Blueprints for the future of the Murray's iconic floodplains and wetlands

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Introduction

The Living Murray program was established in 2002 in response to evidence showing the declining health of the River Murray system. In 2003 the Murray-Darling Basin Ministerial Council made it's 'First Step' decision to recover 500GL of water for environmental use at six iconic sites along the Murray (Figure 1), and invest $150 million in 'works and measures' to make best use of that water. The First Step decision focused those investments on achieving specified environmental objectives at each of the icon sites. In 2006 the Australian Government provided additional funds to deliver The Living Murray, providing extra financial support to the water recovery program, and bolstering the 'works' program budget to approximately $270 million.

Figure 1: The Living Murray icon sites

Since 2003 the 'works' program has invested in the construction of fishways on the main Locks and Weirs of the Murray River under the 'Sea to Hume' fishway program. A number of smaller wetland regulators have been constructed, and over 4000 'snags' have been installed in a program to restore native fish habitat between Hume Dam and Yarrawonga. The water recovery program has made significant progress, Icon Site Environmental Management Plans have been developed, and numerous environmental watering actions have been undertaken. Programs and plans have been developed to monitor the on-ground ecological outcomes. Whilst all this has been undertaken, an 'eye' has remained on the environmental objectives for the sites, and the larger scale works and watering actions required to achieve them.

The achievement of the environmental objectives was always going to be a challenge, but since the First Step decision was made the challenges have intensified as the icon sites have suffered from the ongoing drought, and the possible outcomes of climate change have become more tangible.

'Blueprints' is the term used to describe the works, environmental water requirements, and the associated operating strategies that are being proposed by the State icon site teams to deliver the environmental objectives. This paper explores the Blueprints and the issues and impacts associated with climate change. A case study of the experiences, predictions and proposals at Chowilla are used to explore some of the issues in further detail.

Icon Site Environmental Objectives

Ministerial Council's First Step decision established 'interim' environment objectives for the icon sites (Table 1). More refined objectives and targets have since been established at a number of icon sites.

Table 1: 2003 Ministerial Council First step decision 'interim' environmental objectives

Barmah-Millewa Forest
▪ Successful breeding of thousands of colonial waterbirds in at least three years in ten ▪ Healthy vegetation in at least 55% of the forest area
Gunbower, Koondrook-Perricoota Forest
▪ 80% of permanent and semi-permanent wetlands in healthy condition ▪ 30% of total river red gum forest area in healthy condition ▪ Successful breeding of thousands of colonial waterbirds in at least three years out of ten ▪ Healthy populations of resident native fish in wetlands
Hattah Lakes
▪ Restore healthy examples of all original wetland and floodplain communities ▪ Restore the aquatic vegetation zone in and around at least 50% of the lakes ▪ Increase successful breeding events of colonial water birds to at least two years in ten ▪ Increase the population size and breeding events of the endangered Murray Hardyhead, Australian Smelt, gudgeons and other wetland fish
Chowilla Lindsay-Wallpolla
▪ High value wetlands maintained ▪ Current area of River red gum maintained ▪ At least 20% of the original area of Black box vegetation maintained
Lower Lakes Coorong and Murray Mouth
▪ Open Murray mouth ▪ More frequent estuarine fish spawning ▪ Enhanced migratory wading bird habitat in the Lower Lakes and Coorong
River Murray Channel
▪ Overcome barriers to the migration of native fish between the sea and Hume Dam ▪ Maintain current levels of channel stability ▪ Increase the frequency of higher flows in spring that are ecologically significant

The scale of the program, to achieve the environmental objectives at these large icon sites is ambitious. The four floodplain icon sites (Barmah-Millewa, Gunbower Koondrook-Perricoota, Hattah and Chowilla Lindsay-Wallpolla) cover an area of about 200,000 ha, or 2,000 km^2 and to achieve the objectives will require the ability to inundate many tens of thousands of hectares, which will require substantial environmental water, new infrastructure and innovative river operations.

Drought and Icon Sites Condition
The health of the Murray River and its wetlands and floodplains has suffered from over 100 years of river regulation. Jones *et al* (2002) noted that it was likely that by the 1960's or 1970's the Murray River could no longer be described as healthy.

