Environmental flow allocations and counter-cyclical trading in the River Murray System

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Abstract

Australia's climate is characterized by highly variable rainfall. As a consequence, many aspects of riverine ecosystems need both very wet and very dry periods to function effectively. This contrasts with water demands from industrial and agricultural sectors, which place a premium on access to a constant supply of water. This combination of demands suggests there could be considerable value in using water banking and trading mechanisms to reduce the social cost of achieving environmental objectives.

In this paper, the concept of counter-cyclical trading is outlined and influences on its potential for reducing the cost of achieving environmental flow objectives evaluated. The potential value of using mechanisms to enable counter-cyclical trading across low and high flow years is evaluated using a simple model. The model combines aspects of the natural, engineered and economic systems in place. Broadly these are: the ecosystem requirements of natural systems (described in terms of the frequency of flow objectives); the nature of the current flow regime (inherent in a combination of climatic variation and the regulation of water flows through the system); and the nature of the water market (captured in the shape of the short run demand curve).

The potential value of counter-cyclical trading is evaluated with specific reference to environmental flow banking and trading systems currently operating in the River Murray System. Risks associated with trading are briefly discussed, and some links are made in the context of the state of water market reform in the Murray-Darling Basin.

Key words

Environmental flow, counter-cyclical, water trading, water banking, River Murray System

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Introduction

The irrigation season in 2003-2004 started with some water storages in the River Murray System at their lowest levels on record (Hanna 2003). It is appropriate then, that 2003 saw some of the most significant steps towards better management of Australia's water resources. Government, through the National Water Initiative (NWI)[2] and the Murray Darling Basin Ministerial Council's "First Step" communiqué[3], have made commitments to implement a robust and efficient framework of water entitlements and to allocate both water and money to maximise environmental benefits in the River Murray System. These reforms have built upon those made in 1994[4] and have shifted the debate from how to reform the overall system to more specific issues[5]. There is now discussion about how to source water to meet targeted environmental objectives and management arrangements for environmental water once it has been acquired (see Goesch and Heaney 2003, Young and McColl 2003). Significantly a commitment has been made through the NWI and the "First Step" communiqué to explore, among other options, market based approaches to these issues and this is primarily the aspect of the water reform debate that this paper discusses.

Biodiversity objectives targeted by environmental flows have the characteristics of a public good. In the absence of some kind of government or community intervention on behalf of the environment, there will be a tendency for private market mechanisms to allocate too much water to commercial purposes and too little to the environment (Freebairn 2003). However, any allocation of water to the environment entails an opportunity cost, as water is a scarce resource. In the River Murray System, the opportunity cost of forgone commercial uses of water is reflected in the market price (Freebairn 2003). Market based approaches to acquiring and managing water for environmental uses are advocated on the basis that they reveal socially beneficial exchanges of limited water resources across competing uses, so that social benefits of water use are maximised (Freebairn 2003). In regard to flows allocated to achieving public good environmental outcomes, Watson (2003) points out that purchasing water, at the market price, facilitates political and community judgments on the relative value of environmental flows in terms of other water uses.

While there is some analysis of how government may acquire water by operating in the market (see Goesch and Heaney 2003), ongoing management of water through a market based approach is generally only touched on in the Australian context (for example Young and McColl 2003, Watson 2003). Young and McColl (2003) briefly look at a counter-cyclical approach to managing and trading environmental water allocations. There is some international experience with environmental water managers operating in the market, particularly in the US, however these are not investigated in this paper (PC 2003, Landry 1999, Schiller and Fowler, 1999).

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[2] The National Water Initiative was agreed by COAG in August 2003. The full COAG communiqué can be found at: http://www.dpmc.gov.au/docs/national_water_initiative_progress.cfm

[3] The Murray Darling Basin Ministerial Council (MDBMC) released a communiqué on 14 November 2003. The full communiqué can be found at: http://www.mdbc.gov.au/news_room/media_release/M_Council_Communique_Final_version_14Nov20031.pdf

[4] Overviews and critical analysis of the water reform process can be found in Tan (2002), Tisdell *et al*. (2002), ACIL (2003) and Edwards (2003).

[5] Randall (1981) illustrates that the water reform debate, in terms of designing a robust system that can accommodate environmental and irrigation interests, has been an ongoing issue for decades in Australia.

In this paper, the value and risks of pursuing a market-based approach to the management of a water allocation to the environment are explored. The benefits of exposing the management of environmental allocations to the market price are linked to the value of counter-cyclical trading. Counter-cyclical trading means using water to meet environmental objectives when the price is low.

An attempt is made to quantify the potential value from mechanisms that facilitate counter-cyclical trading. This relies on a simple model combining features of the environmental objectives, flow regimes and demand in the water market. The model is discussed in the context of two examples in the River Murray System where flexible management arrangements have enabled the managers of environmental allocations to achieve better environmental outcomes at considerably reduced opportunity cost to the irrigation sector. Caution should be exercised in extrapolating the quantitative results of the analysis to the real world, as the model is only loosely based on real-world data and does not reflect the full complexity of the arrangements and decision-making processes in place. Nonetheless, the analysis in this paper supports the notion that exposing the management of environmental allocations to the water market and enabling them to take advantage of counter-cyclical trading could make possible the achievement of certain environmental objectives at a considerably lower net cost to society than would otherwise be the case. In addition, some risks in using such mechanisms are noted.

The paper is concluded with an argument that further "learning by doing" approaches to environmental water management in the River Murray system can be designed to have minimal impact on the irrigation sector and the regional communities that depend on it.

1   Environmental water allocations in the River Murray system

There are currently a number of water allocations being used for a variety of environmental purposes in the River Murray System, including the Murrumbidgee and Goulburn Rivers (Gippel 2003). A summary of these environmental water allocations (EWAs) is provided in Table 1.

In this paper, particular reference is made to the management arrangements for the Barmah-Millewa EWA (hereafter the Barmah-Millewa Allocation) and the NSW Murray Wetlands EWA (the Murray Wetlands Allocation) (MWWG 2003, DLWC 2003). See Boxes 1 and 2 for background on these two allocations.

