No Choke: Irrigators’ attitudes towards environmental flows for wetlands in the Murrumbidgee, Australia

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Abstract
In Australia and many countries worldwide environmental flows are becoming an increasingly popular tool for reversing the negative impacts of river regulation. However, there are many factors that restrict the effectiveness of these flows such as thermal pollution, existing regulatory structures and the limited volume of water available. Since the success of environmental flows depends on support from the irrigation industry, the aim of the present study was to investigate whether farmers’ attitudes towards environmental flows for wetlands are influenced by the effectiveness these flows. . Focus groups were used to engage with farmers in the Murrumbidgee Catchment, eastern Australia. A simulation model of the Murrumbidgee River was created to provide focus groups with a tool for examining the effectiveness of wetland-watering releases and to explore alternative management scenarios. The results showed that irrigators support the principle of environmental flows for wetlands however they believed that the existing flows are could be more effective if the restrictions imposed by existing regulatory structures were removed. They also suggested that the volume of translucency releases should be lowered as these flows reduce the amount of water available for wetlands and lower early season allocations for general-security water users. The irrigators provided numerous suggestions for altering the management of water resources so that both the Mid Murrumbidgee Wetlands and farmers would benefit.

Keywords
Attitudes, effectiveness, environmental flows, irrigator, wetlands

INTRODUCTION

Historically, water resource management in Australia was focused on promotion of the agricultural industry. Governments funded the development of irrigation schemes and the construction of large dams to provide secure water supplies to agricultural water users (Crean and Young, 2002). Hydrological regimes of many inland rivers were altered to meet irrigator needs. The seasonality of natural flow patterns was reversed and remaining flows were left considerably lower than under natural conditions (Reid and Brooks, 2000). Inevitably, this lead to the degradation of many inland river systems.

In 1994 in response to growing national and global awareness of the negative impacts of river regulation on riverine ecosystems the Council of Australian Governments adopted a strategic framework for reforming the Australian water industry whereby all State Governments agreed to formally allocate water to the environment (NCC, 1998). In 1998, as part of this process, the Government of New South Wales (NSW) introduced Environmental Flow Rules, which were designed to return a maximum of 10% of agricultural diversions to the environment when averaged across the state. One of the key objectives of these rules was to restore natural flood pulses to address the degradation of wetlands caused by river regulation (DLWC, 2004).

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While some improvements have resulted from the introduction of Environmental Flow Rules, there are a number of factors which restrict the effectiveness of these flows such as cold water pollution, the capacity of existing regulatory structures, the costs involved in flooding private land and the limited volume of water available (Schofield et al., 2003). Due to these limitations conservation agencies such as the Australian Conservation Foundation suggest that the current Environmental Flow Rules are unlikely to bring long-term improvements to the health of wetlands (Blanch, 2000; ACF, 2004). They recommend that these restrictions must be removed and that at least three times the volume of water that is currently committed under the National Water Initiative (COAG, 2004) must be returned to the environment if inland river systems are to be sustained (ACF, 2004).

To address the negative environmental impacts of river regulation through environmental flows requires reducing the amount of water available for irrigators. Since the effectiveness of environmental flows to date has been hindered and any further increase in environmental water allocations will have serious repercussions for the agricultural industry (Caldwell, 2001) it is vital that irrigators' attitudes towards wetland-watering releases are considered.

Previous research suggests there are a number of factors that affect stakeholders' support for conservation activities. In particular many studies have focused on the influence of personal values (Axelrod, 1994; Stern and Dietz, 1994), perceptions of fairness (Lind et al., 1990; Syme et al., 1999) and problem awareness (Cary and Wilkinson, 1997) on environmental concern. A factor that has received less attention is the influence of the effectiveness of natural resource management initiatives on stakeholders' views, which Maguire's (2003) study indicates is as a significant factor. Therefore, the aim of this study is to examine how knowledge about the effectiveness of the current Environmental Flow Rules influences farmers' views towards environmental flows for wetlands.

Case Study - The Murrumbidgee Catchment

The Murrumbidgee Catchment (Figure 1), located in eastern Australia, provides an ideal region on which to base this study due to its long history of river regulation that has significantly affected the nationally important Mid Murrumbidgee Wetlands (DLWC, 2004).

History of river regulation. Regulation of the Murrumbidgee River began with the construction of Burrinjuck Dam in 1907, designed to provide water to the Murrumbidgee Irrigation Area. This was the first large dam to be built for irrigation in NSW (Jeffcoat, 1994). Further development of the river occurred with the construction of the Snowy Mountains Hydro-Electric Scheme and Blowering Dam and the subsequent formation of the Coleambally Irrigation Area. Today, the Murrumbidgee River is the most highly regulated river in NSW with 14 major dams, eight large weirs and over 10 000 km of irrigation channels. Half of the natural flows are diverted for irrigation and the seasonality of peak flows has been changed from winter to summer (MCMB, 2002). The changes in the timing and duration of river flood pulses have invariably lead to the degradation of the Mid Murrumbidgee Wetlands.

Mid Murrumbidgee Wetlands. The nationally important Mid Murrumbidgee Wetlands are located along the Murrumbidgee River between Narrandera and Carrathool (Figure 1). The wetlands are considered to be significant because they support a wide variety of plants and animals, including numerous endangered species (EA, 2001; NSW Fisheries, 2002). The main threat to wetland health is river regulation as 62% of the total area of the Mid Murrumbidgee Wetlands has been affected by changes in the hydrological regime (Whitaker, 1998). This highlights the importance of environmental flows for conserving the wetlands.