Average water consumption in the Basin is about 8,095 GL/year or about 56% of the average available water. In addition flows in the Murray are highly regulated and Dartmouth and Hume Dam regulate about 87% of their total inflow (CSIRO 2008b). This means that when flows are below average there is little spare water and consumption has to be curtailed. The impact on the environment is particular severe as the environment has few defined allocations and relies on unregulated flows which are reduced greatly when water is scarce.

The current drought has placed enormous pressure on all water users including the environment. This drought is harsher than any recorded in the last 117 years as low rainfall and high temperatures have resulted in much reduced river flows. Average inflows to the Murray River system between 2002 and 2008 were 3,800 GL/yr, which is worse than the previous extended droughts from 1897 to 1904 (4,900 GL/yr) and 1938 to 1946 (5,600 GL/yr) (see Figure 2). The last two years have been particularly severe. The combined inflow for 2006/07 and 2007/08 was 3,190 GL, which is only 53% of the previous minimum in 1914 to 1916. In 2006/07 inflows were 1,080 GL the lowest on record and very much below the long term average of 8,900 GL.

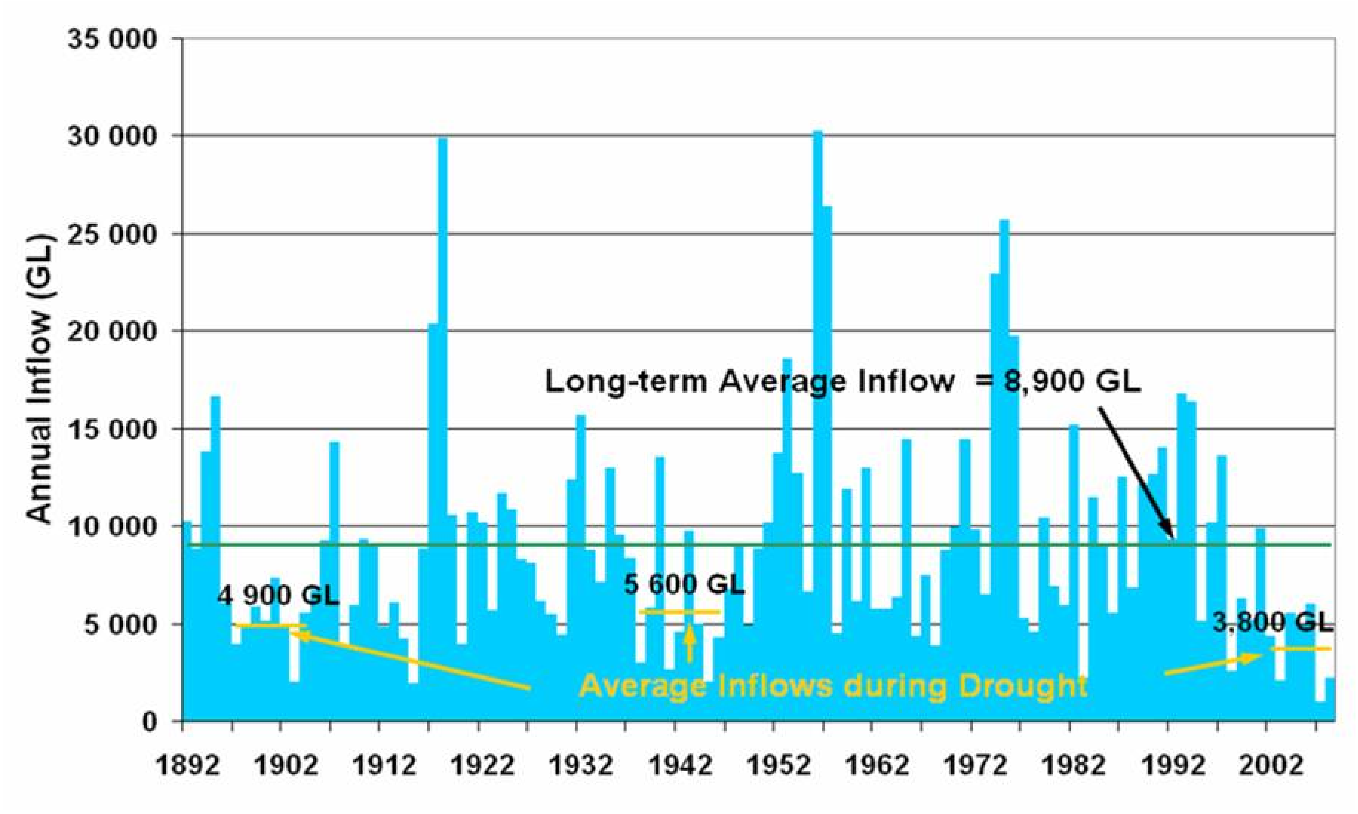

Figure 2: Total Murray River system inflows (excluding Darling River)
Modeled annual inflows under current conditions

Icon Site managers are of the opinion that the current drought has resulted in significant degradation of the health of the Icon Sites. Of particular note is the health of the Lower Lakes Coorong and Murray Mouth and River Red Gum forests. The falling lake levels and lack of flow over the barrages have had severe ecological impacts. Keystone aquatic plant species such as *Ruppia* have been severely affected, and numbers of estuarine fish and migratory wading birds have declined substantially (MDBC 2007). Falling lake levels are becoming critical as the potential exposure of acid-sulphate soils could result in acidification of water and sediments, particularly in Lake Albert.

