Identifying And Redressing The Ecological Consequences Of River Regulation in the Lower River Murray

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ABSTRACT: *The broadscale consequences of river regulation and increasing water diversions from the Murray-Darling Basin have been highlighted in the 1990s. In response, there is a strong impetus towards definition of effective measures to rehabilitate river and floodplain ecosystems.*

Experiences in the Lower River Murray indicate that reinstatement of key elements of the hydrological regime is critical to maintain natural regeneration processes. However, other factors inhibiting these processes also need to be identified before successful rehabilitation of river and floodplain ecosystems can occur. For example, further understanding is required of germination cycles, factors affecting seedling survival, the effects of soil salinity, groundwater salinity and depth to groundwater.

Measures to redress the ecological consequences of river regulation must integrate water management, land management and protection of riparian zones. Trying to get the hydrological regime right is just the first step in determining the complete suite of management actions required to achieve sustainable rehabilitation and management of river systems.

1. INTRODUCTION

A recent comparison of flow management in the Murray-Darling Basin with practices in the basin of the Aral Sea in Uzbekistan drew the startling conclusion that the proportion of water diverted from the Murray-Darling Basin rivers is of the same ratio as diversions which have resulted in the reduction of the world's largest freshwater lake to one-third of its natural size (Blackmore pers comm 1995). In the case of the Murray-Darling, the serious impacts resulting from river regulation are masked by the marine waterbody at its outfall. However, the recent Water Audit report highlights the gravity of ongoing impacts caused by river regulation and unchecked diversion of water (Murray-Darling Basin Ministerial Council 1995). The resulting moratorium on further diversions gives an opportunity to incorporate measures to redress the ecological consequences of river regulation.

The ecological consequences of river regulation in the Lower River Murray (Figure 1) are well documented. The particular impacts are summarised briefly below:

- naturally highly varied flows with a wide range of salinities have been replaced by a series of very stable elongated pools of relatively stable salinities, with former low summer flows eliminated, through the effect of 10 weirs below the Darling junction
- riverine-adapted species such as crayfish and river mussels have declined in the mainstream, being replaced by floodplain-adapted species yabbies and billabong mussels (Walker 1986)
- mean flow to the Lower Murray has been reduced by 37%, although the seasonality of flow peaks (spring) is unchanged (Close 1990)
- retention of flows in upstream storages can remove up to 50% of River Murray flow peaks upstream of Wentworth
- except in high flow conditions, river flows in the Lower Murray are now relatively stable throughout the year, with no significant seasonal variation
- the mixing pattern of Murray and Darling water has been changed through storage and slow release of higher flows in Lake Victoria, extending the natural flow period of highly turbid Darling water from approximately 2 months to 7 months (Suter et al 1993)
- Lakes Alexandrina and Albert have been converted from fluctuating estuarine habitats to stable permanent freshwater lakes, with seawater excluded from the estuary by 5 barrages
- the estuary of the Murray-Darling Basin is now confined to short channels below the barrages and dominated by the marine influence
- extended periods of no flow at the barrages are becoming more frequent, with drought flow conditions now occurring 1 year in 2, and frequencies of severe flow restrictions increasing (MDBMC 1995)
- minor to medium floods have been eliminated (up to the 1 in 7 year event) (Caldwell Connell 1981), with drought frequencies on the floodplain now increased from 1 in 20 to 1 in 2 (MDBMC 1995)

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- floodplain inundation frequencies have been very significantly reduced, for example inundation of the Chowilla floodplain has been reduced from 1 year in 4 to 1 year in 13 (Sharley 1992)
- recruitment of native fish is significantly reduced, with no recruitment of Murray cod since the floods of 1974-75 until overbank flows in 1989-1993 produced four strong year classes of native cod (Pierce pers comm 1994)
- regeneration of key vegetation species such as river red gum is poor and lacking in vigour on the regulated floodplain below Wentworth (Margules et al 1990)
- extremely rapid flood recessions (eg 2m fall in level in 2-5 days), are causing accelerated large scale bank slumping (Thoms, Walker & Sheldon 1992)
- rapid flood recessions may interrupt waterbird breeding cycles, leading adults to abandon unfledged chicks (Jensen 1983)
- peak levels of some medium floods are actively reduced by diversion of water into Lake Victoria to protect key infrastructure on the floodplain in South Australia (eg Berri-Loxton causeway, Loxton Caravan Park) (Figure 2)
- only once floods reach approximately 110 000 ML/d are they largely uncontrolled and a relatively natural pattern of inundation of the floodplain occurs.