The environmental achievements of these allocations are not discussed here (see Gippel (2003) for a review of this aspect). Rather, the focus is on assessing the potential value to the environment and the community inherent in the operating arrangements through which the objectives are achieved.

Table 1. Environmental Water Allocations (EWAs) and Environmental Contingency Allowances (ECAs) available in the River Murray System, the Murrumbidgee and Goulburn Rivers[a]

Allocation Name	Year Approved	Volume and Main conditions	Main Purpose	Key references
Barmah-Millewa Forest EWA	1993	• **100 GL/yr** shared between NSW and Victoria • Provision to carry over up to 700 GL • Allocation can be withheld for up to 4 years • Allocation can be loaned out but must be paid back	Wetland watering, specifically the Barmah-Millewa Forest.	DLWC (2003) MDBC (2001)
Barmah-Millewa Overdraw	2001	• **50 GL/yr** shared by NSW and Victoria • Allocation provided during wetter years (around 80% of years)	Wetland watering, specifically the Barmah-Millewa Forest	DLWC (2003) MDBC (2001)
NSW Murray Wetlands EWA	2000	• **30 GL/yr** • No carry over provision • Allocation can not be withheld • 50% of allocation can be sold	Wetland watering on public and private land	MWWG (2001)
Lower Darling River ECA	2002	• **30 GL/yr** (Menindee Lakes must be >480 GL, and must have been >640 GL, since the last time it was <480 GL)	Flush blue-green algae when at high alert levels	DLWC (2002)
Moira Lakes Savings	2000	• **2.027 GL/yr** (for use in NSW Murray wetlands)	Wetland watering	DLWC (2002)
Murrumbidgee ECA	1998	• **25 GL/yr** (additional volume of 25 GL/yr when allocations are <80%, increasing up to 200GL for allocations 80 – 100%)	Water quality needs, algal bloom suppression, fish breeding and forest and wetland watering	DLWC (2002a)
Victorian Murray Wetlands EWA	1987	• **27.6 GL/yr** (2.6 GL/yr allocated to Hird and Johnsons Swamps)	Wetland watering and salinity control	DSE (2002)
Gunbower Forest EWA	1997/98	• **25 GL** (on average one in three years) and **40GL** (on average one in twelve years)	Top up and extend small to medium sized floods and cause low level flooding after two years of being dry	MWEC (1997) Cooling *et al* (2002)
Goulburn River EWA	1995	• **80 GL** in November in wet years (around 70% of years). Additional **25 GL** when inflows to Lake Eildon have been high and the storage is relatively full	Spring flush	DCNR (1995) DSE (2002)
South Australian Additional Dilution Flows	1987	• **3 000 ML/day** (when storage volumes in Menindee Lakes exceed nominated trigger points, at the same time the combined storage volume of Hume and Dartmouth Reservoirs also exceed nominated triggers)	Reducing the salinity of water to South Australia (there may be incidental environmental benefits)	DLWC (2002)
South Australian Murray Wetlands EWA	2002	• **200 Gl/yr**	Permanent wetland watering	RMCWMB (2002)

a Modified from Gippel (2003). The key case studies referred in this paper are shaded.

Box 1: The Barmah-Millewa Allocation [a]

The Barmah-Millewa Allocation was sourced through legislated environmental flow commitments.

The allocation is held by the MDBC/DIPNR, although the Barmah-Millewa Forum was established in 1994 to play an advisory role to the MDBC. The Forum assists with the implementation of the MDBC's water management strategy for the Forest. The Forum was established under clause 14 of the Murray Darling Basin agreement, which allows private interest groups to review and provide advice on projects funded directly by the Murray Darling Basin Commission. The Barmah-Millewa Forum provides advice on the operating plans of the Forest to ensure coordination between the two states, and also advises the Murray Darling Basin Commission on general water management of the Barmah-Millewa Forest.

The wide-ranging interests within the Forest are represented on the Forum. It includes advisers from private water scheme operators, non-wood and wood based forest users, environment groups and tourism operators. The Forum also has representatives from government agencies including State Forests of NSW, NSW Department of Land and Water Conservation, Victorian Department of Natural Resources and the Environment, Goulburn Murray Water and Department of the Environment and Heritage.

An annual environmental allocation of 100GL/year of high security water, with equal contributions from Victoria and NSW, goes towards meeting the environmental water needs of the Barmah-Millewa Forest. Key outcomes are to achieve, on average, three medium sized, long duration floods every 10 years and to ensure that there is no more than 5 years between these events. 100GL/year can be augmented with 50 GL of lower security water (25GL from each State), which is not allocated until Victoria's seasonal allocations along the Murray reach 100% of water right plus 30% of "sales", and is then fully allocated. On average, this extra water should be allocated in 75-80 years out of 100. All the water allocated to the environment in each year is carried over if not used, up to a maximum volume of 700GL (i.e. 150GL allocated in the current year plus 550GL being carried over). The allocation can be overdrawn by up to 100GL provided there is "sufficient" water in storage. Each State's share of the environmental allocation can be borrowed for consumptive use by that State, subject to clearly defined borrowing and payback rules. Any water borrowed by either of the States must be paid back. The MDBC is looking at crediting return flows from the environmental allocation, where the return water is not surplus to requirements, but this has not occurred yet (MDBC 2001).

Releases for the Barmah-Millewa forest will be made to top up the Yarrawonga flow using target flows similar to the following (MDBC 2001):
- If there's a flood ≥500GL/m from September to November, then maintain at 400GL in December (if sufficient volume in the allocation)
- If there's a flood ≥500GL in September or October and kitty is ≥400GL (including overdraw), keep at 500GL/m till November & 400GL in December.
- If 4 years passes with no release, & no flood of ≥500GL in September to November & 400 in December, try for 500 GL/m in October & November & 400GL in December;
- If 3 years pass with no month in August to November with ≥660GL, then if a release starts in October or November, the target flow increases to 660GL at Yarrawonga.