River red gum health is a useful indicator of the broader decline of the riverine ecosystems and the floodplain icon sites. An assessment of the condition of Icon Sites in 2007 found that less than 20% of River Red Gums are in good condition with the majority in declining condition and more than a third poor or stressed (Table 2).

Table 2: Condition of River red gums at icon sites

Condition	**% of Area of River Red Gum**				
	Barmah Millewa	Gunbower Koondrook-Perricoota	Hattah Lakes	Lindsay Wallpolla	Chowilla (all tree species)
Good	20	19	5	21	32
Declining	75	NA	19	45	26
Poor	5	59	31	21	21
Stressed or Dead	0	22	45	12	21

Source MDBC 2007, except Chowilla – CSIRO 2008a

Climate Change

The current drought and the associated ecological, economic and social impacts provide an insight into the management challenges of the hotter and drier climate predicted for South East Australia. The implications for the Murray-Darling Basin and specifically the Murray River are much reduced river flows, due to lower rainfall, increased evaporation and increased absorption by dry soils.

These issues are explored in CSIRO's Sustainable Yields Project, which has recently been completed (CSIRO 2008b). This project has modeled the impacts of potential climate change scenarios on the water resources of the Murray-Darling Basin. This modeling has shown that projections from global climate models mean that future runoff in the Murray region is more likely to decrease than increase.

The Sustainable Yields Project included assessment of impacts of potential climate change on flood indicators at the icon sites. A summary of the results is provided in Table 3. The modeling demonstrates that flooding frequency and volumes will decrease at all of the sites if the recent weather pattern continues, or current 'best estimates' of climate change eventuate. The frequency of flooding is likely to shift beyond the tolerance of many riverine ecosystems.

The combined impacts of river regulation and water resource use, drought and climate change provide a challenge for the future management of the icon sites and the achievement of the First Step decision environmental objectives.