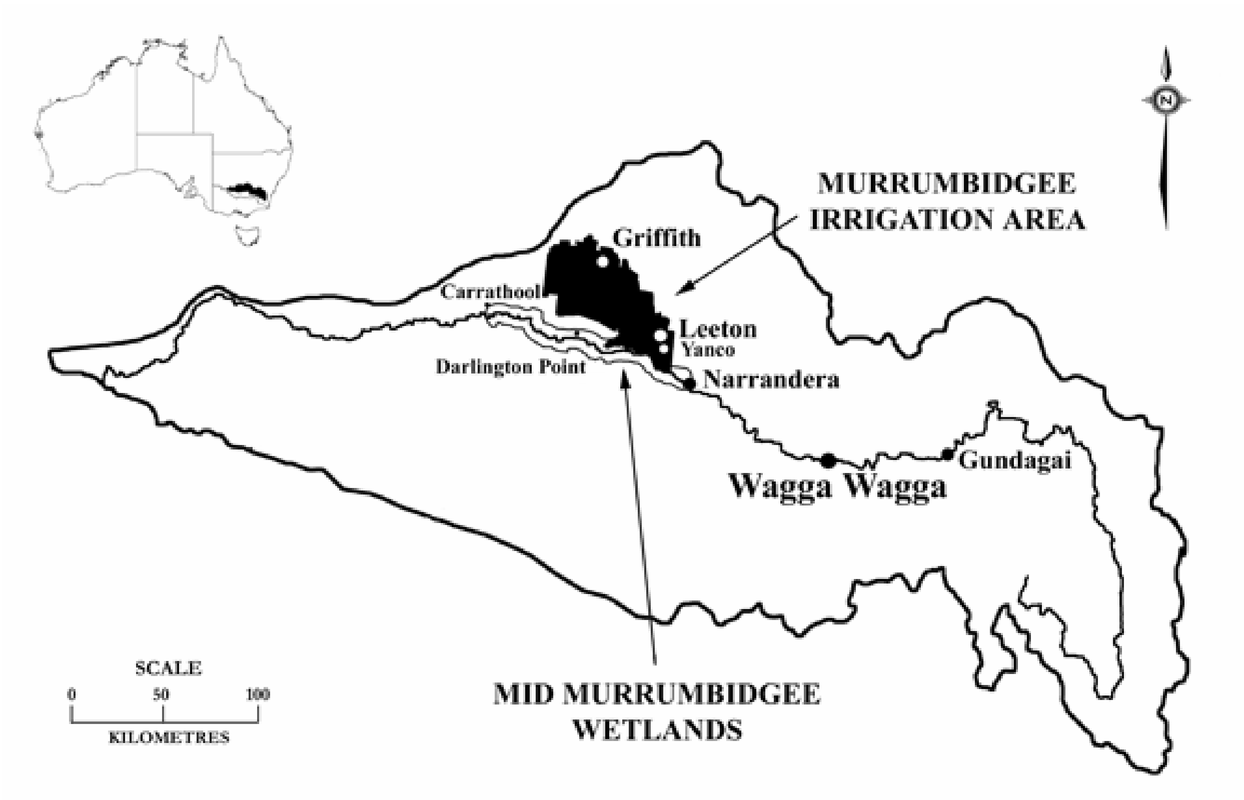

Figure 1. The study area: the Murrumbidee Catchment, the Mid Murrumbidgee Wetlands and the Murrumbidgee Irrigation Area. Map adapted from DWR (1989).

Environmental flows. Environmental Flow Rules were introduced to the Murrumbidgee Catchment in the 1998/99 water year and were expected to reduce general-security allocations by 4.5% on average and up to 17.3% in the driest years (MRMC, 2002). During the development of the rules it was recognised that the wetlands in the mid to lower reaches of the river (i.e. the Mid Murrumbidgee Wetlands and Lowbidgee floodplain) are the most significant feature of the riverine environment (Shields and Good, 2002). Consequently, a maximum of 50 GL (later revised to 100 GL in the final Water Sharing Plan for the Murrumbidgee Regulated River Water Source) of water was allocated as an Environmental Contingency Allowance (ECA) to provide water to wetlands and other water quality issues (MRMC, 2002).

Allowances were also made in the Water Sharing Plan for translucency, transparency and end-of-system flow releases (MRMC, 2002). Translucency releases are designed to reinstate some degree of natural flow variability and seasonality. Transparency releases are intended to protect low flows in the river reaches immediately downstream of Blowering and Burrinjuck dams. End-of-system flows are designed to provide connectivity between the Murrumbidgee and the Murray Rivers.

Effectiveness of Environmental Contingency Allowance releases. There are two main factors that limit the effectiveness of ECA releases in the Murrumbidgee. The main restriction is known as the 'Gundagai Choke' which limits the volume of water passing Gundagai to 30 000 ML/day due to some cropland and a low-lying bridge near Gundagai (Maguire et al., 2001). To achieve maximum effectiveness under the current system managers must 'piggy-back' ECA releases on natural high flows from tributaries entering the river below Gundagai. While three ECA releases have been made since the introduction of environmental flows only one release has been successfully piggy-backed on natural flows (Bowmer, 2002). This release provided significant benefits for river productivity, connectivity and biodiversity (Maguire et al, 2001) and indicates the potential benefits that could be achieved more frequently if the 'Gundagai Choke' were to be removed and more water were available for ECA releases.