These operating practices for releases can be varied from time to time, by agreement between the managers of the forest water in consultation with water managers in the two states, and with the agreement of the MDBC.

a MDBC (2001)

2   The allocation to the environment

The manner in which an environmental allocation is defined can range from being tightly linked to triggers associated with meeting particular environmental objectives, to more generic allocations that managers have discretion over and can try to maximise environmental benefits from. None of the environmental allocations in the River Murray system can be managed with the same degree of control that the irrigation sector has over their asset.

The managers of the Barmah-Millewa Allocation and Murray Wetlands Allocation both have a secure annual flow allocation, which is available to them regardless of flow conditions in that year. In addition, they have some discretion in the management of their asset in order to maximize the environmental outcomes from its use.

In the case of the Barmah-Millewa Allocation, the benefits of counter-cyclical trading enable the allocation manager to be banked across years and use it in years when it will be most beneficial to the environment. This is achieved by temporarily lending the water to irrigators in years when it is not optimal to use it for the environment.

Box 2: The Murray Wetlands Allocation (from MWWG, 2001).

The Murray Wetlands Allocation, of 30 GL/year was acquired from "new" water as a result of infrastructure induced water savings.

The NSW Water Administration Ministerial Council (WAMC) holds the Murray Wetlands Allowance. The former Department of Land and Water Conservation (DLWC) and the WAMC agreed to manage the Allowance to achieve environmental improvements under advice from the NSW Murray Wetlands Working Group Inc. This was announced in May 2001 for a trial period of three years, with a review of this arrangement after three years.

The NSW Murray Wetlands Working Group (MWWG) was formed in 1992 as an initiative of the Murray and Lower Murray-Darling Catchment Management Committees. The NSW Murray Wetlands Working Group's membership is comprised of independent landholders and representatives of community groups, local councils, non-Government and Government agencies (MWWG 2001).

NSW MWWG advises state government on the use and management of 30 GL for the environment with the primary objective to achieve the optimum environmental benefit within the Murray region. Specific management of the allocation varies as the flow conditions change from year to year.

Identification of potential scenarios for the use of water are identified prior to August and a final operating plan is prepared between August and October each year when flow conditions are clearer. The operating plans sets out the use of the water each year and have detailed management targets and options. If no suitable trigger flows are achieved portions of the 30 GL may be traded on the temporary transfer market.

Up to 50% of the allocation (15 GL) can be traded on the temporary market. The sale of water is conducted through an independent broker and complies with the usual legal requirements for other sellers of water. Funds from the trade cannot be used to buy water – only to fund wetland rehabilitation and remediation works. There is no carry over of the allocation, which is consistent with the NSW storage policy of allocating all water for use during the immediate irrigation year.

Water can be used for environmental objectives in wetlands on private, as well as public, land. To assess the use of water on private land the MWWG and Murray Irrigation Limited call for expressions of interest from landholders in the environmental water. Details of the proposed water use are then considered and the successful applicants then enter into a contract to ensure the water is used for "specific environmental uses", not irrigated agriculture.

The Murray Wetlands Allocation has to be used in the year it is received, but under certain conditions the managers of the allocation can choose to sell up to 50% on the temporary market and put the funds to other wetland enhancing uses. These conditions are based on the likely effectiveness of using the allocation to achieve the Murray Wetland Working Group's primary objectives, which centre on 'piggy-backing' on high flow events within the Murray region. If the conditions are not met, the remaining 50% of the allocation is allocated for private wetland

watering purposes on the basis of a targeted, expression of interest process. This latter aspect is not discussed further in this paper.

At present, the managers of the Barmah-Millewa and the Murray Wetlands allocations cannot enter the temporary and permanent water market in order to expand their allocation.

As for the irrigation sector, the entitlement under the Barmah-Millewa and Murray Wetlands allocations does not extend to the return flows from the uses to which the allocation is put. As for the initial allocation, the value of return flows depends upon the time they become available. See Box 3 for a comment on return flows in the context of counter-cyclical trading.

3   Demand for Environmental Flows

The water flowing through the River Murray system has value for a variety of non-commercial purposes, such as biodiversity conservation and recreation and amenity values, as well as the irrigation sector, chiefly irrigation. However, it is the requirements of irrigated agriculture and, to a lesser extent, navigation that have driven the regulation of the River Murray System. As well as capturing flows for the irrigation sector, regulation of the system has served to reduce the frequency and impact of extreme climatic variation on the water supply. In Figure 1, it can be seen that flow variability has been 'flattened out', with considerably reduced likelihood of years in which flows are extremely small or large, and reduced severity of extreme events at either end of the spectrum.