Table 3: Flood frequency and volume indicators for the icon sites

Icon Sites and Associated Flood Indicators	Historical Climate No Development	Historical Climate Current Development (A)	Recent Climate* Current Development	Future Climate* Current Development
			% change from (A)	
Barmah-Millewa Forest				
Average period between floods	1.8 yrs	3.5 yrs	30%	13%
Maximum period between floods	4.7 yrs	10.9 yrs	211%	95%
Average flood volume per year	1217 GL	291 GL	-81%	-49%
Average flood volume per event	1947 GL	905 GL	-75%	-43%
Gunbower Koondrook-Perricoota Forest				
Average period between floods	1.7 yrs	3.8 yrs	30%	15%
Maximum period between floods	4.8 yrs	11.8 yrs	219%	77%
Average flood volume per year	680 GL	118 GL	-90%	-52%
Average flood volume per event	1016 GL	401 GL	-87%	-45%
Hattah Lakes				
Average period between floods	1.6 yrs	3.7 yrs	35%	12%
Maximum period between floods	4.6 yrs	11.7 yrs	223%	9%
Average flood volume per year	2379 GL	403 GL	-88%	-52%
Average flood volume per event	3373 GL	1326 GL	-84%	-46%
Chowilla Lindsay –Wallpolla				
Average period between floods	2.4 yrs	9.3 yrs	502%	101%
Maximum period between floods	5.7 yrs	28.7 yrs	113%	21%
Average flood volume per year	2431 GL	947 GL	-71%	-42%
Average flood volume per event	2226 GL	836 GL	-74%	-45%
Lower Lakes Coorong and Murray Mouth				
Average period between floods	1.2 yrs	2.2 yrs	37%	10%
Maximum period between floods	1.7 yrs	5.8 yrs	121%	35%
Average flood volume per year	4389 GL	885 GL	-77%	-44%
Average flood volume per event	4820 GL	1740 GL	-69%	-38%

Source: CSIRO 2008b
**Recent climate – based on climate data for 1997 to 2006.*
**Future climate – based on the median or 'best estimates' of climate change in 2030.*

'Works and Water' Blueprints: Management Strategies for the Icon Sites
Since First Step decision in 2003, icon site teams have developed hydraulic models of the sites, assessed the watering regimes required to achieve the environmental objectives, and undertaken feasibility studies into options to deliver those water requirements into the future. 'Blueprints' for the future of the icon sites, comprising the proposed works, their water needs and operating strategies, and the associated environmental outcomes, are now being developed by State icon site teams. A short summary of the Blueprints is provided in Table 4.

A key feature of most of the proposed works is that they will allow managed watering of significant floodplain areas at the icon sites. Importantly the works will enable floodplain inundation, independent of floods, at regulated flow levels. This will allow for the flexible operation of the works to address the ecological needs and water availability. In many cases the proposals will provide the greatest environmental outcomes that are currently feasible within the constraints provided by topography and technology, and with acceptable levels of risk.

Table 4: Brief summary of Blueprints for the icon sites

Gunbower Koondrook-Perricoota Forest Proposed works: ▪ A 3.8 km channel from the Torrumbarry weir pool into Koondrook-Perricoota forest (NSW) to deliver environmental flows of up to 6,000 ML/d into the natural flow paths of the forest ▪ A 2 km channel from the Torrumbarry weir pool on the River Murray into Gunbower forest (Victoria) to deliver environmental flows of up to 4,000 ML/d into the natural flow paths of the forest ▪ Regulators and levees to control flooding within the forests, and fishways to provide fish passage in and out of the forests Works will enable flooding of up to 24,000 ha of forest and wetlands, and have a total estimated cost of $105 million.
Hattah Lakes Proposed works: ▪ A pumping station with capacity to deliver up to 1,000 ML/d of water from the River Murray into the lake system ▪ Construction of 4 regulators and two levee banks to manage flows within the lake complex ▪ Excavation of small sections of the natural creek beds to lower commence to flow thresholds and increase flooding from natural flow events Works will enable flooding of up to 6,000 ha of lakes and surrounding floodplains, and have a total estimated cost of $29 million.
Chowilla Lindsay-Wallpolla Proposed works: ▪ Two large flow control regulators, on the Chowilla Creek and Lindsay River anabranches, to enable water levels to be manipulated through those anabranch systems to push water into wetlands and onto floodplains ▪ New secondary regulators, and upgrades to existing regulators, to control flows into and out of the anabranch systems and enable operation of the main regulators ▪ A smaller scale package of regulators on Potterwalkagee Creek/Mulcra Island to push water into wetlands and onto floodplains ▪ Fishways to provide fish passage whilst the regulators are in operation Works will enable flooding of up to 11,500 ha of floodplain and wetlands, and have a total estimated cost of $89 million.
Barmah-Millewa Forest The Blueprint will focus on: ▪ Measures to increase the capacity to deliver environmental flows, to target higher elevation parts of the forest that can’t be reached by the existing Environmental Water Allocation ▪ Works or measures to minimise ‘unseasonal’ flooding created by river regulation Further assessment of options to address these issues is required before the Blueprint can be finalised.

