Amendment date: 30 August 2017

1.	**Title of measure**	**Yarrawonga to Wakool Constraints management strategy**
2.	**Proponent undertaking the measure**	**NSW**
3.	**Type of measure**	**Supply (Constraint measure submitted as supply)**
4.	**Requirements for notification**	
a)	Date by which the measure entered into or will enter into operation *Must be before 30 June 2024*	The measure will be operational by 30 June 2024.
b)	Confirmation that the measure is not an 'anticipated measure' *'Anticipated measure' is defined in section 7.02 of the Basin Plan to mean 'a measure that is part of the benchmark conditions of development'.*	Yes It is a new measure (not already included in the benchmark conditions).
c)	Confirmation that the proponent state(s) undertaking the measure agree(s) with the notification ***Basin Plan 7.12(3)(c)*** *Joint proposals will need the agreement of all proponents*	Yes
5.	**Surface water SDL resource units affected by the measure**	
	This measure identifies all surface water resource units in the Southern Basin region as affected units for the purposes of notifying supply measures. The identification of affected units does not constitute an agreement between jurisdictions on apportioning the supply contribution, which will be required in coming months.	
6.	**Details of relevant constraint measures**	
	This supply measure is for the Yarrawonga to Wakool Reach constraints management strategy, one of three integrated constraints measures for the Murray River (see separate supply measure notifications for the Hume to Yarawonga and River Murray in South Australia Constraints measure business cases).	
7.	**Date on which the measure will enter into operation**	
	The date by which the measure will enter into operation is 30 June 2024.	
8.	**Details of the measure**	
a)	Description of the works or measures that constitute the measure	The Constraints Management Strategy (CMS) aims to optimise the environmental benefit gained from managed environmental flow events that will reconnect rivers and floodplain environments. There is currently a range of river based constraints which prevent the passage of higher environmental flows through the Murray Darling Basin. Relaxing these constraints to allow flows to reach the lower levels of floodplains would produce environmental benefits. This measure explores the potential for relaxing the current flow constraints to 30,000 ML/day at Yarrawonga, and up to 50,000 ML/day at Yarrawonga under certain circumstances. The proposed approach includes working with landholders, State Government agency personnel and affected stakeholders to observe and trial flows, gradually increasing above the current threshold of 10,600 ML/day in (winter and spring months).

		This will be coupled with the investigation and implementation of practical mitigation strategies that would allow the passage of managed flows, without unacceptable third party risks, up to 50,000 ML/day downstream of Yarrawonga. This measure aims to achieve the environmental objectives of filling wetlands, flushing of organic matter to improve water quality, provide organic matter and other food sources between the floodplain and river channel, and improve lateral and longitudinal connectivity facilitating movement of fish and other fauna. A number of infrastructure and operational activities will need to be undertaken to achieve the relaxation of constraints, including activities to avoid or mitigate third party impacts resulting from inundation of public and private land. Activities may include: a) Negotiating agreements with landholders for easements or other measures to allow inundation of low-lying land; b) Relocating private pumping infrastructure higher up river banks above anticipated flow levels, or improving the infrastructure allowing pumps to be easily moved; c) Increasing the height of low-lying infrastructure, including crossings and roads, above anticipated flows levels; d) Improving and maintaining low-lying roads that will be inundated by anticipated flows to ensure they are in good condition following events; e) Implementing erosion control measures to maintain public and private land after inundation; f) Installing pumps for stormwater systems where stormwater gates may have to close during events; g) Implementing notification systems so the community has the ability to undertake management measures prior to and during higher flows. The location of the focus area of the measure is shown in Figure 1 in and described in Section 3 of **Attachment A**.
b)	Capacity of the measure to operate as a supply measure *'Supply measure' is defined in section 7.03 of the Basin Plan to mean 'a measure that operates to increase the quantity of water available to be taken in a set of surface water SDL resource units compared with the quantity available under the benchmark conditions of development'*.	Yes