This long list of environmental consequences associated with river regulation in the Lower River Murray highlights the major threats to the long term health of the riverine environment and the sustainable use of its resources. Clearly, significant changes must occur in river management to redress these impacts.

2. DEFINITION OF ENVIRONMENTAL FLOW REQUIREMENTS

2.1 Defining Key Elements of Hydrological Regime

A return to a pre-regulation hydrological regime cannot be accommodated within the current social and economic dependency on the water resource (Jacobs 1990). Therefore, the key to rehabilitation and sustainable water resource management will be in the smart use of any opportunities to restore key elements of the hydrological regime. What are these key elements?

The preferred approach for the Lower Murray is to concentrate on restoration of broadscale processes, rather than to define the needs of individual species or to attempt to address each of the separate impacts listed above (Jensen et al 1994).

This process-targeted approach is very similar to the holistic approach described by Arthington et al (1992), which advocates identification of key elements in the hydrological regime, such as the timing, peak, duration or rate of recession of floods. It avoids the difficulty of having to define environmental flow requirements in terms of the needs of individual species, which can require significant investigation time. The species-targeted approach may lead to delays, conflicts between the needs of different species or lack of flow provision for some species because of lack of data.

For the process-targeted approach, the Lower Murray Flow Management Working Group has defined a general management aim in riverine rehabilitation as follows:

> *to achieve broadscale inundation of the floodplain environment that will stimulate regeneration and revitalisation of native aquatic and terrestrial plant communities and breeding in waterbirds, native fish and aquatic invertebrates. Inundation should occur on a natural cycle. In the case of a natural drought, inundation of the floodplain would not be required.*

For the Lower Murray, a number of key elements of the hydrological regime have now been identified for inclusion in a package of environmental water requirements. The package should address one or more of the following environmental management aims:

- inundation of the floodplain during spring peak flows to reinstate as many as possible flood events up to 1 in 7 year frequency
- inundation of the floodplain for a minimum of two months and maximum of four months for waterbird and fish breeding
- minimum inundation of the floodplain for two weeks or more to water stands of floodplain vegetation and to replenish freshwater lenses in the groundwater for future water reserves
- inundation of the floodplain for two to six weeks to stimulate flowering of floodplain vegetation

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- inundation of waterbird rookeries for a minimum of two months to ensure completion of fledging
- slower rate of recession after flood peaks to prevent bank slumping
- drying of permanent and semi-permanent wetlands for a minimum of two months at least once every three years
- minor variations in mainstream river levels to favour increased diversity in food chains
- maintenance of a relatively natural pattern of flow variations in the mainstream, and seasonality, frequency and duration of high flow peaks
- reduction of the influence of turbid Darling flows to near-natural patterns.

Clearly, the package of measures to redress the impacts of river regulation and identify environmental water requirements must be a flexible mixture which outlines options for varying river conditions and climatic cycles. The objectives outlined above would only be met over a period of time, which might be many years, depending on climatic cycles.

2.2 Defining Opportunities for Changed Management of Hydrological Regime

In defining opportunities to implement delivery of environmental water requirements, two major groups of constraints must be considered. Engineering constraints include the physical constraints of operation and safety of the structure (dam, weir, size of outlets, etc) and the consumer demands for water delivery.

Social and economic constraints include the demand for irrigation and domestic supplies to be delivered in a different sequence to the natural flow regime, and requirements for specific, usually stable water levels for pumps and recreation uses. Another constraint is the demand for protection of development on the floodplain, to reduce or prevent flooding to protect economic investment, even though the location is known to be flood-prone.

As a first step in identifying opportunities to deliver environmental water requirements in the Lower Murray, Ohlmeyer (1991) outlined opportunities to vary release sequences and sources in the operation of storages, particularly Lake Victoria and Menindee Lakes, and to manipulate flows in a limited way at individual weir structures under particular flow conditions.

The Lower Murray Flow Management Working Group has developed these opportunities in more detail, preparing data sheets which indicate the physical constraints of each weir structure, flow thresholds for key floodplain wetlands controlled by operation of each weir, and key social and economic constraints (eg minimum depth for ferry operation, effect on irrigation pumps).