Table 4: Brief summary of Blueprints for the icon sites (continued)

Lower Lakes Coorong and Murray Mouth The current drought has had a severe impact on the Lower Lakes, Coorong and Murray Mouth Icon Site, and the future management of that site is now being considered in a dedicated project requested by Ministerial Council. To date the Living Murray has funded the construction of barrage fishways and investigations into the feasibility of reconnecting natural flow paths to the Southern Lagoon of the Coorong.
River Murray Channel Works include: ▪ The construction of fishways to provide fish passage between the Sea and Hume Dam, (including through the Edward River anabranch) a distance of 2,225 km ▪ A 'resnagging' program to restore native fish habitat between Hume Dam and Yarrawonga ▪ Smaller flow control regulators that will enable weirs along the Murray River to be manipulated to create seasonal water level variability The final Blueprint will further explore the management and delivery of environmental flows to the icon sites to achieve environmental outcomes in the River Murray Channel.

Together the proposed works will enable flooding of over 40,000 ha of forests, wetlands and floodplains. If implemented and operated as proposed, the works are likely to achieve the First Step decision objectives at Gunbower Koondrook-Perricoota and the Hattah Lakes. At the other sites the works will provide major contributions to the objectives.

A case study of the proposed Chowilla Creek Environmental Regulator is provided later to give a more detailed insight to the projects being proposed, their outcomes and associated risks.

Modeling the Feasibility of Water Delivery and Operation

Nearly all of the works proposed in the Blueprints can be operated under regulated river conditions. The volume of water required to operate the works is substantially less that the volume of water associated with a natural flood of comparable size. For example, at Koondrook-Perricoota, an effective natural flood of 35,000 ML/d for 3 months requires 3,150 GL of water. Operating the proposed works to achieve a similar inundation extent and flood duration would require a gross volume of about 490 GL. The net volume used for each operation is much less as approximately 60% of this water would be returned to the Murray River for other environmental or consumptive uses.

The volumes of water required to operate the proposed works are still significant, and to avoid impacts on third parties, must be met from water recovered and/or available to The Living Murray. The MDBC is currently implementing a program of hydrologic modeling to determine the feasibility of delivering the volumes of water required to operate the proposed works. The modeling will also inform future decisions regarding the distribution of environmental water between the proposed works to optimise the environmental outcomes from the available water.

The modeling is being undertaken using the MDBC's river simulation model MSM-Bigmod. MSM-Bigmod simulates the operation of the river over the 116 year period between May 1891 and April 2007. It draws upon historical inflows and climate data, and can be used to model different climate and river operation scenarios. The model has been enhanced to simulate the 500 GL of water recovery, and the operation of the proposed works. The operation of the works is rostered according to need, water use is accounted and restrictions are applied if there is insufficient environmental water available. The model will also consider different climate change scenarios, drawing upon the outputs of the Sustainable Yields Project (CSIRO 2008b).

The first stage of modeling, which is exploratory in nature, has recently been completed. Whilst it has some simplistic assumptions and limitations, the outcomes are favorable. The second stage of modeling is now underway. It is refining assumptions and providing more robust results to inform future investment decision making. Future stages of modeling will look at optimisation of environmental water use and potentially the make up of the environmental water portfolio. This will be undertaken in parallel with the refinement of the Blueprints and link to MDBC's River Murray System Operations Review which has recently commenced. A range of operating strategies are being modeled, reflecting the diversity of ecological systems and the flexibility of the structures.

Case Study - The Chowilla Creek Environmental Regulator

The Chowilla Floodplain is a diverse system of wetlands, floodplains and anabranch creeks covering an area of approximately 17,700 ha. It lies predominantly on the northern side of the Murray River, straddling the border between South Australia and New South Wales. The site is recognised for its diversity of habitats; populations of rare, endangered and threatened species; and cultural and recreational values (MDBC 2006).

