime, not just the low flow and cease to flow components. (sub. 23, p. 1)

Maintaining the health of some environmental sites that are highly valued for their biodiversity also requires maintaining the health of hydrologically-connected sites and river reaches and their dependent processes (DEWHA 2009a).

4.4 Temporal and spatial characteristics of environmental water demands

The criteria used by DEWHA to guide water purchases under the RTB program include some assessment of the capacity to deliver environmental water. Both temporal and spatial characteristics, discussed in this section, influence the flows required to deliver environmental benefits to rivers and wetlands across different parts of the Basin.

Temporal characteristics

The main temporal characteristics of the Murray-Darling Basin that cause natural variation in stream flows are climate variability, extreme wet events, long wet periods and drought (Kirby et al. 2006). The hydrological flows required to meet environmental watering needs can be categorised into two types. The first are annual base flows that promote system-wide health of the Basin and maintain ecological processes by flushing out, and preventing build-up of nutrients and acidification in river ways and provide longitudinal connectivity in the system. The second are the more irregular flows that aim to simulate or enhance natural seasonal floods to wetlands by increasing their peak or duration. The health of many ecosystems in the Basin depends on periodic inundation rather than consistent annual flows.

Creating flooding events is generally not achievable due to the high river levels that are required before an area can be flooded with overbank flows. Therefore, environmental managers might attempt to enhance natural flooding events. The CSIRO (2008) have forecast that under certain climate scenarios by 2030, the duration of the dry periods between environmentally beneficial flooding events will increase for most floodplain wetlands. Under this scenario, opportunities to ‘piggyback’ off natural flooding events will be greatly reduced. But the ability to hold carryover rights may enhance the ability of environmental managers to

generate the volumes of water necessary to top up natural flooding events (chapter 10).

Spatial characteristics

Hydrological conditions vary across the Basin, creating difficulties in delivering water to environmental assets. A number of factors influence flow variability and the quantity of surface and groundwater resources in a catchment area:

- climate variation (in rainfall and levels of evapotranspiration)
- hydrological connectivity between locations across the Basin
- surface water characteristics such as topography
- surface water and groundwater connectivity
- land use changes (that impact on stream runoff and recharge to aquifers)
- variations in storages and flow diversions.

Hydrological connectivity between surface water systems varies across the Basin, so that water recovered in one location may not be deliverable to another location, or may result in substantial conveyance losses. For example, CSIRO hydrological modelling estimated that a ML of water purchased from the Gwydir catchment in the upper reaches of the northern Basin would be expected to only yield about 0.17 ML at the mouth of the Murray River, assuming pre-development conditions and historical conditions (table 4.2).

Given such hydrological constraints, water purchases in some parts of the northern Basin may improve the condition of some terminal wetlands but can not be relied on to result in significant environmental benefits in the southern-connected Basin. This was pointed out by a number of study participants:

... the Gwydir Valley Irrigators Association estimates that Commonwealth and NSW Government purchases of water in the Gwydir of some 86,000 ML equates to almost 20 per cent of entitlements in the Valley ... Gwydir ends in terminal wetlands and only in very wet years does it contribute to the rest of the Basin — to a large degree it is a closed system. (NIC, sub. 24, pp. 2-3)

... a key concern is whether the water purchased will be able to reach the specific environment that it is intended for. The availability of conveyance water is a key consideration in this respect. For example, a purchase of supplementary access water in the northern part of the Basin is unlikely to contribute to changes in environmental attributes in the Lower Lakes. (South Australian Government, sub. 52, p. 6)

Table 4.2 Average surface water delivery efficiencies between locations across the Murray-Darling Basin

<i>Region</i>	<i>Maximum flow (GL/y)</i>	<i>End-of- system^a (proportion)</i>	<i>Menindee (upstream of lakes)^a (proportion)</i>	<i>Murray mouth^a (proportion)</i>
Paroo	445	0.77	..	..
Warrego	423	0.16	0.07	0.03
Condamine-Balonne	1 298	0.43	0.33	0.18
Moonie	98	0.98	0.74	0.34
Border Rivers	905	0.92	0.62	0.32
Gwydir	782	0.48	0.33	0.17
Namoi	888	1.00	0.76	0.36
Macquarie	1 460	0.48	0.35	0.17
Castlereagh	107	0.68	0.50	0.25
Barwon-Darling				
Bourke	3 484	0.84	0.84	0.46
Menindee	2 944	1.00	1.00	0.54
Lachlan	1 139	0.25	..	..
Murrumbidgee	3 842	0.69	..	0.61
Ovens	1 776	1.00	..	0.70
Goulburn-Broken	3 233	1.00	..	0.75
Campaspe	275	1.00	..	0.75
Loddon	201	0.61	..	0.45
Avoca	84	0.30	..	..
Wimmera	219	0.08	..	..
Eastern Mount Lofty Ranges	122	0.99	..	..
Murray	14 493	0.84	..	0.84