Figure 1. Flow and price probabilities [a]
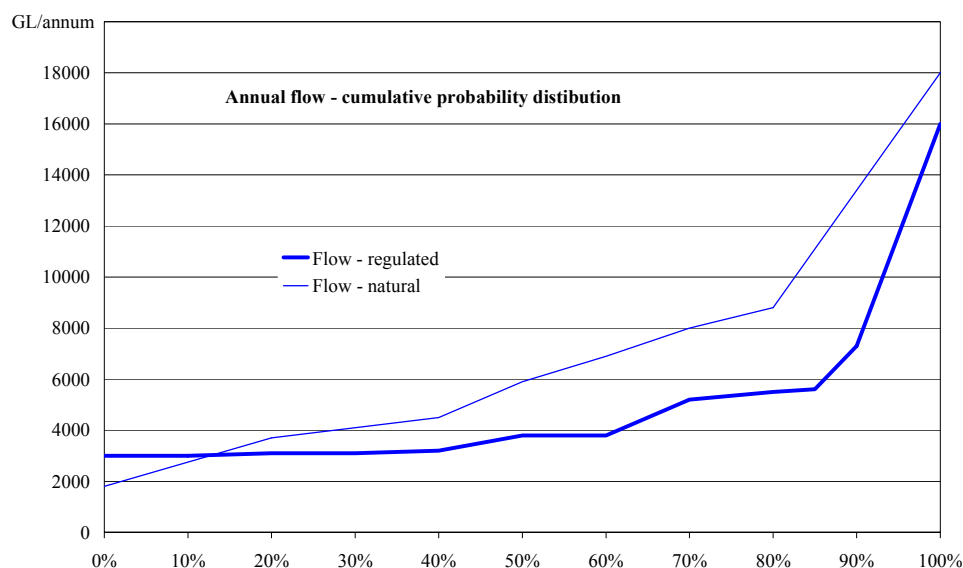
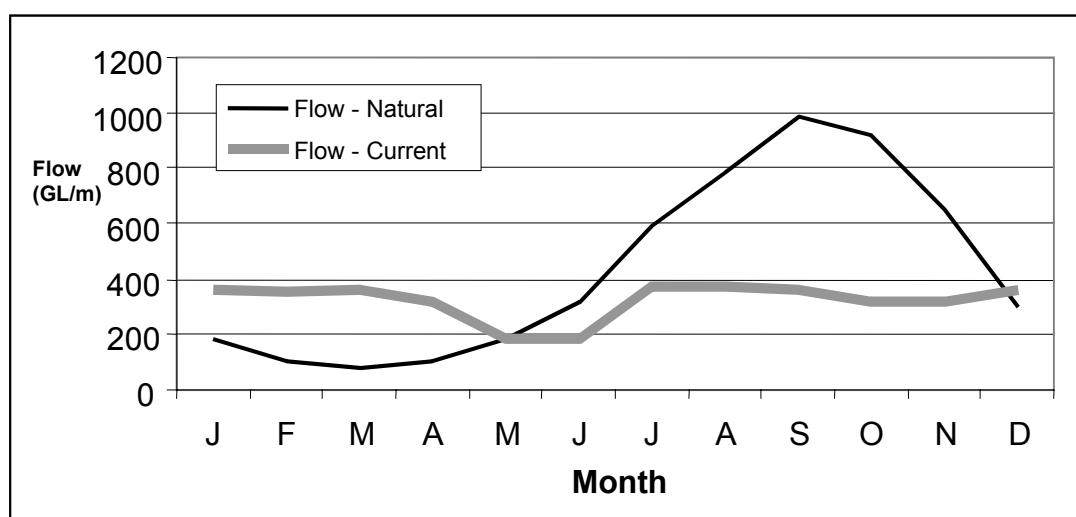a   Annual flow at Yarrawonga Weir (Thoms *et al.* 2000)

The wetland ecosystems targeted by the Barmah-Millewa and Murray Wetlands allocations are suited to a large natural variability, and generally require periods of low flow as well as flood

(MWWG 2001, MDBC 2000). For maximum environmental effect, these allocations are managed so that environmental releases coincide with the high flow events that still occur within the regulated river system, increasing the frequency and intensity of high flows at a local scale.

Young and McColl (2003) note that seasonal flow variability within the year, as illustrated in Figure 2, is potentially of value in reducing the opportunity cost of achieving environmental objectives, although it is not discussed further in this paper. For the irrigation sector, in the case study regions, water is generally of the most value during the peak crop growing months, September to May, and particularly in years of low rainfall.

Not all wetlands and environmental objectives require large variations in flow. The Gunbower Forest allocation in Victoria, for example, is used to deliver small, frequent inflows to assist in rehabilitating permanent wetlands in the forest (Cooling *et al.* 2002).

Figure 2. Monthly flow

a   Monthly flow rates at Yarrawonga Weir (Thoms *et al.* 2000)

4   Demand for water from commercial users

The irrigation sector places a premium on a constant, secure, supply of water. Prices are expected to be higher in years when water availability is low. This is due to a combination of reduced rainfall for crops that rely on a combination of rainfall and irrigation, and as businesses that can most cost-effectively reduce their allocation do so in order to sell their allocation to those that need it more.

In Table 2, water prices in the Murray Irrigation Area over the last five years are aligned with meteorological information indicating the dryness of the year. Water traded at $15/ML in 2000-01, a comparatively high rainfall year season, but at $228/ML in 2002-03, a drought year. Factors other than the supply of water also influence the price of water between years, such as on

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and off-farm storage, soil moisture and changes in commodity prices. Note the similarity in prices between 1999-2000, a wet year, and 2001-02, a very dry year.

**Table 2.** Annual price of water traded in southern NSW [a] (Murray Irrigation Limited 2004).

Season	Price ($/ML)			Probability of receiving lower rainfall[a]	Estimated annual flow [c] (GL/annum)
	Average	Low	High		
1998/99	$15.33	$6.00	$65.00	8%	8953
1999/00	$37.68	$21.00	$85.00	10%	7266
2000/01	$15.49	$8.00	$30.00	25%	5347
2001/02	$40.82	$20.00	$75.00	80%	3099
2002/03	$228.09	$100.00	$350.00	75%	3100

a Prices for temporary trades in the Murray Irrigation Area over the irrigation season. (Murray Irrigation Limited 2004)
b A low probability indicates a wet year. Based on rainfall data for Sep-May over past 100 years, in southern NSW. (Bureau of Meteorology)
c Annual flows extrapolated from the Bureau of Meteorology rainfall probabilities and the regulated annual flow probability distribution in Figure 1.

Figure 3. Fitted short run demand curve[a]
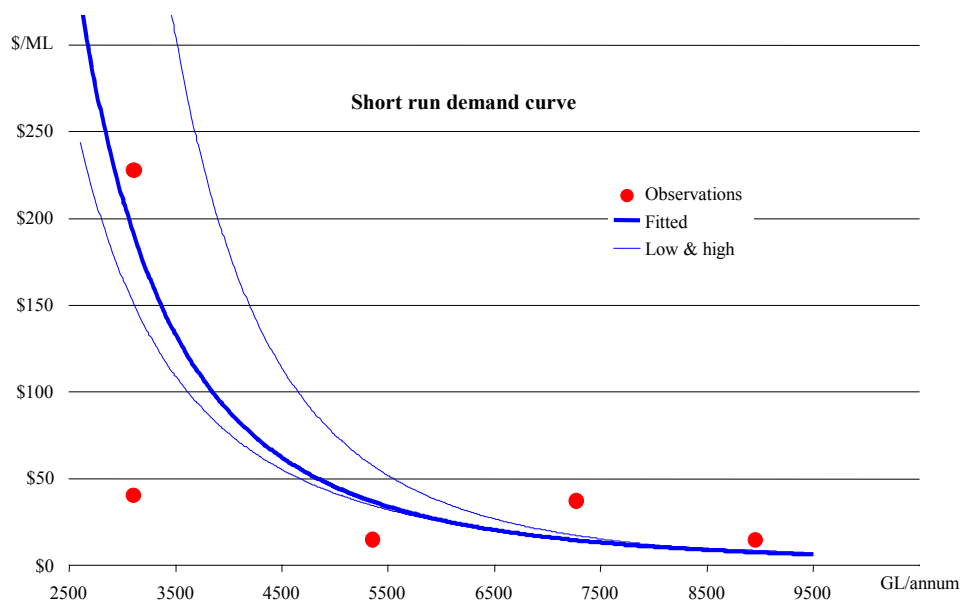
a See text for derivation. Constant elasticity curves fitted to minimize sum of squared errors. Footnote e in Table 3 gives details on lower and higher elasticity curves.