The floodplain has suffered from a number of threatening processes, the most significant of which is altered flooding regime. Under natural conditions floods of 80,000 ML/d (a threshold for substantial flooding) occurred on average once every two years. Under current conditions this frequency has decreased to once every 8 years (MDBC 2006). The CSIRO MDB Sustainable Yields Project estimates that under median climate changes conditions the duration between floods will double, and under dry climate change conditions could stretch to over 50 years (CSIRO 2008b).

The impact of altered flow regimes and other processes on the flora and fauna of the site has been substantial and is ongoing. Tree health is a useful indicator of these impacts and it has been the subject of monitoring and predictive spatial modeling. Table 5 plots the decline in tree health as modeled by CSIRO (2008a). The 2037 predictions assume that flows over the next 30 years will reflect those of the past 15 years. Further decline could be expected under dry climate change conditions. Without intervention the character and productivity of the Chowilla landscape will change substantially and many of its values will be lost.

The Chowilla Creek Environmental Regulator is an innovative works proposal that would enable water levels through the Chowilla anabranch system to be manipulated under regulated river levels, to flood large areas of wetlands and floodplains. The proposal involves a package of structures centered around a large regulator (similar in design to the existing River Murray weirs – see Figure 3) near the downstream end of Chowilla Creek. The package includes additional structures to manage flows into the site and through smaller secondary watercourses, and to provide fish passage. The package of works has an estimated construction cost of $42 million.

Table 5: Modeled Tree Health at Chowilla

Date and Scenario	Proportion of Trees Dead or Very Stressed	Proportion of Trees Healthy
2003 – actual	19%	37%
2007 – actual	21%	32%
2037 – repeat of flow conditions from last 15 years and no intervention	30%	28%
2037 – repeat of flow conditions from last 15 years and with Chowilla regulator	18%	50%

Operation of the regulator would be flexible and adaptable. To reflect the natural flood patterns and ecological needs, the aim would be to operate it once every 2 to 3 years for a period of 2 to 3 months during spring and early summer. The area of inundation would vary with flow. At low flows the regulator would inundate about 5,500 ha, or 30% of the site (see Figure 3). Approaching the upper limit of operation, at flows to South Australia of 40,000 ML/d, the regulator would inundate about 7,000 ha, or 40% of the site. When not in use the regulator would effectively be removed so flows and water levels through the site would not be impacted.