c)	Geographical location of the measure	The Yarrawonga to Wakool Reach encompasses the mid-Murray downstream of Yarrawonga Weir to the Wakool junction including the Edward, Wakool and Niemur Rivers (see Figure 1). Other important creek systems contained within this reach include the Tuppal, Bullatale, Native Dog, Gulpa, Colligen, Yallakool and Merran Creeks.The rivers in this reach, along with their associated creeks and floodplain systems make up one of the most significant environmental landscapes within the Basin. See Section 2.2 and Figure 1 in **Attachment A.**
d)	Spatial data describing the inundation extent associated with the operation of the measure	An initial assessment of the inundation extent associated with this measure along the Murray River has been made using the CSIRO River Murray Floodplain Inundation Model (RiMFIM), and has been used to inform an assessment of impacts described in Section 7.1 and Appendix 2 of **Attachment A**. It is intended that inundation extent will be further investigated during the implementation phase, including through flow trials and observation.
e)	Representation of the measure in the MDBA modelling framework	The MDBA will represent the proposed operating strategy and water use in the MSM-BigMod model.
f)	Representation of each operating strategy in the MDBA modelling framework.	See Section 4.5 and Appendix 2 in **Attachment A** as described above.

Attachments:

A	NSW DPI Water, October 2016	Yarrawonga to Wakool Junction Reach Draft Constraints Measure - Concept Proposal Business Case

NSW GOVERNMENT | Department of Primary Industries

CONSTRAINTS MANAGEMENT STRATEGY

Yarrawonga to Wakool Junction Reach Constraints Measure

Concept Proposal Business Case

October 2016

Published by the NSW Department of Primary Industries, Office of Water

Constraints Management Strategy – Yarrawonga to Wakool Reach Draft Concept Proposal

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Acknowledgments DPI Water would like to acknowledge the valuable input provided to this Concept Plan Business Case by the members of the Landholder Reference Group.

Executive summary

The construction of major dams and weirs and regulation of the Murray River and its major tributaries over the past hundred years has supported the development of diverse and prosperous irrigated agricultural industries on which many of the communities in the Yarrawonga to Wakool reach depend. The area generates in excess of $500 million of irrigated agricultural production at the farm gate (Murray Irrigation Limited, 2014), with dryland agriculture and food processing industries generating further economic activity, including local and regional jobs.

However, the growth and prosperity of agriculture and rural communities has had an impact on the environment, with a reduction in the frequency, height and duration of flows linking important floodplain environments with the rivers and creek systems that support them.

The Yarrawonga to Wakool Junction Constraints Management Strategy (CMS) aims to reinstate the passage of a modest pattern of environmental flows and optimise the environmental benefit gained from flow events that will reconnect rivers and floodplain environments.

There is currently a range of river based constraints which prevent the passage of higher environmental flows through the Murray-Darling Basin. Easing these constraints to allow flows to reach the lower levels of floodplains will produce environmental benefits and reduce the volume of water that needs to be recovered from irrigated agriculture. However, higher managed flows will cause access and commercial impacts for adjoining farms, businesses and public infrastructure, which must be mitigated if easing of constraints is to proceed.

It is also acknowledged that the movement of water away from some reaches of the catchment and increased watering of other areas has the potential to create negative environmental outcomes as well as social and economic impacts, and it will be important for governments to consider this change at a landscape level to ensure that the optimum triple bottom line outcomes are achieved.

The NSW Department of Primary Industry – Water is the project proponent for the CMS in the Yarrawonga to Wakool reach. The Department has established a Landholder Reference Group (LRG) to provide guidance and advice on the development of the project.

The NSW Government approach to constraints management is aimed very firmly at achieving not just positive environmental outcomes, but economic and socio-economic benefits for farming businesses and communities as well.

The reach supports nationally and internationally significant ecological systems as well as extensive areas of irrigated and dryland agricultural production, on which the economy of the region depends. There is a range of flow constraints within the reach, with the main operational constraint being an upper regulated flow of 15,000ML/day at Tocumwal during winter and spring and 10,000ML/day during the summer[1] months. The reach also includes a 250ML/day constraint to managed flows leaving the Koondrook-Perricoota Forest.