It has been generally agreed by the Working Group that the greatest potential for improving flows to floodplain wetlands lies in raising water levels at weirs, since lowering of levels would have unacceptable social and economic impacts on large sections of the community. These could include stranded ferries and pump offtakes, as well as draining of saline deoxygenated backwaters prior to high flows. However, minor lowering of levels to introduce variations in mainstream levels would be feasible.

The application of variation in storage management has already been demonstrated, with the diversion into Lake Victoria of 12 000 ML/day during the peak of 1993 flow (Figure 2). This action reduced flood levels by 100mm and prevented closure of the key road link between Berri and Loxton. The flood peak was extended from approximately four days to nearly four weeks. While a very small area of outer floodplain was not wetted because of this action, widespread inundation lasting nearly four weeks instead of four days had a very beneficial effects on large areas of the floodplain ecosystem.

Analysis of opportunities for changed flow management indicates a range of flow bands with varying control over flows. These are outlined in Table 1. An area of major debate is whether to enhance or mitigate flood peaks. The social and economic pressure is always to mitigate, and this has been the primary objective of past flow management during floods. In times of normal flow, the primary objectives are security of supply and water quality. Both of these objectives have driven the operating rules for Lake Victoria, with the resulting extended influence of turbid Darling water.

The environmental consequences of mitigating floods have not been fully investigated, although the best judgement for the 1993 mitigation was that the environmental consequences were more positive than negative. Further investigation is required for sound environmental judgements on the consequences of the mitigation scenario.

This debate will require major community involvement, since the issue of how river levels and flows are managed has a very direct impact on all river users and residents. The community consultation phase of the flow management process is seen as the most important activity, requiring time and resources to ensure informed debate and constructive input from all parties.

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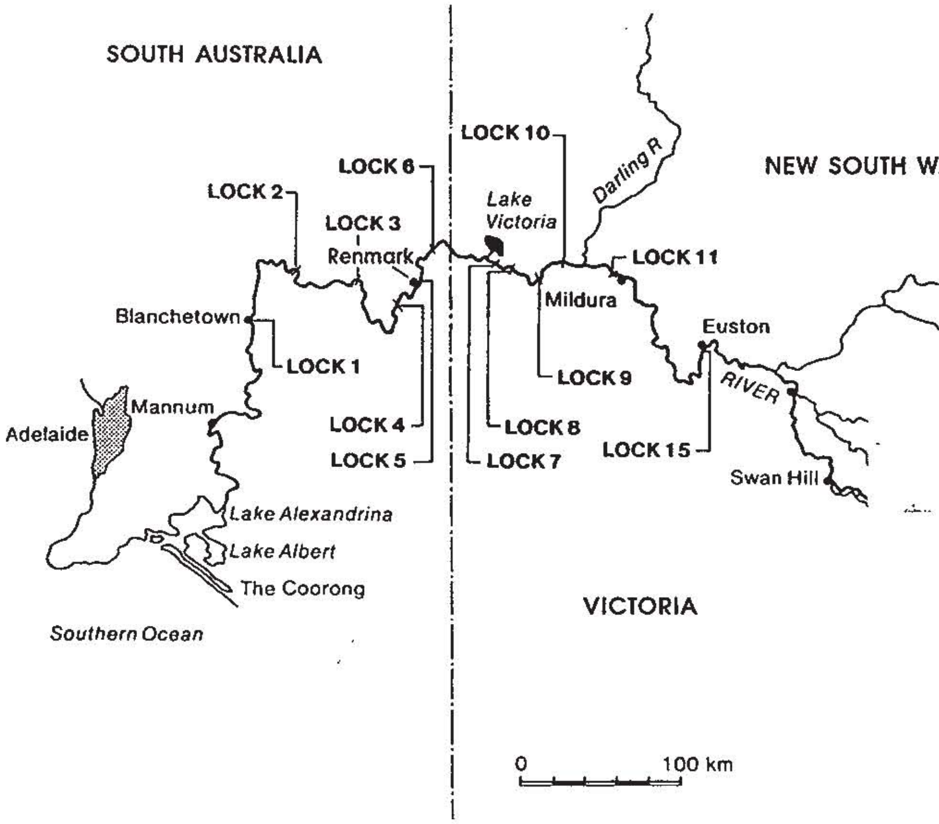