The second factor that influences ECA releases in the Murrumbidgee Catchment is translucency releases. By releasing water throughout the winter months, the amount of water available in storage is significantly reduced and often compromises the ability for ECA releases to be made as well as reducing early season general-security allocations. While the Provisional Storage rule and limitations on translucency releases introduced in the Draft Water Sharing Plan (MRMC, 2002) go some way towards addressing this, the release of translucency water continues to be contentious.

Farmers' attitudes towards environmental flows for wetlands in the Murrumbidgee. It was previously suggested that the effectiveness of environmental flows may influence farmers' attitudes. An additional factor that may be relevant to the Murrumbidgee Catchment is the influence of translucency releases on early season general-security allocations, as this affects irrigators' planting decisions. Given the argument that farmers' support for conservation activities depends on the implications of the activity for their farming practices (Finlayson and Rea 1999), it is likely that farmers' with general-security water licences may be more willing to support environmental flows for wetlands than translucency releases as they have less ramifications for farming practices. It is therefore hypothesised that farmers' attitudes towards ECAs will be influenced by their perceptions of the effectiveness of the existing ECA flows and concerns regarding early season allocations.

METHODS

A combination of qualitative and quantitative research methods was chosen to investigate farmers' attitudes towards environmental flows. Focus groups were used to engage with farmers while a simulation model was developed to encourage discussion regarding the effectiveness of ECA releases and allow participants to investigate alternative management scenarios.

Focus Groups

Three focus groups, each of three hours duration, were held at Darlington Point, Yanco and Griffith (Figure 1). The discussions were held during July 2002, one week after the closing of the public exhibition period of the Draft Water Sharing Plan for the Murrumbidgee Regulated River Water Source (MRMC, 2002). There were six people in attendance at Darlington Point, four at Yanco and nine at Griffith. The main crops grown by participants included: rice, grapes, wheat, soybeans, canola, barley and vegetables. There was only one female present at the Darlington Point discussion group and none at either of the other two groups. All the focus group participants had general-security water licences with the exception of one participant who grew only grapes and consequently had a high-security water licence.

The main topics discussed at each focus group were: water management in the Murrumbidgee Catchment; environmental flows; wetlands; and alternative water management strategies.

Simulation Model

The model was required to be user-friendly, have short run times and be adaptable, so that changes could be made to the model during the focus group meetings. Due to the size of the catchment and focus on macro-scale processes, i.e. environmental flows and inundation of the Mid Murrumbidgee Wetlands, it was decided that a lumped-parameter model (Bevan, 1989) would be most suitable. Given these requirements Powersim (Powersim Software AS, 1997) was determined to be an appropriate modelling platform.

The model comprised a network of nodes representing dams, river sections and wetlands (Figure 2). The volume of water contained within each node was determined by rainfall, runoff, dam releases, stream flows from upstream, irrigation diversions, evaporation and leakages. Each component is discussed below.

Rainfall. Since rainfall is highly variable within the catchment and tends to decrease from east to west, the catchment was subdivided into eight rainfall regions rather than sub-catchments (Figure 2). Bureau of Meteorology rainfall data were used to define these areas. The main towns and locations indicating the lower limit of each rainfall region were: Blowering Dam (1000), Burrinjuck Dam (950), Tumut (800), Gundagai (650), Wagga Wagga (550), Narrandera (400), Darlington Point (350) and Balranald (300). Figures in brackets refer to the average annual rainfall (mm) of each region.

To simulate daily rainfall a random number between 0 and 1 was generated each day for each rainfall region. This number was then compared to the probability of a rain day, calculated from historical data. If the number was within the probable range daily rainfall was randomly generated based on a log-normal distribution of historical rainfall data.