^a Numbers indicate the fraction of surface water available in the region that would reach the end-of-system gauge in each region, assuming without-development conditions under the historical climate from mid-1895 to mid-2006. Efficiencies will differ between wet and dry years and between regions depending on connectedness of the river network. ‘..’ indicates where no efficiencies are estimated because the location is downstream of the region or because estimation was not possible.

Source: CSIRO (2008a).

The extent to which hydrological connectivity limits the transfer of water between locations will vary depending on climatic conditions, rainfall events and the amount of conveyance water already in the system. There have been recent cases where water from the northern Basin has been successfully delivered to the southern Basin for environmental watering. In 2008, water entitlements purchased from Toorale station by the Australian and NSW Governments were used to enhance flows to the Murray (box 4.8). In January 2010, the New South Wales and South Australian governments agreed to allocate at least 148 GL of flood water from northern New South Wales to the Lower Lakes (Keneally and Wong 2010).

Box 4.8 Delivery of the Toorale allocation for environmental use

In September 2008, the NSW Government purchased Toorale Station for \$23.75 million. Under an agreement with the NSW Government, the Australian Government made a substantial financial contribution to this purchase in return for the Toorale water entitlements to extract up to 14 GL of water from the Darling and Warrego Rivers, along with rights to harvest water from the floodplain. The water rights were to be transferred to the Commonwealth Environmental Water Holder (CEWH). These entitlements and floodplain harvesting rights are expected to return an average of 20 GL to the Darling River each year and up to 80 GL in flood years.

A large rainfall event in February and March 2009 provided flows in the Darling and Warrego Rivers that would collectively provide inflows of 190 GL to the Menindee Lakes storages, if they were not diverted. At the time, the NSW Government had control of Menindee Lakes under the Murray-Darling Basin Agreement. Under a trial, 11.4 GL of water that would have otherwise been stored or diverted on Toorale Station was accredited to a Water Access Licence issued to the NSW Water Administration Ministerial Corporation and was allowed to continue downstream to the River Murray via the Menindee Lakes.

To determine the proportion of the 11.4 GL that would reach the River Murray, the NSW Department of Water and Energy estimated the losses associated with various stages of the transfer. This included transmission losses from Toorale to the Menindee Lakes (1 GL lost in seepage or evaporation), evaporation losses in the Menindee Lakes (0.5 GL) and transmission losses from Menindee Lakes to the River Murray (1.1 GL). In total, of the original 11.4 GL attributable to Toorale, 8.7 GL was calculated as reaching the River Murray.

Additional flows from the Darling River into the Murray River are shared between New South Wales, Victoria and South Australia under the Murray-Darling Basin Agreement. However, in the case of the 8.7 GL of water from Toorale Station, New South Wales (7.2 GL) and South Australia (1.5 GL) agreed to make this water available to the CEWH for environmental watering.

Sources: ACCC (2009a); DWE (2009).

By comparison, the delivery efficiency of incremental flows in the southern-connected Basin are much higher due to more reliable and much greater amounts of conveyance water, meaning that additional environmental flows will result in relatively less evaporative losses. This illustrates the complexities in delivering water for environmental use that are related to hydrological connectivity between locations in the Basin and the potential for transmission losses.

Water recovered in the northern Basin can result in infrequent, but at times significant, environmental benefits for the southern parts of the Basin, given hydrological constraints. Water recovery within the northern catchments that are often disconnected should be driven primarily by environmental priorities within those catchments. Conversely, the southern Basin — including the Murrumbidgee, the Murray and the Goulburn rivers — is highly interconnected, allowing considerable flexibility in sourcing and delivering water for environmental purposes throughout these valleys.