Figure 1: Regulating Structures on the Lower River Murray

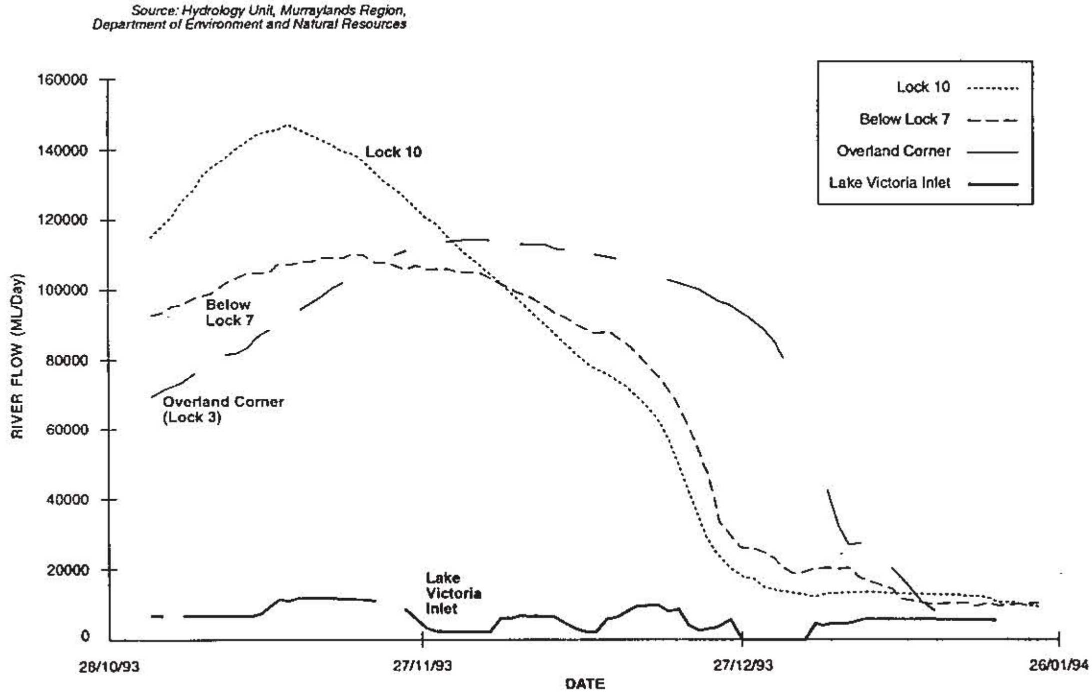

Figure 2: Mitigated River Murray high river flows into South Australia in 1993

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Flow band	Potential control
> 35 000 ML/d	local regulators on individual wetlands, manipulation of mainstream levels at weirs
35-50 000 ML/d	manipulation of weir levels to simulate higher flows to achieve selected wetland filling
50-80 000 ML/d	manipulation of weir levels (where structure still in place) plus storage release sequences to achieve selected floodplain inundation
80-100 000 ML/d	social and economic demand to lower flood peak to protect floodplain development

Table 1 Potential for environmental flow management for different flow bands in the Lower River Murray