The CMS aims to produce environmental, social and socio-economic benefits for the Yarrawonga to Wakool Junction Reach, and proposes releasing managed environmental flows at levels that are safe, sensible and have no unacceptable third party impacts.

Based on discussions with the Landholder Reference Group a maximum regulated flow limit of 30,000ML/day downstream of the Yarrawonga Weir will be targeted for investigation as part of this concept proposal to reconnect the lower areas of floodplain with the rivers and creeks that support them. This will correspond to an equivalent flow footprint throughout the reach inclusive of any additional sources of inflow, for example using private irrigation infrastructure to deliver

[1] Note: the 10,600 ML/day is a nominal flow rate. The river operators manage the flows through the Barmah Choke utilising the Picnic Point gauge and flow release rates out of Yarrawonga.

flows. In addition to the Yarrawonga flows and consistent with the requirements of the Koondrook-Perricoota forest watering project, a maximum regulated flow limit of up to 6,000ML/day can be diverted via the forest regulator into the forest. This may create a higher flow footprint in those areas of the reach downstream of the forest, and this will need to be considered in any future program of consultation and potential mitigation.

The impact of flows in the Hume to Yarrawonga reach downstream of Yarrawonga also need to be considered. The LRG has advised the NSW Government that it does not support any increase to the current operating limit of 25,000ML/day in the Hume to Yarrawonga reach without due consideration of the potential elevated flood risk downstream, and proposes that a coordinated approach led by the NSW Government is necessary to ensure that the potential risks and impacts on NSW landholders and floodplain businesses are well understood and adequately managed and mitigated.

The height, timing, frequency and duration of environmental watering events will vary from year to year as a result of seasonal conditions and environmental requirements. The majority of environmental flow events will depend on rainfall events and subsequent unregulated flows from the tributaries to the reach to trigger commencement. Smaller, targeted flow events delivered in drier times may depend largely on water volumes held in storage.

The ability of environmental water managers to clearly articulate future environmental flow scenarios in terms of frequency, duration and timing remains a challenge to community acceptance of constraints management. Adding to this complexity, the Yarrawonga to Wakool Junction Reach environmental flow requirements will need to be considered within the broader Murray and Lower Murray Darling system requirements.

With fully developed Environmental Watering Plans not due to be completed until 2019, it will be important for environmental water managers to identify the upper boundaries of future flow scenarios more quickly to allow constraints management projects like Yarrawonga to Wakool to progress.

Under the Murray Darling Basin Plan, there is an opportunity in mid-2017 to adjust the Sustainable Diversion Limit (SDL) for consumptive use upwards and reduce the amount of water recovery required for the environment, if more efficient environmental water management and use can be implemented.

The NSW Government has made a commitment to achieving triple bottom line outcomes in the implementation of the Basin Plan. A key aspect of this is retaining as much water as possible within commercial agriculture and finding more efficient ways to manage and deliver water to achieve environmental benefits.

Constraints management has the potential to achieve greater environmental outcomes using less water because it facilitates reconnection of lower floodplain environments more often and to a greater degree than under current conditions. In this context constraints management constitutes a “supply” measure under the SDL Adjustment process. Supply measures have the potential to reduce the volume of environmental water required to achieve an equivalent environmental outcome with managed environmental flow releases. If it proceeds, the NSW Government has proposed that the Yarrawonga to Wakool Junction reach project will form part of the SDL Adjustment package supported by state jurisdictions.

A program of community engagement and consultation has been running since 2013 under the MDBA. In early 2016 DPI Water restarted the community engagement process with the aim of developing and implementing constraints management options in a way that gives careful consideration to landholder and community concerns and develops mitigation strategies that meet the needs of floodplain businesses. The formation of the LRG is central to this new approach.