As a crude estimate of a short run demand curve, the constant elasticity curve in Figure 3 has been fitted through the price and annual flow points in Table 2. No attempt has been made to

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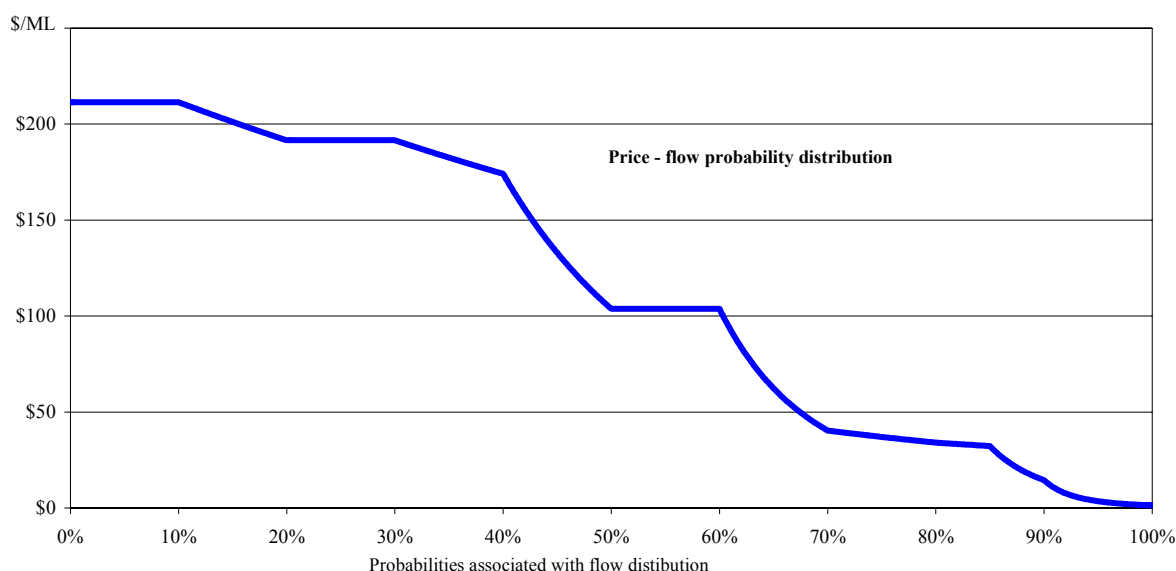Australian Agriculture and Resource Economics Conference, Melbourne, 2004

account for the large disparity between the price in 2001-02 and 2002-03, both very low rainfall years. A constant elasticity curve has been chosen for heuristic simplicity. However, as noted in Table 4, in a mature market, price elasticity is likely to vary along the demand curve, exhibiting a lower price elasticity (i.e. demand is less responsive to price) when prices are high and demand is low. A more rigorous price analysis is warranted than that undertaken here.

5   Maximising cost effectiveness of environmental water

Counter-cyclical trading means timing environmental flows to coincide with periods of low demand from other water users, minimizing the social cost to achieving environmental outcomes. However, future flows are not known with certainty, and decisions on the timing of environmental flows to achieve maximum benefit must be made on the balance of probabilities. Counter-cyclical trading makes use of the inverse relationship between prices and water availability.

The triggers that determine the use of the Barmah-Millewa Allocation are based on enhancing, on average, high flow events in 3 out of 10 years. Presuming that such events are strongly correlated with high annual flow years, this suggests that the allocation managers expect to use their allocation in years with flows higher than the 70th percentile in Figure 1. In these high flow years, based on the demand curve in Figure 3, the price of water can reasonably be expected to be low. Figure 4 combines the demand curve for water in Figure 3 with the flow probability data in Figure 1 to calculate a price associated with each of the flow probabilities. To the extent the demand curve is correctly estimated, the prices to the right of the 70th percentile in Figure 4 are the prices that may be expected to prevail in years when the flow conditions for releasing the Barmah-Millewa Allocation are met. On average, the flows will be used for the environment when the price is less than $40, and loaned to irrigators when the price is more than $40 and could exceed $200.

Figure 4. Derived cumulative price curve [a]

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a Derived on the basis of price and quantity data used in Figures 1 and 2. Relates to 'base case' in Table 3.

Delivering water to the environment when the value of water to the irrigation sector is low, reduces the net cost of environmental outcomes to society. The average price of water in years when it is used for the environment and in years when it is not may be used to estimate the value (or cost) to society of concentrating the use of the allocation for the environment into a small number of years. In Equation 4 (see Appendix), the value of delivering environmental flows in a counter-cyclical fashion is compared to the market value of the permanent allocation.

From Equation 4, the relative value of using the environmental flow allocation in years when the price is low is the price differential relative to the average price, weighted by the frequency of years in which the flows are not used for the environment. The frequency of environmental flows also interacts with the discount rate in capitalizing this value to present day terms.

5.1   Banking

To increase the impact of its allocation, the manager of the Barmah-Millewa Allocation 'bank' their water in dry years, when trigger points for the use of the allocation are not met. This is achieved by temporarily loaning the water to irrigators, who are required to repay the water from their own allocation in the following year. By rolling over this arrangement, the flow from the secure entitlement may be accumulated and used when a sufficiently wet year occurs.