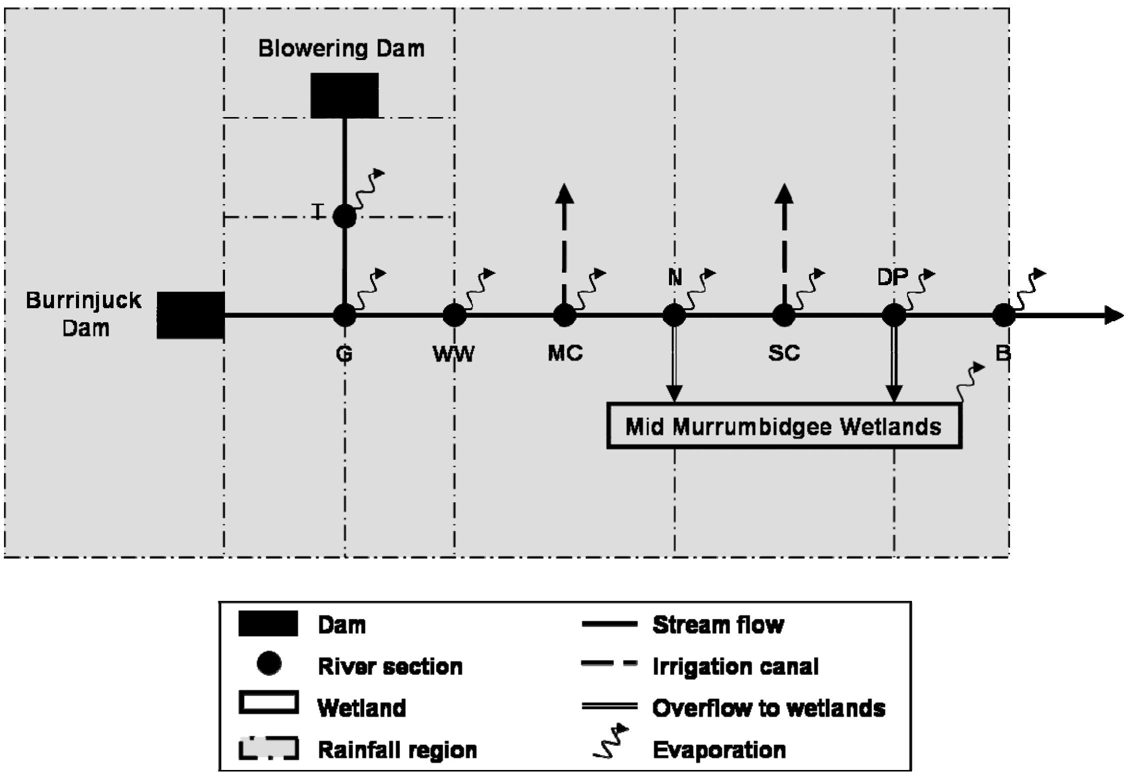

Figure 2. Diagrammatic representation of the simulation model of the Murrumbidgee River. River section names abbreviated to Tumut (T), Gundagai (G), Wagga Wagga (WW), Main Canal (MC), Narrandera (N), Sturt Canal (SC), Darlington Point (DP) and Balranald (B).

Runoff. Daily runoff from each rainfall area was determined by multiplying the area (km^2) of each rainfall region by the amount of daily rainfall (mm) by a runoff coefficient (Pilgrim, 1987).

Dam releases. Two models were constructed to represent pre and post-environmental flows management. The management of releases from Blowering and Burrinjuck dams in the pre-environmental flows model was based on information provided by the former NSW Department of Land and Water Conservation (DLWC), now part of the NSW Department of Infrastructure, Planning and Natural Resources. Dam releases in the post-environmental flows model were based on the Draft Water Sharing Plan for the Murrumbidgee Regulated River Water Source (MRMC, 2002).

Irrigation diversions. Only the Main and Sturt Canals were included in the model as these canals carry greater than 80% of irrigation diversions in the Murrumbidgee. General-security water allocations were not predetermined by the model rather participants were given the option of choosing their desired allocations. This approach was taken to provide focus group participants with greater control over water management and allow them to explore the implications of changing general-security water allocations for environmental flows.

Stream flow. Stream flow was determined by the volume of dam releases, runoff from the surrounding rainfall area, evaporation, diversions and overflow to wetlands.

Wetlands. The Mid Murrumbidgee Wetlands were incorporated into the model using Whigham and Young's (2001) river and wetland system, with water entering the wetlands via Narrandera and Darlington Point. Frazier and Page's (2001) curves for area of wetland inundation versus flood peak discharge were used to determine the volumes of water entering the wetlands and the percentage of wetlands between Narrandera and Carrathool inundated by significant flow events.

Calibration. Pre-environmental flows data was used to calibrate the model as environmental flows had only been in place for 4 years at the time of model construction and had undergone numerous changes since their inception. To calibrate the model average annual flows into and releases from the dams as well as river flows past Tumut, Wagga Wagga, Narrandera, Darlington Point and Balranald were compared to historical data to ensure that the model outputs were within 5% of historical averages, when the model was run for 100 years (Table 1). Consideration was also given to the seasonality of flows with model hydrographs at each site compared with DLWC data. Once the pre-environmental flows model had been calibrated the data from the post-environmental flows model was compared with the DLWC data from 1998/1999 onwards to ensure there were no major discrepancies between the modelled and actual data.

Table 1. Comparison of historical and simulated average annual flows for 10 sites along the Murrumbidgee River over a 100 year period. Data for historical averages obtained from DWR (1989) and DLWC (2004).

Location	Historical Average Annual Flows (ML)	Simulated Average Annual Flows (ML)	Difference (%)
Burrinjuck (inflows)	1296443	1334437	2.93
Burrinjuck (outflows)	1276562	1284840	0.65
Blowering (inflows)	1748713	1786932	2.19
Blowering (outflows)	1779303	1747752	1.77
Diversions from the Snowy Mountains Hydro-electric Scheme	550000	550028	0.01
Tumut	2136516	2136516	1.47
Wagga Wagga	4320000	4471593	3.51
Narrandera	3180000	3104067	2.39
Darlington Point	2570000	2513267	2.21
Balranald	2250000	2187289	2.79

Graphical user interface. Due to the complexity of the Environmental Flow Rules for the Murrumbidgee Catchment, special consideration was given towards making the model user-friendly. This involved designing an interactive display, which could be used by focus group participants. There were three main sections in the display (Figure 3). The first was a control panel, which allowed users to change their allocations, whether they wanted ECA releases to occur, and the volume of these flows.

The implications of any changes made were shown in the second section through the use of graphs and an Environmental Benefits Index. The graphs showed the number of ECA releases made as a result of each user-defined scenario and the percentage inundation of the Mid Murrumbidgee wetlands over a period of one year. The Environmental Benefits Index was designed to consider factors other than flood size that affect the health of wetlands. These factors included the seasonality of flows (3/10), the interflood period (2/10), the percentage of wetlands inundated (4/10) and the volume of water in the wetlands (1/10). Figures in brackets refer to the weighting given to each factor. The index had a minimum value of zero and a maximum value of one hundred.

The final section of the graphical user interface allowed participants to compare the outcomes of their alternative management strategies with the Draft Water Sharing Plan and past environmental flows.