A significant volume of information outlining landholders', Local Councils' and business owners' concerns regarding higher, more frequent environmental flows has been generated. Key issues relate to commercial losses, land access, loss of productivity and increased business risks caused by higher flow events. The NSW Government has committed that no relaxation of flow constraints may proceed unless acceptable mitigation measures are in place.

Studies commissioned by the MDBA have assessed the impacts of relaxing constraints, and increasing the height and duration of managed environmental flows. Though significant limitations in the accuracy of the underlying information has been identified at a local scale and landholders have little confidence in the costing studies as a result, it has enabled potential mitigation measures to be identified and indicative costs of implementation to be calculated at a catchment scale. Most studies of impact and mitigation cost relied on desk top assessments and remote imaging, and there has been limited in-field verification. The NSW Government and LRG have reviewed some of the studies of mitigation costs that relate to farming businesses and included additional cost contingencies in this Concept Proposal to account for some of the uncertainties in the data. Further investigations into the impact and cost of mitigation to agricultural businesses will be undertaken between August and February 2016 to ensure that the accuracy of information is improved.

While a maximum allowable flow of up to 30,000ML/day downstream of Yarrawonga is the flow target for investigation in this concept proposal, as a further contingency for costing purposes, cost estimates for mitigation at a level of 50,000 ML/day at Yarrawonga will be adopted as a starting point for budgeting. This level of cost contingency has been adopted by DPI Water following discussions with the LRG. Depending on the final maximum flow heights for managed environmental flows agreed to by government and community, it is likely that mitigation measures will build in a safety margin above this height to offer further protection to landholders. The level of safety margin required may vary across the reach in line with the identified risks, and will be determined once a clearer picture of impact and risks are identified and understood.

If the Yarrawonga to Wakool Constraints Management Project forms part of the final SDL Adjustment package, detailed project planning and design will continue from mid- 2017. One of the first tasks would be detailed, property by property assessments of the impacts and changes to inundation patterns – safety, timing, height, frequency and duration. Landholders would be involved in every step of this detailed design phase which will inform three things – risk management, impact mitigation and associated costs, and compensation payable to landholders.

Regardless of the form of agreement made with landholders (event-based payments, infrastructure, easements or other form of landholder agreement) standard compensation considerations, that are consistent with just-terms compensation provisions in NSW legislation, would apply. They are:

1. Deprivation of possession of the land's surface;
2. Diminution of the land's value;
3. Restrictions on use that may be made of the land or any improvements on it;
4. Temporary severance of land; and
5. Additional costs, damages and losses arising from inundation.

There is an overriding commitment to working with riparian landholders and local communities in the selection and adoption of mitigation measures, and the development of policies and protocols to guide implementation. A mitigation and compensation package that contains a range of options and flexibility to suit the needs of individual businesses, is equitable, fair and provides value for money for both governments and stakeholders will be developed based on

property by property assessments. Some mitigation strategies may also deliver some benefits to landholders and local communities.

The most significant risks to achieving the commercial, environmental and socio-economic objectives of the Yarrawonga to Wakool Constraints Management Project relate to inadequate mitigation of, and compensation for, commercial impacts of inundation and interrupted land access. The design and development of fair and commercial mitigation and compensation strategies will go much of the way to achieving a low residual project risk, and build confidence in the process and approach adopted by the NSW Government, with affected landholders and communities.

The implementation of works and infrastructure on private and public lands, and the finalisation of legal agreements with landholders and riparian business owners regarding easements or alternative offset arrangements will only commence once all outstanding policies and protocols are in place and agreed to, and detailed design and costings have been established. This means that costs must account for price increases and acceleration over the period of project implementation.

It is expected that project planning and design will continue up to early 2017 with further investigation into mitigation and cost of compensation and infrastructure on farms and in local communities. This may involve case studies or sub-reach investigations and consultation to gain a more accurate idea of mitigation strategies and cost estimates. A detailed design and planning phase will progress between 2017 and 2018, and it is only at this stage of project development that the full range of mitigation measures and costs will be known. If there is a decision by government to fund the project and agreement by landholders and community to proceed, implementation of legal agreements and a program of works and measures would follow between 2019 and 2024.