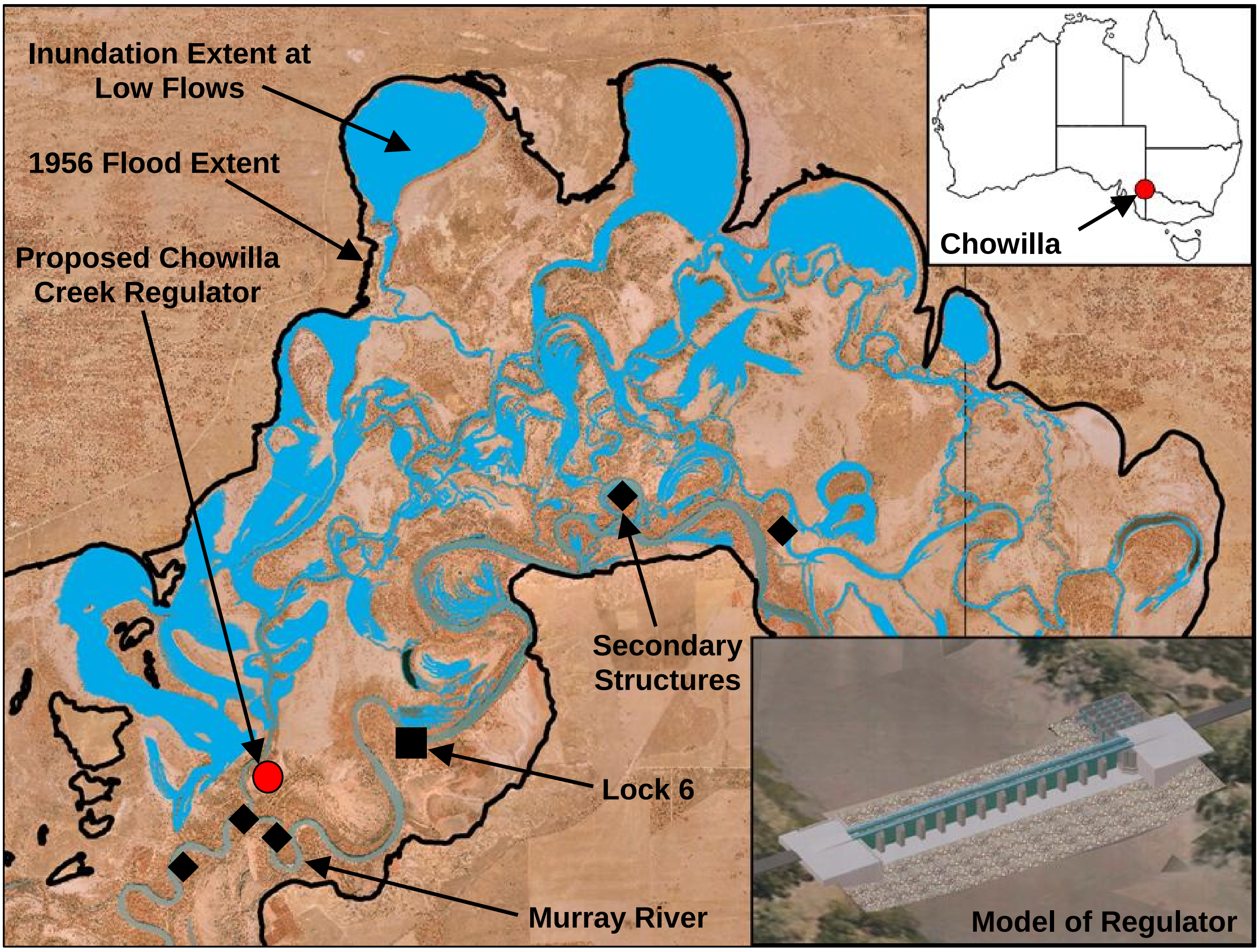

Figure 3: Inundation extent of proposed Chowilla Creek Environmental Regulator

The regulator will have substantial benefits for a wide range of biota including trees, understorey and wetland vegetation, birds, frogs and many species of native fish. With operation of the proposed regulator superimposed on flow conditions representative of the past 15 years, modeling predicts that in 2037 the proportion of dead or very stressed trees will reduce to 18% and the proportion of healthy trees will increase to 50% (CSIRO 2008a).

Notwithstanding the benefits, innovative engineering solutions such as this are not without their risks. The Chowilla anabranch is recognised for its high value native fish habitat, particularly fast flowing habitats favoured by large-bodied species such as Murray Cod. The operation of the regulator has the potential to temporarily reduce the flow velocity in some watercourses. The Chowilla anabranch is also known to contribute significant salt loads to the River Murray and operation of the regulator is expected to increase these loads above current levels. Although this salt export would have occurred under natural conditions, the impacts still need to be considered and managed. Rigorous scientific investigations are being undertaken to understand risks such as these in detail, and to develop strategies to manage the risks within acceptable limits.

The Chowilla Creek Environmental Regulator proposal is in development. Detailed design has just commenced, in parallel with ecological risk assessments and analysis of possible operating strategies. After completion of this work, and contingent on approvals being granted, construction of the regulator is forecast to commence in early to mid 2010.

Next Steps

The imperative for The Living Murray is to complete the 500 GL of water recovery and construct the works required to deliver this water to the icon sites as soon as possible. Without this water and these works, or a significant natural flood event, the flood dependent ecosystems may degrade to a point that the character of the icon sites is irretrievably changed. Both the water recovery and works programs are being driven forward rapidly.