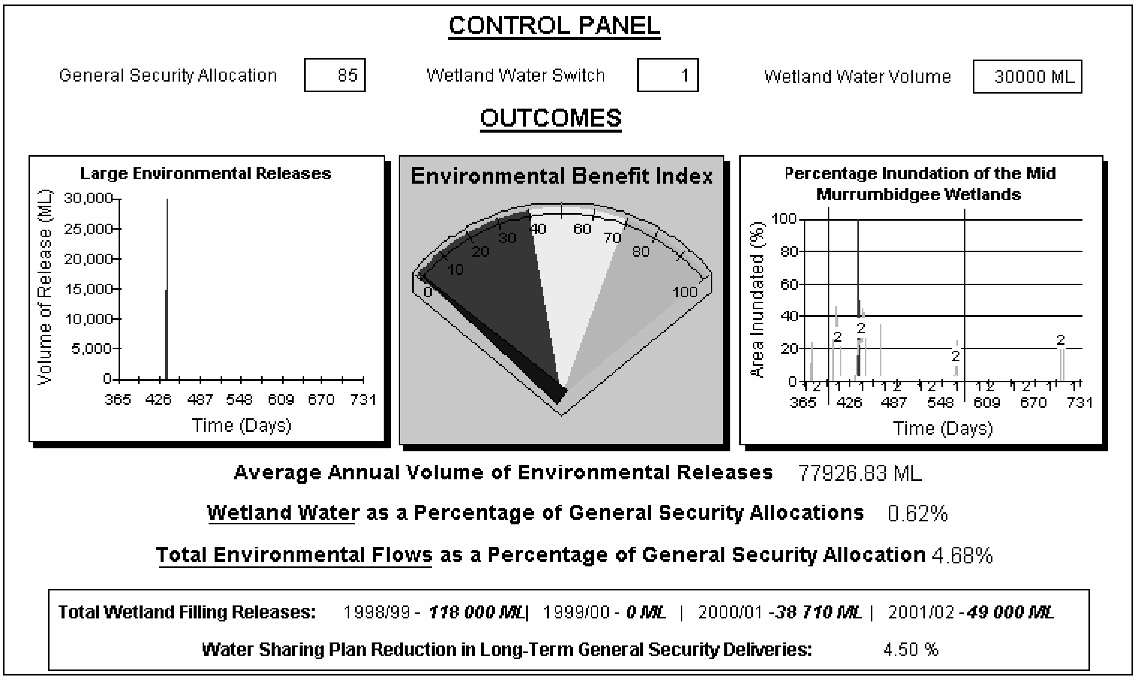

Figure 3. Interactive display of the simulation model, created for use in the focus groups. In the control panel 'general-security allocation' refers to the allocation announced each August. The wetland watering switch can be adjusted from zero 'off' to one 'on', with zero preventing and one allowing the release of ECA water. The wetland water volume refers to the volume of the ECA release.

RESULTS

Simulation Model

Prior to conducting the focus groups, the results of the pre and post-environmental Flow models were analysed to investigate the effectiveness of ECA releases. The main finding was that the existing Environmental Flow Rules and the rules outlined in the Draft Water Sharing Plan do not significantly increase (α=0.05) the frequency with which the Mid Murrumbidgee Wetlands are inundated.

On average environmental flows occurred 5.2 years in 10 and were mainly released in August, September and October. The majority (93%) of ECA releases inundated less than 40% (1012.4 ha) of the Mid Murrumbidgee Wetlands. The remaining flows were clustered around 60% (1518.5 ha; Figure 4).