In some parts of catchments or river systems, capacity constraints and topographical features present physical constraints on water flows and trade between locations. As noted in chapter 2, the Barmah Choke restricts the capacity of flows through the River Murray. However, the Murrumbidgee and Goulburn Rivers both join the Murray downstream of the Choke and, therefore, provide alternative opportunities for providing environmental flows downstream.

The relationship between surface and groundwater sources in the Basin is generally not well understood and groundwater is inconsistently managed. Rivers may receive flow from groundwater sources or may leak water to aquifers, although most rivers are gaining flows. As noted in chapter 2, use of groundwater has increased significantly in recent years. Where groundwater extraction reduces inflows to rivers and, hence, surface water availability, it can compromise the capacity of surface water entitlements purchased by environmental managers to actually deliver environmental benefits.

The way land is used can result in water being diverted or intercepted, potentially affecting the ability to deliver water for environmental use. For example, plantation forestry and regrowth after bushfires may affect inflows to rivers. Both the construction of large farm dams and floodplain harvesting may reduce the extent of overland flows to wetlands or reduce return flows, a concern expressed by the Australian Floodplain Association:

Unregulated water is currently extracted from Australia's floodplains via overland flow, channels/levees and floodplain harvesting. For there to be an effective environmental outcome for the Murray Darling Basin catchments which are largely floodplain riverine systems, current structures on floodplains that take water need to be accurately mapped, and the water that is taken monitored and measured. (sub. 30, p. 2)

In summary, the capacity for environmental allocations to deliver water to environmental assets is affected by:

- hydrological connectivity of river systems to environmental sites

-
- potential losses from evaporation and leakage and amount of conveyance water required to transfer water
 - impacts of land use and groundwater extraction (the potential for environmental water delivery to be intercepted by other users)
 - capacity of storages (to release pulsed flows in environmentally beneficial volumes).

Therefore, achieving environmental outcomes across different areas of the Basin depends on more than the quantity of water that is allocated. These factors are important considerations as part of choices under the RTB program and the Basin Plan. Responses to environmental demands may need to be coordinated to take into account spatial and temporal considerations, given that watering actions in one part of a river system can have implications elsewhere. Monitoring environmental responses is important to evaluate, improve and prioritise various watering actions.

4.5 Environmental watering and land management

Environmental outcomes depend not only on the volume of water that is left to flow through river systems, but also on environmental managers using other inputs to produce environmental outcomes. This can involve engineering works, specific watering strategies and land management practices.

Engineering works are often required to divert water to specific locations for environmental use by using weirs, regulators, pumps or channels to provide control over the volume and variability of water flows to specific locations.

A range of environmental watering actions have been implemented along the River Murray systems and key tributaries including:

- varying flows within river channels and releasing flows from storages
- providing natural wetland watering and drying regimes (including drawing down from weir pools to promote drying cycles of wetlands that are typically inundated, and raising some weir pools to water wetlands that are typically dry)
- pulsing and flushing water flows to disperse salt and blue-green algae and move sediment from water bodies like the Murray mouth
- managing in-stream structures to allow fish passages (Gippel 2003).

Land management practices can be as important as increasing water flows for improving outcomes for environmental assets. This includes controlling the spread of exotic species that threaten native species, preventing weed infestation and

control of farming practices that have adverse environmental effects. The Australian Conservation Foundation (sub. 41, p. 3) commented that it will become increasingly important to address other threats to the Basin (aside from water flow shortages) such as livestock control, weeds and feral animals. Measures, such as fencing and revegetation, can be important to prevent these threats. As part of an investigation into river red gum forests in the River Murray, the Victorian Environmental Assessment Council (2008) found that domestic stock grazing generally adversely affects environmental values, including biodiversity, water quality and soil condition. Accordingly, the Council recommended that domestic stock grazing be excluded from public land in a defined area, with limited exceptions.

Structural works such as pumps and regulators, can be used to deliver environmental water and achieve outcomes with much less water compared with that required for overbank flows. For example, structural works proposed for Lindsay Island are expected to reduce the amount of water required to flood these areas from 1000 to around 90 GL for each watering event (DSE 2009).

The purchase of water is likely to be more effective and efficient in achieving specific environmental outcomes if purchasing decisions are not made in isolation from decisions about works, specific watering actions and land management practices (discussed further in chapter 9).