Table 3: Estimated value of counter-cyclical trading to achieve flow objectives

		Flow variability[d]		Elasticity of demand for water[e]		Frequency of flow for environment[f]	
		Base case[c]	More variable	Lower	Higher	1 in 3 years	1 in 12 years
Value of allocation[a]	$/ML	2050	1722	4923	1664	2050	2050
Value from counter-cyclical trading[b]	$/ML	1691	1643	4396	1319	1647	2013
	%	82	95	89	79	80	98

a   Expected net present value of permanent flow allocation
b   Net present value of benefit to irrigation sector for access to low-priced water, and as a proportion of the value of the allocation. (Derivation in Appendix.)
c   Values referred to in text; other scenarios are variations on this one. Presumes flow objectives require allocation to be used in 3 out of 10 years, on average. Calculations based on the 'regulated flow' probability data in Figure 2, and the 'fitted' demand curve in Figure 3.
d   The base case is estimated based on the 'current' flow regime in Figure 1, the 'more variable' scenario corresponds to the unregulated, 'natural' flow regime.
e   Based on the 'Low and High' demand curves in Figure 3, reflecting the sensitivity of the fitted curve to the two price points at 3100 ML/annum. The base case has an elasticity of -0.33; the lower elasticity curve has an elasticity of -0.26 and is fitted without the lower price observation ($41/ML); the higher elasticity curve has an elasticity of -0.37 and is fitted without the higher price observation ($282/ML).
f   The base case presumes environmental objectives require the flows to be used, on average, 3 times in 10 years. This is equivalent to primary objective of the Barmah-Millewa Allocation. The higher and lower frequency scenarios reflect the objectives of the Gunbower allocation (Table 1).

At present this loan arrangement is based on volumes alone—no money changes hands between the managers of the Barmah-Millewa Allocation and irrigators. To some extent, it is in the irrigators' interests to voluntarily enter this arrangement in part because it is a free loan of an asset. In addition, water is being loaned to the irrigation sector in times of low flows and when the price is relatively high. The loaned water is recalled in high flow years, when the supply of water is plentiful and the price likely to be low.

Based on the prices in Figure 4 and an environmental trigger associated with 3 in 10 year high flow events, the value to the irrigation sector is estimated to be 82% of the value of the permanent allocation (Base case, Table 3.) By implication, the net social opportunity cost of achieving the Barmah-Millewa Allocations flow objectives could be a low as 18% of the value of the permanent allocation.

5.2   Exposure to the market

Up to 50% of the Murray Wetlands Allocation can be sold on the temporary water market at the market price, if conditions are not sufficiently wet, with the funding going towards specific environmental projects such as wetland rehabilitation. This arrangement gives the irrigation sector access to the water when conditions are dry and, consequently, the when opportunity cost of water to the sector is high.

In contrast to the Barmah-Millewa Allocation, the transaction is a financial one. However, the managers of the Murray Wetlands Allocation are not able to re-invest the funds in purchasing either permanent or temporary water from irrigators. If they could buy and sell their allocation, a permanent allocation in the order of 18% of what the Murray Wetlands Working Group has at its disposal now could conceivably be used to achieve the primary objectives to an equivalent degree.

Instead, exposure of the allocation to the market price allows the manager of the Murray Wetlands Allocation to respond to the change in relative cost-effectiveness of wetland water objectives and other environmental works as market prices change in response. In a dry year, when water availability is low and prices high, the opportunity cost of allocating water to wetland watering purposes is high. In comparison, other forms of wetland rehabilitation become cheaper and, hence, more desirable.

Box 3: The value of return flows

Return flows [a]

The concepts of "gross" (volume allocated) and "net" (volume consumed) drive the difference in evaluating the benefit of return flow volumes from environmental as opposed to consumptive uses (Young and McColl 2003). Some environmental uses of water, such as wetland watering, can have a relatively low net water use. For example, it is estimated that approximately 20–30% of water is "used" in the wetland watering process (MDBC, pers. comm. 2004), implying that 70–80% is being returned to the system for use by downstream irrigators and other users. In contrast, 60% could be expected to return to the system from consumptive uses, depending upon their degree of water efficiency (Young and McColl 2003). Environmental uses with high return flows will, on balance, extract a relatively low amount of water from the system and leave more available use by other users.

However, as seen elsewhere in this paper, the timing of flows can have a significant impact on its value to the community. Where an allocation is used infrequently and its associated return flows re-appear in the system at times when demand for water is low, the value of the return flows will be of less value to downstream users and the community at large.

This may be the case for allocations used for some environmental uses. Based on the price and flow probability data used to create Figure 3, we estimate that the net present value for downstream users of return flows realised immediately from a 3 in 10 year objective would be 95% lower than if the flows were spread evenly over time. This estimate of the reduction in value more than offsets the difference in return volumes for the environmental use and irrigation uses cited above.

The MDBC is considering whether to include the rights to the return flows as part of the Barmah-Millewa Allocation (MDBC 2001). Currently no allowance is made in the water market for different return flow rates between users, be it on the basis of individual irrigators, different irrigation sectors, or flows for the environment. Young and McColl (2002) and others suggest that consideration of return flows should be incorporated into water market design (see Gyles 2003).

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a Salinity and water quality impacts of return flows are not considered here.

6   Discussion

6.1   Sequencing

Young and McColl (2003) have pointed out the importance of managing the rate and sequence that water market reforms are pursued. They point out that rapid development of the trading aspects of the market before the institutional infrastructure is put into place to manage important issues, such as salinity and the allocation of water to public environmental values, risks extending pressure from high value commercial users to areas of the catchment that may have been sheltered to some extent by the inefficiencies of the market. Severe or irreversible environmental damage would be particularly unfortunate in cases where this may have been avoided if the appropriate regimes to manage these impacts had been in place before, rather than after, other market reforms (see Table 4).

The development of institutional capacity to manage environmental flows is particularly important in areas where high value environmental assets interact with regions that may undergo some restructuring in response to the further development of water markets. Such regions are likely to be characterized by irrigated activities with low long run returns, or high value regions where salinity is a significant threat to biodiversity.