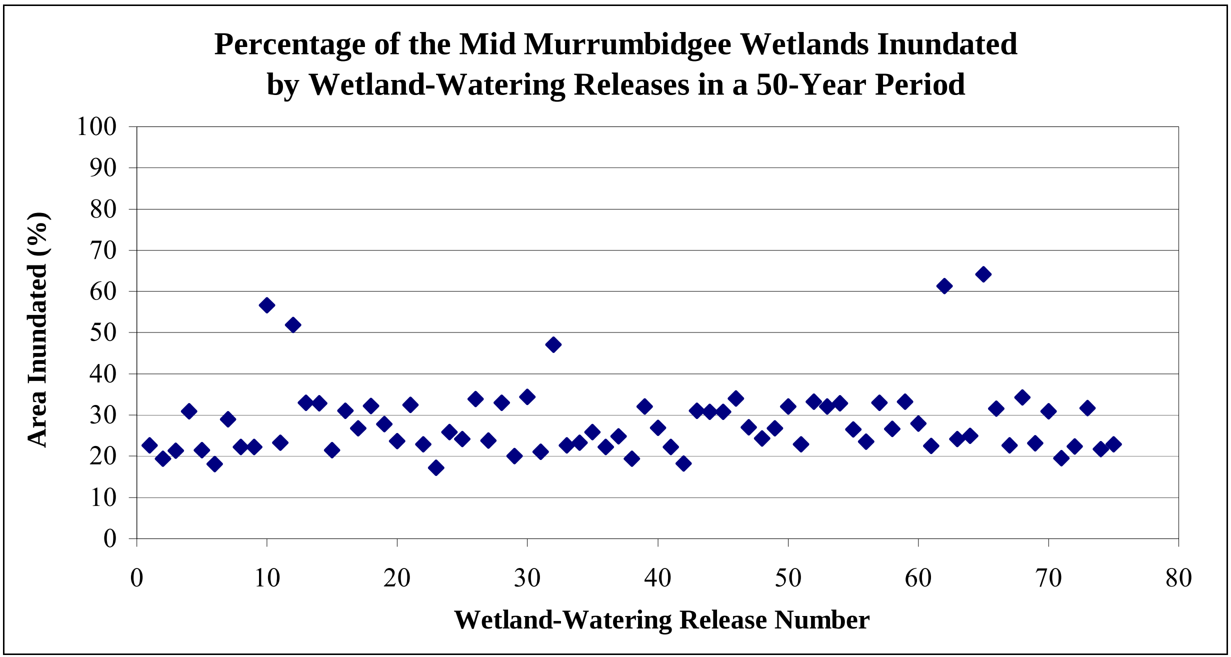

Figure 4 – Simulated inundation of the Mid Murrumbidgee Wetlands by ECA releases over a 50-year period.

Raising the volume of ECA releases to 40 000 ML did not significantly increase ($\alpha=0.05$) the frequency with which 60% of the Mid Murrumbidgee Wetlands were inundated (Table 2) compared to releases of 30 000ML. Releases above 50 000 ML inundated 60% of the wetlands at least twice as often as releases of 30 000 ML.

Table 2. Simulated number of times at least 60% of the Mid Murrumbidgee Wetlands are inundated by ECA releases of increasing volume. A target of 60% was chosen because some high commence-to-fill wetlands require exceptional flow events to be inundated and Figure 4 indicates it is feasible to inundate 60% of wetlands using ECA releases.

	Volume of ECA Releases (ML)				
	30 000	**40 000**	**50 000**	**60 000**	**70 000**
Number of times 60% of wetlands are inundated in a 10 year period	0.975	1.15	1.95	2.00	3.00

Response to the simulation model

At all three focus groups the presentation of the simulation model stimulated discussions regarding the limitations of existing the Environmental Flow Rules, the tradeoffs between translucency and ECA releases, the implications of translucency releases for early season allocations and alternative management scenarios. Each topic is discussed in greater detail in the following sections.

Questions about the development of the model arose at all three meetings with participants inquiring about the data source, whether tributaries were included in the simulation model and whether it had been shown to the DLWC for approval. They ware also interested in learning how the Environmental Benefits Index had been developed and the relationship between this model and the existing Integrated Quantity and Quality Model run by the DLWC.

Direct quotes from focus group participants are cited according to the location of the focus group. The locations have been abbreviated as follows Darlington Point (DP), Yanco (Y) and Griffith (G).

Effectiveness of ECA releases

Focus groups participants' experiences with previous environmental flows led to concern about whether environmental flows are effective in improving wetland health. They believed that only one of the three previous releases made for wetlands were effective and that the restriction of 30 000 ML a day past Gundagai *"makes a mockery of the attempts to do something for the environment … if they were fair dinkum about an environmental flow for the environment, that bit of dirt would get flooded"* (Y1, 2002). Therefore, participants believed that ECA releases are *"a waste of time unless you can get environmental flows up over the bank and that is upwards of 30 000 ML per day"* (DP3, 2002).

Participants suggested numerous alternatives for making ECA releases more effective, given the existing constraints. These included building enroute storages, removing debris from channels that fill wetlands, using portable pontoons to temporarily dam the river at strategic locations to flood nearby wetlands as well as pumping water directly into the wetlands from the river.

Translucency releases

Farmers believed that environmental flows should be focused on *"what we can physically enhance"* (DP3, 2002) and on achieving *"environmental outcomes"* (G1, 2002). They believed that wetlands should be a priority and that translucency releases are a waste of water as they reduce the amount of water available for wetlands. They also felt that translucency releases were being released with insufficient scientific evidence regarding their ecological benefits as *"nobody can tell me… what they are getting [achieving]"* (G1, 2002) and *"I don't think we've got the luxury of mimicking the river we've got to manage our environmental flows much better than what we do. There's a whole host of different ways of doing it rather than just throwing a lot of water at the problem and thinking, hoping it will fix it"* (Y2, 2002).

Participants were also concerned about translucency releases due to their combined impact on both the volume of farmers' allocations and early season general-security allocations. At all three groups it was suggested that some farmers have experienced at least a 30% reduction in their allocations due to the deregulation of the agricultural industry, introduction of water markets and environmental flows. Since translucency releases reduce early season allocations *"that sort of has doubled the impact as … he doesn't know whether he is … going to have access to enough water to do what he wants."* (Y1, 2002).

Alternative management scenarios

Participants at some focus groups were comfortable using the simulation model as a tool for investigating alternative management scenarios while others that felt that they *"probably don't know enough to ask the right questions"* (Y2, 2002). At all the focus groups participants preferred the facilitator to input the scenarios and run the model.

In Griffith, farmers were interested in exploring the relationship between announced allocations, of 40, 80 and 120%, and the effectiveness of ECA releases. At 40% no releases were made, as there was insufficient water available in the Environmental Water Accounts. At 80% allocation little extra water entered the wetlands than would have entered prior to the introduction of Environmental

Flow Rules. Similarly, when farmers' allocations were set to 120% and the volume of ECA releases increased to 45 000 ML (i.e. removing the Gundagai Choke) little extra water entered the wetlands than would have occurred otherwise.

Participants at Griffith were also interested in changing the translucency curves to investigate the implications for both wetlands and general-security allocations. In particular they were interested in changing the wet and normal curves to complete parabolas with maximum values of 50% (Figure 5) and then increasing the volume of ECA releases to 40 000 ML, however this required more time than was available during the focus groups (see Post Focus Group Development section).