4.6 Assessing the benefits and costs of environmental watering

The buyback reveals the opportunity cost of water to irrigation but what is unknown are the benefits of using that water to restore or maintain environmental assets.

Conceptual issues

It is common for people to say that the science implies a certain policy response. For example, the Wentworth Group (2008) suggest that:

If we are to maintain healthy rivers and provide high quality water to produce food, our analysis suggests that the consumptive use of water across the Murray Darling Basin may have to be cut by between 42 and 53 percent below the current cap. (p. 1)

Does this mean that the government should recover at least 4000 GL of water? In this instance, science can provide necessary information on the impacts of reallocating 4000 GL to the environment — the different outcomes that are possible, and the probabilities associated with those outcomes — but the science

can not say that an allocation of an additional 4000 GL to the environment has any normative basis. While 4000 GL would generate better environmental outcomes than 3000 GL, it would generate worse agricultural outcomes (reduced agricultural income). The science can not determine whether the environmental benefits of reallocating additional water outweigh the agricultural losses, yet understanding these complexities is fundamental to maximising the wellbeing of the Australian community. Community wellbeing could be higher with an environmental allocation that delivers something less (or more) than ‘river health’, as defined by the Wentworth Group.

A similar issue arises when allocating environmental water among environmental assets (wetlands, forests, rivers, ecosystems, and so on). For example, suppose there is just enough water to flood a wetland that will increase the population of an endangered bird species, or another wetland that will increase the population of an endangered frog species, but not both. There is no scientific basis for assigning water under these circumstances. From an economic efficiency perspective, the question is whether the community will benefit more from the increase in the number of the birds or frogs. This highlights the importance of taking preferences and values into account (box 4.9).

Box 4.9 Participant views on incorporating community preferences

Some study participants have expressed concern about the lack of information about community preferences considered as part of purchasing decisions under Restoring the Balance:

The concern is however that governments are entering the market without adequate knowledge of what they are buying and the strength of the community’s preferences for that good. First, the biophysical information relating water purchases to environmental outcomes is mostly poorly defined. Second, there have been only a small number of community demand estimation studies that have focussed on the environmental benefits of rivers. (Bennett, sub. 7, p. 1)

As now conceived and implemented, the buyback program allows no opportunity for expression of individual, group or local preferences for environmental projects — nor financial contributions. (Watson, sub. 11, p. 1)

There should be a defensible scientific multi stage approach to determine a range of environmental outcomes supported by broad community input. (The Goulburn Valley Environment Group Inc., sub. 21, p. 1)

Economics provides a conceptual framework for allocating water to maximise the overall benefits to the community (section 4.1), as well as quantitative methods to better understand the benefits and costs of different water allocations.

Quantitative methods

Where there is a water market, the cost of allocating water to the environment is generally easy to measure. The market price reflects the marginal value of water to irrigators and other consumptive users. Unless there are substantial distortions, or price changes as a result of the buyback, the expenditure on buying water allocations and entitlements in the market provides a reasonable estimate of the cost to the community of withdrawing that water from agricultural uses (Boardman et al. 2001). By contrast, it can be exceedingly difficult to measure the benefits of allocating water to the environment (box 4.10). This is because these values are generally not revealed by markets.

Box 4.10 Conceptual issues in economic valuation

Economic valuation is inherently anthropocentric — an environmental change that makes no contribution to people's wellbeing (taking future generations into account) would not be considered. Economics takes a 'triple-bottom-line' approach. Healthier rivers might increase agricultural incomes and benefit indigenous communities who have a cultural attachment to the river. These benefits are given equal conceptual standing, as are non-use values, such as the benefits that people receive from knowing that an ecosystem is healthy (even if they never visit). Community values are based on an aggregation of individual values.

There are a number of ways to formally estimate non-market values:

- Simulation modelling might be used to estimate physical changes in river salinity as a result of increased environmental flows, and subsequent changes in agricultural income.
- Revealed preference methods use statistical analysis to estimate non-market values from peoples' behaviour. For example, under the travel cost method, basic survey data — how often do you visit a site, where do you come from, and so on — can be used to estimate the recreational value of an environmental asset.
- Stated preference studies, like contingent valuation and choice modelling, people are presented with a hypothetical situation where they are asked to make tradeoffs between the condition of an environmental asset and other things. For example, someone might be asked how much additional tax they would be prepared to pay to return a wetland to its natural condition.