The involvement of the community in the development and implementation of the Blueprints is essential if they are to be implemented successfully. Whole-of-program engagement is being driven through The Living Murray Community Reference Group and Murray Lower Darling Rivers Indigenous Nations. At the icon site level, engagement is facilitated by icon site Community Reference Groups, community engagement officers and Indigenous facilitators. A program of Indigenous ‘use and occupancy’ mapping is underway. It will inform future icon site management and the operation of the proposed works to achieve cultural outcomes.

The Blueprints will be finalised and form a major input into the next revision of the Icon Site Environmental Management Plans. The updated plans will need to draw on the lessons of the drought and focus on the future management of the icon sites under climate change.

Clearly, given uncertainty around the future climate and flow conditions, and the innovative nature of the projects, a monitoring and adaptive management framework will be required to underpin the environmental watering program going forward. Intervention monitoring within a broader condition monitoring framework is essential and is being implemented.

Future Directions

Looking beyond The Living Murray First Step decision there are a number significant risks and opportunities that will need to be addressed in the coming decades. The current drought has given an insight into the possible future climate. The drought has highlighted a number of management issues that cannot be addressed in the short term but will need to be addressed if the icon sites and other wetlands and floodplains of the Murray River are to survive.

First, there is a need to have sufficient environmental water with the appropriate mix of security to:

- provide water to key drought refuges in the very dry years;
- enable sufficient watering in the dry-average years to maintain the broader health of wetlands and floodplain habitats; and
- achieve larger-scale watering in the average-wet years to support breeding and recruitment event for flood dependant fauna, and to build-up the resilience of the floodplain vegetation communities.

Second, the environmental manager needs flexibility to use the water when and where it is most needed, regardless of jurisdictional boundaries. The manager should also have the ability to optimise the water portfolio, trading or converting entitlements where required to achieve environmental outcomes efficiently.

Third, better integrated river management is required to ensure that water deliveries are used in an efficient and effective manner to maximise the environmental benefits. The recently commenced River Murray System Operations Review will provide some opportunities to better align the environmental and consumptive management of the system. Improvements can be made through better defining the environmental opportunities of river operations and identifying opportunities to achieve multiple objectives.

Fourth, the value of interventionist management will increase if the climate becomes drier. The works proposed in the Blueprints are very cost effective, in terms of water use efficiency and management flexibility. If the benefits of the current suite of works are realised, further works should be considered.

Finally, our knowledge base needs to be improved. We need to understand and quantify the outcomes of the works proposed in the Blueprints, the implications of climate change, the resilience thresholds of our ecosystems, and the tolerances of key species.

The issues set challenges for future environmental water recovery programs, such as the 1500 GL proposal under the National Water Plan, and the development of the Basin plan by the newly established Murray-Darling Basin Authority.

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- Department of Environment and Climate Change
- Forests NSW
- Department of Commerce
- State Water
- Lower Murray Darling and Murray CMAs

Victoria
- Department of Sustainability and Environment
- Goulburn-Murray Water
- Mallee, North Central and Goulburn-Broken CMAs

South Australia
- South Australian Murray-Darling Basin Natural Resources Management Board
- Department of Water, Land and Biodiversity Conservation
- SA Water

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References

CSIRO (2008a). *Groundwater, Surface Water, Salinity and Vegetation Responses to a Proposed Regulator on Chowilla Creek*. SA Murray-Darling Basin Natural Resources Management Board. May 2008.

CSIRO (2008b). *Water availability in the Murray. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project*. CSIRO, Australia. July 2008.

Jones G., Hillman T., Kingsford R., McMahon T., Walker K., Arthington A., Whittington J. and Cartright S. (2002). *Independent Report of the Expert Reference Panel on Environmental Flows and Water Quality Requirements for the River Murray System*. Cooperative Research Centre for Freshwater Ecology. Prepared for the Environmental Flows and Water Quality Objectives for the River Murray Project Board. February 2002.

MDBC (2006). *The Chowilla Floodplain and Lindsay Wallpolla Icon Site Environmental Management Plan 2006-07*. MDBC Publication 33/06. Murray-Darling Basin Commission, Canberra.

MDBC (2007). *The Living Murray Icon Site Condition Report - 2007*. Murray-Darling Basin Commission. October 2007.