At both Yanco and Griffith, it was suggested that the model would be of greater value to farmers had it allowed the user to set *"environmental flows and then come back and see what your allocation is"* (G1, 2002) rather than allow users to specify their desired allocation.

Post Focus Group Development

Some of the suggested changes to the simulation model required more time to develop than was available during the discussion sessions. This included changing the way in which general-security allocations were determined and changing the wet and normal curves that control translucency releases.

In order to show how different environmental flow scenarios would affect farmers' allocations, the model was redeveloped to mimic the process through which the DLWC determined allocations. This required information about historical inflows into the dams, dam storage levels and diversions to date.

Comparing the pre and post-environmental flows simulation models showed that the introduction of environmental flows led to a 4.59% reduction in farmers' allocations (note the Draft Water Sharing Plan indicated that general-security allocations would be reduced by 4.5%). When ECA releases were increased to 40 000 ML per day, in accordance with a suggestion made at the Griffith focus group, there was an average reduction in allocations of 5.44%. When ECA releases were raised further to 50 000 ML per day, to double the frequency with which 60% of wetlands are inundated (Table 2), allocations were reduced by 7.32% on average.

At Griffith, it was hoped that changing the translucency curves would increase the volume of water in provisional storage, thereby improving early season allocations whilst maintaining variability of river flows. Prior to the development of the environmental simulation model, farmers had not been given the opportunity to investigate such possibilities. When changes to the curves (Figure 5) were incorporated into the post-group simulation model there was an average reduction of 17.4% (42 925.5 ML) in the volume of translucency releases. This had no significant effect on allocations ($\alpha=0.05$). However, if translucency releases were halved then the impact of environmental flows on farmers' allocations would be reduced by 28.5% and the frequency with which ECA releases could be made would be increased by 35%.

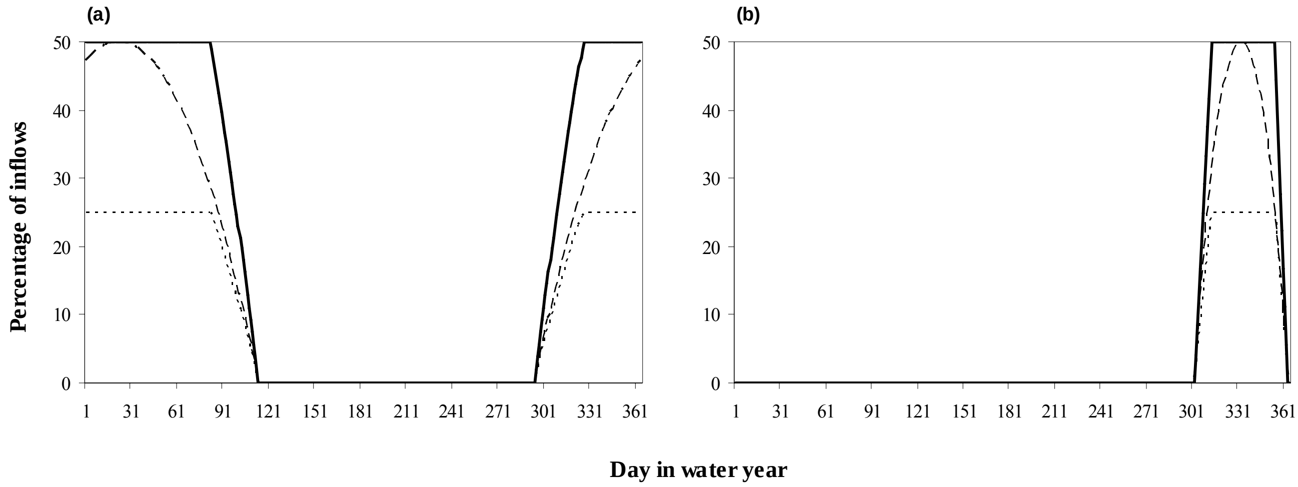

Figure 5. Actual and proposed translucency curves for (a) normal and (b) wet catchment conditions when Burrinjuck Dam is below 30%. Solid lines indicate curves used in the Draft Water Sharing Plan for the Murrumbidgee Regulated River Water Source (MRMC, 2002). Dashed lines represent curves proposed at the Griffith focus group. Dotted lines indicate possible curves which could reduce translucency releases by half.

DISCUSSION

It was initially proposed that farmers' attitudes towards environmental flows would be influenced by the effectiveness of ECA releases and concerns regarding early season allocations. The results indicated that both factors were significant in influencing farmers' views and in addition farmers' were concerned that the environmental benefits of translucency releases had not been proven.

Farmers' previous experiences with environmental flows led them to believe that large volumes of water were being released with limited improvements in wetland health. This was supported by the results of the simulation model, which found that the existing Environmental Flow Rules do not significantly increase the frequency with which wetlands are inundated, due to the Gundagai Choke. Therefore, if farmers are to support environmental flows, the limitations of the existing Environmental Flow Rules must be addressed. The Water Sharing Plan for the Murrumbidgee Regulated River did not achieve this. If no changes are made to the plan it is therefore unlikely that environmental flows will significantly improve the long-term health of wetlands and support among farmers is likely to decline.