While these methods have been applied widely¹, they suffer from a number of limitations. Simulation models and revealed preference methods can not estimate ‘non-use values’. In addition, simulation models typically require detailed and complex hydrologic, agronomic and economic information. Revealed preference methods rely heavily on statistical inference, which can sometimes be unreliable, while stated preference methods suffer from the hypothetical and sometimes unfamiliar nature of the problem presented to survey respondents.

Another limitation is that non-market valuation studies are generally situation-specific. For example, a simulation modelling project might examine the impact on agricultural incomes (via water quality) of a 100 GL allocation to an environmental ecosystem. However, the benefits from a 200 GL allocation may not be immediately obvious. How these benefits might change over time is also unclear. More importantly, the benefits associated with a change in the condition of an environmental asset may not reveal much about the benefits associated with changes in the condition of other environmental assets. This matters because there are thousands of environmental assets in the Basin, and hence, understanding the benefits of changes to, say, 20 environmental assets through non-market valuation is likely to be of limited immediate value to decision makers in their larger water allocation task.

Non-market valuation can be expensive and should only be conducted when the benefits of undertaking such analysis are likely to justify the costs. This is most likely when making decisions regarding key environmental assets, such as the Lower Lakes, where the gains from improved decision making are likely to be substantial. Non-market valuation could also be worthwhile where it contributes to a better understanding of the value of other environmental changes. Quantitative methods like meta analysis can be used to partially overcome the situation-specific nature of non-market valuation studies by examining why some environmental changes are more valuable than others. This allows the analyst to apply the values from one situation to another, with appropriate adjustments for any differences.

While non-market valuation has serious drawbacks, and is unlikely to eliminate the need for people to use sound judgment in allocating environmental water, it can help decision makers better understand the benefits and costs of environmental watering. The government might also be able to collect information on various proxies (for non-market values). For example, it might assemble existing information on the number of visitors to environmental assets in the Basin, or survey people in Basin towns about what environmental assets they value most highly. While not generating numerical estimates, this would nevertheless help

¹ See Dyack et al. (2007) and Bennett (2008) for recent applications to the Basin.

decision makers, and might be less expensive and more comprehensive than ‘formal’ non-market valuation studies.

Multi-Criteria Analysis (MCA) is an alternative to cost-benefit analysis. Under MCA, a decision maker typically assigns weights to different environmental outcomes, resulting in a (environmental) benefits index. For example, a thousand frogs might be worth one point, while a thousand birds might be worth two points. With these assumptions, a project that saves two thousand birds would be preferred to a project that saves three thousand frogs. Unlike cost-benefit analysis, the values used in MCA are imposed by the decision maker, and may not sufficiently take community preferences into account. That said, it may be more transparent than existing systems.

What does this mean in practice?

Defining environmental priorities requires scientific information on the ecological responses to different environmental watering regimes. This is a necessary initial step to understanding the benefits of environmental watering to the community. Horne et al. (2009) argue that, while there are difficulties in determining the response curves to environmental flows, it is worth persevering because even relatively crude assessments should lead to improved outcomes compared with current environmental allocation methods. Analysis of the benefits and costs of proposed watering actions should be undertaken to prioritise competing environmental uses of water, with consideration given to community preferences for different environmental outcomes (box 4.11).

FINDING 4.2

Decisions on allocating water between competing uses in the Basin should be based on good science. But the values the community attaches to alternative uses are also crucial in achieving the best outcomes for Australia. Difficult tradeoffs are required between different environmental outcomes, and between environmental and consumptive outcomes.

Box 4.11 A hypothetical cost-benefit analysis

Suppose that the government is considering devoting 100 ML of entitlements to a wetland. If the market price of entitlements is \$2 500 per ML, the estimated cost would be \$250 000.

On the benefits side, the science might suggest that the allocation would maintain the wetland's condition, while it would die without the additional water. It might also improve the health of the local river, but no quantitative information is available. Suppose that around 35 per cent of people in the local town nominated the wetland as an important environmental asset, while a non-market valuation study estimated the recreational benefits of a similar wetland to be \$100 000.

In this framework, the benefits and costs (both quantified and unquantified) might then be considered alongside the governments' other objectives, and a decision made.