If an acceptable range of constraint relaxation is agreed to, the approach to delivering higher flows will be incremental, with flow heights and durations gradually increased as the opportunities for managed environmental flows arise. The impacts and effectiveness of mitigation strategies will be carefully monitored before higher flows would be permissible.

At the March 2016 meeting of the MDB Ministerial Council, Ministers again emphasised the importance of Basin states working together to integrate their proposals for measures to ease river flow constraints, and ensure that community consultation is effective in identifying and developing options that mitigate any third party impacts. This Concept Proposal is consistent with this Ministerial position.

Communique from the Yarrawonga to Wakool Landholder Reference Group

The Landholder Reference Group (LRG) was established by the NSW Government in January 2016 to provide guidance and advice to the development of a Constraints Management Project for the Yarrawonga to Wakool Junction Reach. The NSW Government approach was instigated as a response to the landholder and community concerns expressed over the MDBA approach to consultation and reporting of community views relating to constraints management.

This Draft Concept Proposal, which proposes investigation into a level of constraint relaxation up to a maximum regulated flow limit of 30,000ML/day downstream of Yarrawonga, represents a work in progress. In particular, the lack of reliable and accurate information to support the extent of impact on riparian farms and businesses is a major deficiency impeding project development and progress. As is the inability of governments to articulate the scope and scale of future environmental watering regimes, including duration, frequency and seasonality of future flows.

This has meant that informed consultation with affected landholders, local Councils and riparian businesses has not been possible to date at a level that the LRG can fully support and endorse. Similarly, the identification of appropriate mitigation strategies and the costs associated with production losses, damage and loss, additional business costs, elevated flooding risks and the design and cost of appropriate farm and public infrastructure has meant that the costs and budgets contained in the concept proposal remain preliminary estimates at best and the LRG has limited confidence in their adequacy.

The LRG has undertaken to work with the NSW Government to continue to improve the information base on which the project is based, and ensure that any future program of constraints management is safe and practical to implement. The LRG will also work to ensure that all affected landholders and communities are well informed of the impacts and risks of constraints management and supported to develop and implement suitable mitigation strategies that are fully funded by government.

The LRG proposes that the management of constraints in the reaches above Yarrawonga should be led and coordinated by the NSW Government to ensure that the potential for elevated flood risks are well understood and mitigated. Consistent with this the LRG does not support any increase to the current operating limit of 25,000ML/day in the Hume to Yarrawonga reach without due consideration of the impacts of elevated flooding below Yarrawonga. Similarly, the LRG proposes that the impacts of Goulburn flows through the Koodrook-Perricoota Forest on riparian landholdings in that part of the Yarrawonga to Wakool reach need to be better understood before a change to the current operating rules below the forest are agreed to.

The Draft Concept Proposal has been guided in its development by the principles adopted by the LRG over the past six months. It is expected that these principles will be honoured in full by governments as the Yarrawonga to Wakool Junction project is further developed and implemented.

Landholder Reference Group Principles:

1. Project and business case development should reflect a partnership between government and community.
2. Consultation and engagement should be participatory with appropriate notification and timeframes, a two way conversation, transparency and monitoring of effectiveness along the way.
3. Processes must focus on rebuilding trust and confidence.