Table 4. Characteristics of expansionary and mature phases of the water market[a]

Item	Expansionary phase	Mature phase
Long run supply of impounded water	Elastic	Inelastic
Demand for delivered water	Low, but growing; elastic at low prices, inelastic at high prices	High and growing; elastic at low prices, inelastic at high prices
Physical condition of impoundment and delivery system	Most is fairly new and in good condition	A substantial proportion is aging and in need of expensive repair and renovation
Competition for water among irrigation, industrial and urban uses and environmental flows	Minimal	Intense
Externality and other environmental problems	Minimal	Pressing: rising water tables, land salinisation, saline return flows, groundwater salinisation, water pollution etc.
Social cost of subsidising increased water use	Fairly low	High, and rising

a   Randall (1981)

6.2   Regional impacts of environmental flows

There is some concern about the cost to society of allocating flows to achieve environmental objectives. This concern is expressed in terms of direct impacts on the irrigation sector of not being able to access the water, and in terms of the industries and communities that support and depend on the irrigation sector.

The analysis of the net opportunity cost of an environmental flow allocation suggests that the opportunity cost of environmental objectives that may be achieved using counter-cyclical flows may have a considerably smaller impact on the existing market. These kinds of environmental objectives will tend to be relatively infrequent and associated with times of high water availability, i.e. when the price differential in Equation 4 is large. See the 'frequency of flow' column in Table 3 to see the impact of using flows allocations more or less frequently.

To the extent that water markets are segmented, there will be significantly more potential to leverage counter-cyclical trading in parts of the market where the flow regimes are highly variable and demand for water is inelastic. A more variable flow profile (*e.g.* increasing the overall slope of the curve in Figure 1) will tend to give greater opportunities for counter-cyclical trading. If the flow regime looked like the natural flow regime in Figure 1, the value of counter-cyclical trading as a proportion of the asset value is estimated to be 95% (Table 3, column 2). In this regard, river systems that rely less on investment in storage and flow regulation, like the storage policy that operates in NSW, could be expected to present more opportunities for counter-cyclical trading.

Inelastic demand will tend to be the case in regions characterized by high value agriculture and significant investment in perennial crops such as fruit and viticulture. Both of these aspects will tend to increase the spread of prices over time, i.e. increasing the overall slope in Figure 3 and the spread between high and low prices in Equations 1 to 4. See the 'elasticity of demand' column in Table 3 for the impact of more or less elastic demand for water on the value of counter-cyclical trading.

Managers of environmental allocations need to be exposed to the market price for it to drive counter-cyclical trading. Both of the examples discussed in this paper exhibit operating rules that allow the community to access this value, although neither quite fully engages with the market.

Goesch and Heaney (2003) note that at a large scale, the allocation of water to environmental flows will tend to increase the market price as low value users leave the market. On the other hand, counter-cyclical trading of a permanent environmental flow allocation will tend to dampen the impact of variation in annual flows on the market price.[6]

The analysis in this paper gives an indication of how environmental allocations can be managed to achieve significant environmental outcomes with minimum impact on the irrigation sector, particularly at a small, localized scale. The development of localised capacity and expertise need not impact significantly on other consumptive use of water, and the management of these allocations can interact with water markets in a similar manner to consumptive users.

6.4   Governance and Risk

The cost savings from enhancing the flexibility of managing environmental allocations can increase risk in two ways. First, there is risk associated with making mistakes in regard to predictions of flow condition and market prices that could undermine the achievement of environmental objectives. The vast range in dry year prices and the poor fit of the demand curve in Figure 3 give some indication of the uncertainties in the analysis in this paper.

In both examples discussed in this paper, conditions have been placed on the ways in which the environmental allocation can be managed to ameliorate risks for the irrigation sector and environment. In the case of the Murray Wetlands Allocation, there is a restriction on the proportion of the allocation that may be sold. For the Barmah-Millewa Allocation there is a requirement for a maximum of five years between flood events. To meet this target with a certain degree of confidence would require a greater allocation and a minimum volume to be kept 'in the bank' than would otherwise be the case.

While these kinds of measures reduce the risk in achieving environmental and market objectives, they come at a cost in terms of constraining the capacity of the environmental allocation manager to access the benefits of counter-cyclical trading.[7] Other ways of managing risk could include

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[6] The analysis in this paper presumes the marginal effect on the water market is small and does not consider the costs and benefits of these impacts to irrigators.

[7] In the case of the Barmah-Millewa Allocation as the benefits of counter-cyclical trading do not accrue to the allocation managers, so that this is a moot point.

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financial market style options or hedging contracts with irrigators or water brokers, or maintaining a centrally controlled reserve of water that could be drawn upon in emergencies.

Second, where more sophisticated trade offs are being considered there may be more scope for various sectors of the community to try and influence the decision making process for their private benefit. This could potentially undermine the environmental outcomes for which the allocation is intended. As greater flexibility is extended to the management of environmental allocations, it becomes more important that governance arrangements are sufficiently robust and transparent. Both case studies discussed in this paper and the other allocations in the Murray System are a starting point for considering what governance arrangements could work.

7 Conclusion

The preliminary analysis undertaken in this paper suggests that in many instances, the net cost to the community of permanent allocations of water to the environment can be much lower than the market value of the allocation. Giving the managers of environmental allocations the flexibility to transfer allocations over time and engage with the water market is likely to facilitate the timing of environmental flows so that net costs to the irrigation sector and community are minimised.

The manner in which environmental allocations are currently managed in the River Murray system demonstrates that environmental benefits from the localised use of environmental flows, which may be significant on a regional or system-wide scale, can be achieved in the current water management framework. These allocations provide a starting point for developing models for environmental flow management capacity and institutions in other parts of the system.

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APPENDIX — Details of analytical method

1. Estimation of value of counter-cyclical trading of environmental allocation

The method is outlined in a context similar to the manner in which the secure element (i.e. 100 GL/annum) of the Barmah-Millewa Allocation is banked over time (Box 1).

Method
Greater environmental objectives can be achieved if the water allocation is not used each year, but is accumulated and used, on average, over a small number of years. The mechanism by which this is achieved is to loan the water to the irrigation sector when it is not required, and have irrigators re-pay the water when it is used for the environment.