Throughout the focus groups, participants made numerous suggestions about how the limitations of the Gundagai Choke could be overcome. One suggestion was to put inflatable dams, made of flexible membranes, along the river at strategic points to force ECA releases to breach the riverbanks and fill the wetlands. Once each set of wetlands was inundated, the dams could be deflated. Although it was suggested that these should be portable, it would be more practical if they were permanent features, inflated as required. Since it takes at least five days for large river flows to reach Narrandera from Burrinjuck Dam (DWR, 1989), this would allow ample time for the dams to be inflated.

Numerous inflatable dams have been created worldwide, mainly for recreational purposes (Gannet Flemming, 2000), with the tallest being six metres in height (Satujo, 1998). They can be remotely operated by computer and are ideally suited to medium-sized watercourses where the width is greater than the depth (City of Tempe, 2001). Since each dam would be inflated for less than one week, it is unlikely that they would have serious adverse impacts on other riverine processes.

Depending on the costs involved, this may be one feasible alternative to building a new bridge that would be required if the Gundagai Choke were to be removed.

An alternative to inflatable dams, suggested by focus group participants, involved pumping water from the river into the wetlands. One of the participants who proposed this had a wetland on his property, which he was willing to have flooded. The feasibility of using pumps to artificially inundate wetlands was investigated by the DLWC (Hardwick et al., 2001). The main weakness of this approach is that it does not allow for the movement of fish and other aquatic animals between the river and the wetlands. To overcome this limitation alternative non-flow options are being investigated including the development of off-stream storages, the use of aquifer storages and altering access to wetland fill channels (Pratt Water, 2002). In the interim pumping water into wetlands does provide ecological benefits to the floodplain and can be a useful management tool for inundating wetlands with high commence-to-fill that are difficult to flood under current flow regimes (Hardwick et al., 2001).

The Murrumbidgee River Management Committee recognised the importance of using non-flow options to achieve improvements in wetland health (Bowmer, 2002). However, non-flow alternatives could not be included in the Water Sharing Plan as they did not fit with the statutory planning process. This suggests that future environmental water management policies, such as the National Water Initiative, need to consider non-flow options not only to improve the effectiveness of environmental flows but also to strengthen community support.

Farmers' other concerns about the environmental flows Rules related to translucency releases. There were three main reasons for this. Firstly, these flows lower the frequency with which wetlands can be inundated. The simulation model indicated that the frequency of ECA releases could be increased by 70% if there were no translucency releases and 35% if these flows were reduced by half.

Secondly, translucency releases reduce the amount of water available in the dams at the beginning of the irrigation season, resulting in lower general-security allocations. This makes it difficult for irrigators to decide what types and area of crops to grow. For these reasons focus group participants believed that the same variability in river flow could be achieved with less water and consequently the volume of translucency releases should be reduced. While changing the translucency curves as per the suggestion made at the Griffith focus group would not significantly improve irrigators' allocations, reducing translucency releases by half would reduce the impact of environmental flows on irrigators' allocations by 28.5% and significantly improve the frequency of ECA releases.

The third reason why farmers were unsupportive of translucency releases was because they believed that there is insufficient information available regarding the environmental benefit of these flows. While it has been found that translucency releases are beneficial for suppressing algal blooms (Maier et al., 2001) and managing sediment build up the benefit of small-scale flow variability to the riverine environment is unknown (Schofield et al., 2003). Consequently a number of studies are underway to investigate the ecological benefits of translucency releases (Watts et al., 2001; CRC Freshwater Ecology, 2004; DLWC, 2004; MDBC, 2004).

Since focus group participants were not aware that the translucency releases provide benefits for sediment build up and suppressing algal blooms, the results of previous studies may not be reaching farmers. Alternatively, Harrison et al. (1998) and Syme et al. (1999) suggest that farmers will not necessarily accept advice solely based on scientific findings. This implies that the way in which information on the benefits of translucency releases is being presented may not be in a form that is accepted as valid by farmers. Considering farmers were concerned about the implications of environmental flows for farm management decisions one option would be to clearly explain the follow on benefits of suppressing algal blooms for farming practices. If the results were also endorsed by key farming organisations such as the Ricegrowers' Association or Murrumbidgee Irrigation Ltd the results may gain more credibility among farmers and encourage greater support for translucency releases.

Broader Implications

In July 2004, Water Sharing Plans for all major inland NSW catchments were gazetted. Since there are a number of factors that impede ideal environmental flow regimes across the state (Schofield et al., 2003), concerns regarding effectiveness that have undermined farmers' confidence in the Murrumbidgee Catchment are likely to be representative of broader statewide concerns. Therefore, to foster support for environmental flows releases across NSW, greater consideration must be given to the effectiveness of existing environmental flows, the tradeoffs between the different types of releases and the implications of these flows for farm management decisions.

CONCLUSION

Overall, the present study showed that irrigators residing with the Murrumbidgee Irrigation Area support the concept of environmental flows for wetlands. However, they are apprehensive as to whether the existing rules can achieve significant long-term improvements in the health of riverine ecosystems due to the Gundagai Choke and trade-off between translucency and ECA releases. They were less supportive of translucency releases than ECA releases due to the combined impact of translucency releases on the volume of general-security water allocations and announcement of early season allocations. To increase support among irrigators for ECA releases requires the limitations of the existing Environmental Flow Rules to be addressed and consideration given to the cumulative impacts of environmental flows on irrigators' allocations. This could involve removing the Gundagai Choke and increasing ECA events to 50 000 ML, whilst altering the translucency curves to increase provisional storage and provide farmers with higher early season allocations. Alternatively farmers' suggestions about inflatable dams or pumping water into the wetlands could be adopted.

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