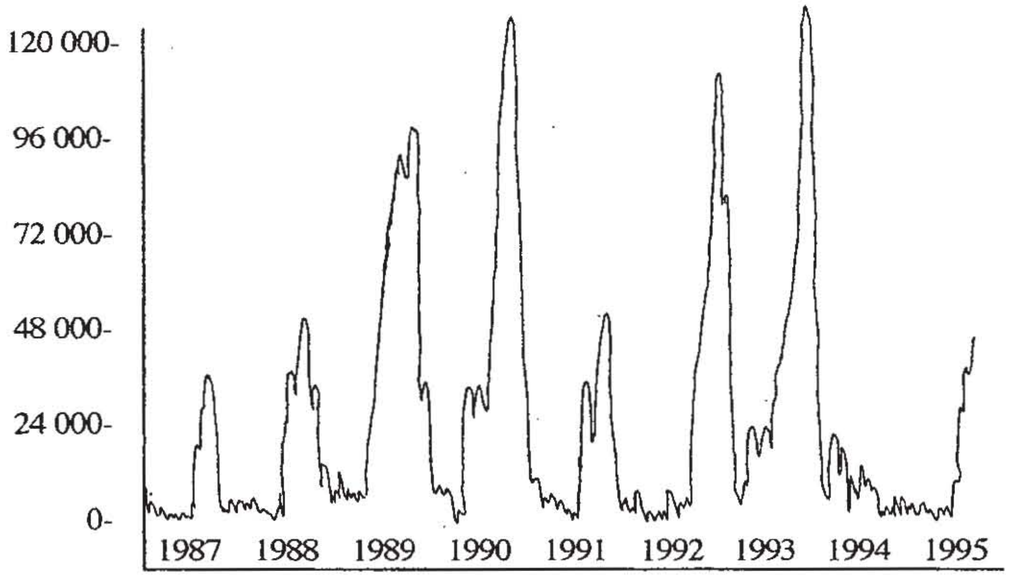

Figure 3 Flow hydrograph for River Murray at Overland Corner, showing peak spring flows (Ml/day) since 1987

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3. DISCUSSION

As a first stage in developing a flow management strategy for the Lower Murray, a draft flow management package has been formulated and presented to key policy bodies, including the South Australian Water Resources Council. The package sends the clear signal that the area of greatest potential for improved environmental management is in the band of flows from 15 000 ML/d to 60 000 ML/d. The package is outlined in Table 2.

These flow bands are above the minimum entitlement conditions which govern allocations and normal river operating rules. Flows in this range may be declared 'surplus' by the Minister, allowing unregulated diversion by irrigators (similar to 'off-allocation' water in upstream states). The call for environmental water allocation from this band of flows is thus potentially in conflict with preliminary proposals for 'opportunity' licences which would offer water with reduced security. However, it is anticipated that a compromise could be reached which allows both activities.

The amount of water which could be used for environmental purposes within the minimum entitlement flow of 3-7000 ML/day is only a small component of the environmental needs, since it could only supply individual wetlands. No overbank flows are possible within the entitlement flow range. It is more important to fluctuate levels within the mainstream to increase biodiversity in the littoral zone, and this would not require a water allocation, just a change in operating rules.

An important distinction which must be made in this debate is that flushing flows for algal management and water quality objectives do not benefit the riverine environment. They are generally too small in volume and too short in duration to achieve overbank flows or to fill wetlands. Environmental flows in the Lower Murray must reach the floodplain to have significant environmental benefits.

Discussions of environmental water requirements frequently seek to define these requirements in terms of a share of the annual average flow volume. However, environmental flows must incorporate the natural variability of the hydrological regime, which is not easily expressed in averages. It is suggested that the answer might lie in allocating water from the secure part of the average hydrograph for consumptive uses and allocating the upper variable section of the hydrograph, with its peaks and troughs, to the environment (eg flood peaks above 25 000 ML/day; Figure 3). Thus the consumer has a reliable supply and the environment has a hydrological regime with variation on a natural cycle.

4. CONCLUSIONS

It is the firm conclusion of investigators and managers in the Lower Murray that the reinstatement of key elements of the hydrological regime is the primary objective in rehabilitation of the riverine ecosystem.

The first key element of the hydrological regime defined for environmental water requirements in the Lower Murray is the reinstatement, or simulation, of overbank flows to compensate for the lost small to medium floods with frequencies up to 1 in 7. This altered flow regime has already been achieved for six sites through on-site works.

A flow management strategy is being developed to increase overbank flows for whole reaches along the length of the Lower Murray. This strategy will seek to build in the flexibility required to incorporate the natural variability of the hydrological regime and to make smart use of available opportunities to provide key elements of the hydrological regime. It will incorporate changing operating guidelines for both regulated and flood flows.

Owing to the potentially controversial nature of proposals to alter river levels and flow patterns, a long process of negotiation and community involvement will be required before this strategy can be finalised and implemented.

Flow Band	Flow Management Strategy
< 15 000 ML/d	fluctuate mainstream levels
15-25 000 ML/d	allocate water to individual wetlands
25-60 000 ML/d	manipulate weir levels to create overbank flows
25-80 000 ML/d	enhance flood peaks
80-100 000 ML/d	mitigate flood peaks
> 100 000 ML/d	enhance flood peaks

Table 2 Preliminary Flow Management Package for Lower River Murray

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