As for the Barmah-Millewa Allocation, the water is loaned and re-paid in volumetric terms only; no financial transactions take place. As a result, the value of counter-cyclical trading accrues to irrigators who accept the loaned water. To the extent that the timing of environmental flows coincides with low prices in the water market, irrigators have an incentive to voluntarily accept the water when it is offered.

Let:
p_0 = Value of 1 ML water on the temporary market in the year the water is loaned, i.e. $t = 0$.

p_L = Expected market price at time 1 ML re-called. This is calculated as the probability-weighted average of the price at times when the allocation is used for environmental purposes, based on the data in Figure 3.

f = Probability of the water being recalled in any future year, i.e. $t \geq 1$

p_E = Present value of cost to irrigation sector of loan re-payment, at time of loan, i.e. $t = 0$.

d = Discount rate

The value of the transaction to an irrigator is determined by the differential between the cost of temporarily purchasing water on the water market when the water is offered, p_0, and the likely cost of water when the water is re-called for use for the environment. The cost to the irrigator of entering into this arrangement in any given year also on depends how far into the future the re-payment is likely to be made. The lower the probability of the loaned water being re-called next year, the year after, and so on, the greater the impact of the discount rate on the value of the payback in today's terms.

The probability of the water being re-called in t years time is $f(1-f)^{t-1}$. This is the joint probability that the water is recalled in year t, and is *not* recalled in the intervening years 1 to t-1. Hence:

Eq 1 p_E = $p_L f(1+d)^{-1} - p_L f(1-f)(1+d)^{-2} - p_L f(1-f)^2(1+d)^{-3} - \ldots$
 = $p_L f/(d+f)$

The net value to the irrigation sector of accepting the water at the time it is loaned is then $p_0 - p_E$. Irrigators will be prepared to enter this arrangement as long as $p_0 - p_E \geq 0$. Due to discounting, the

expected cost of re-paying the water, p_E, is less than the expected price at the time the water is re-paid.

Let:

p_H = Expected price in years when the water is not used for environmental purposes.
p_A = Expected price of water, in any year.
V_I = Net present value of access to loans for irrigation sector.
V = Market value of the permanent environmental allocation on the permanent water market.
$V_\%$ = Expected value of the loans to irrigation sector compared to market value of enviornmental allocation

The value to the irrigation sector of having access to the loan arrangement can be calculated for each year as the expected value to the recipient irrigator when the water is loaned, weighted by the probability that the water is offered, i.e. $(1-f)(p_H - p_E)$. Discounting this stream of expected benefits to value in today's terms gives V_I, the value to the irrigation sector of having access to the loaned water:

Eq 2 $\quad V_I \quad = \quad (p_H - p_E)(1-f) + (p_H - p_E)(1-f)(1+r)^{-1} + (p_H - p_E)(1-f) +)(1+r)^{-2} + \dots$
$\qquad\qquad = \quad (p_H - p_E)(1-f)(1+r)/r$

The value of the environmental allocation on the permanent water market, V, is evaluated at the expected price of water on the temporary market, discounted to the present day.

Eq 3 $\quad V \quad = \quad p_A + p_A (1+r)^{-1} + p_A (1+r)^{-2} + \dots$
$\qquad\qquad = \quad p_A (1+r)/r$

The proportion of the value of the environmental allocation accruing to irrigation sector through counter-cyclical trading, $V_\%$, is:

Eq 4 $\quad V_\% \quad = \quad V_I/V$
$\qquad\qquad = \quad (1-f)(p_H - p_E)/p_A$
$\qquad\qquad = \quad (1-f)[p_H - f p_L/(d+f)]/p_A$

If the discount rate is set to zero in Equation 4, the relative value derived from the counter-cyclical use of the flow allocation collapses to the price differential as a proportion of price, weighted by the proportion of years in which the allocation is not used for the environment. Further, when there is no price differential, or an equal flow allocation is used each year ($f = 1$), this value is zero, i.e. there is no value arising from the timing of flows.

Assumptions and notes
The method of estimation is based on the expected frequency with which environmental flows are used over the long run, as are calculations of expected prices. The analysis presumes a allocation volume of flows to the environment, with only the timing of these flows varying over the years.

As such, while the analysis is described in terms of the context of the banking mechanism used for the permanent Barmah-Willewa Allocation, the method and estimated values do not reflect:

- the MDBC's ability to access additional low security water;
- the implications of additional environmental targets such as no more than 5 years between flood events, or constraints on the volume of water that may be banked;
- the actual history of loans and the prices that may have prevailed at the time they were made;
- price uncertainty and the implications for decisions made by the managers of the environmental allocation and the irrigators that accept the water when it is loaned.

2. Estimation of the value of return flows

Estimating the value of return flows is based on the method above and presumes that a proportion of water returns to the river system after it is used for either irrigation or wetland watering. The proportion that is returned differs depending on the use.

As for environmental flows above, the value of the return flows varies according to the time they are captured and made available to downstream users.

Let:

r_i = Proportion of flows returning to system from 1 ML put to use i.
V^R_i = Value of return flows from 1 ML put to use i.
$V^{R\%}_E$ = Value of return flows from 1 ML put to use i.

The calculation of the present value of return flow is analogous to that in Eq 2. The value of return flows to downstream users from use i is the proportion that is returned, evaluated at the expected price of water at the time, weighted by the probability of the water being put to that particular use in any given year. If i = E for environmental uses and I for consumptive uses (irrigation), then:

Eq 5 $V^R_E = f r_E p_L (1+r)/r$
Eq 6 $V^R_I = r_I p_A (1+r)/r$

The proportionate impact on the value in return flows from environmental uses compares the value of the return flows, V^R_E, to the value if the allocation had been used at the same rate each year.

Eq 7 $V^{R\%}_E = V^R_E / [r_E p_A (1+r)/r]$
            $= f p_L / p_A$

Assumptions and notes
The analysis takes no account of the potential for water quality or salinity impacts on downstream users from return flows.

Return flows are presumed to be captured and re-used in the same year, and to have the same value to downstream users as upstream users.