4. Environmental flows must be safe, realistic and practical.
5. The project must be evidence based (based on fact and data).
6. The work previously done by Group members and the community should be recognised as provide a starting point for discussion.
7. Environmental flows should not result in unacceptable third party impacts.
8. The project should focus on local and regional benefits as a priority.
9. Projects should aim to deliver social and economic benefits as well as environmental benefits (triple bottom line).
10. Environmental flows should be implemented incrementally once mitigation measures are in place.
11. The potential for negative environmental outcomes must be acknowledged, monitored and reported.
12. Monitoring, reporting and evaluation of projects should involve community and landholders.
13. Constraints management, SDL Adjustment and Prerequisite Policy Measure project decisions should not undermine existing property rights, including reliability of water supply to irrigation users.
14. Risks and mitigation measures should be identified by those impacted.
15. Past effort and improvements in environmental health need to be acknowledged.
16. Governments should weigh up the cost of constraints management against other opportunities to gain positive outcomes.
17. The Chair will communicate the views endorsed by the LRG.
18. The importance of ongoing and long term local involvement and ownership, capacity for locally driven solutions and localism in the implementation of Constraints Management (eg. Landcare, Land and Water Management Plans) must be acknowledged and realised.
19. The cost of mitigation of constraints management must be covered in full by government.
20. Environmental solutions need not be flow related.
21. A suite of mitigation options that best suits their farming businesses should be available for landholders to choose from.
22. Governments should display a willingness to be open and transparent in the sharing of available information.
23. If a natural flow event occurs on top of a regulated environmental flow event, the combined flow should be deemed a managed event.

Chairman

26 July 2016

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1 Introduction

Murray-Darling Basin communities and governments have made substantial efforts and achieved significant gains in the restoration and maintenance of the health of river systems over the past thirty years. While it is recognised that we will never return the rivers to their original state, much of the prosperity and growth of industries, towns and agriculture in this region and throughout Victoria and South Australia, can be attributed to the development of dams and water management infrastructure over the past 100 years. Irrigation infrastructure has also contributed to ecological diversity in areas on and off the floodplain.

Through restoring a part of the natural flow pattern and reconnecting lower lying areas of the floodplain more often with the rivers and creeks that support them, we can take steps toward ensuring that the diversity and resilience of our natural systems are maintained and enhanced in the long term. It has been recognised that in order for flows and floodplain connectivity to be restored to some degree, system constraints need to be considered and addressed.

Under the Constraints Management Strategy (CMS) seven key geographic areas (riverd reaches) have been targeted for further investigation, including the:

- Hume to Yarrawonga Reach of the Murray River
- Yarrawonga to Wakool Junction Reach of the Murray River
- South Australian Murray River Reach
- Goulburn River
- Gwydir River
- Murrumbidgee River
- Lower Darling River Reach

Harmonising environmental benefits derived from easing constraints across all of these reaches is an important goal for Basin Governments as is ensuring that any adverse commercial and social impacts on riparian landholders and their associated communities are effectively and adequately mitigated and compensated.

Importantly, easing river constraints will achieve environmental benefits by using the available environmental water more effectively, which means that more water can be retained for irrigated agriculture and commercial use. The NSW Government is committed to achieving triple bottom line outcomes from the Basin Plan, balancing commercial, environmental and socio-economic outcomes.

Many of the local environmental benefits derived from easing constraints are partly realised on, or in conjunction with, private land. Inevitably, there will also be disruption and inconvenience, with associated commercial costs, to some farm businesses through more frequent flooding of the lower reaches of their floodplains, cutting off access to areas of their farms for extended periods, and the potential for elevated flood risks associated with natural rainfall events occurring on an already wet floodplain. An important aspect of constraints management relates to the provision of an adequate package of mitigation and commercial compensation measures aimed at offsetting impacts to businesses and public infrastructure located along the reach.

2 Background

2.1 The process of constraints management

Since the early days of the Basin Plan there has been a strong community view that governments should look at more effective and efficient use of environmental water, including revising river management practices, and not just rely on a solution based on a total volume of water savings, as the only means of achieving environmental outcomes.

Following significant community concern regarding physical and operational constraints within the Murray-Darling system, investigation into the factors constraining the passage of environmental flows was identified as a key aspect for Basin Plan implementation. Early results using hydrological modelling showed that for modest increases in peak flow heights, significant environmental benefits could be achieved for the lower lying areas of the floodplain environment.

These are areas of the floodplain that are already inundated during naturally occurring overbank flow events under current conditions. The aim of the CMS is to increase the frequency and duration of inundation, which will have significant benefits to wetlands and forest ecosystems. As these low lying areas are naturally flood prone they generally don't support significant town or farm infrastructure.

However, it is recognised that more frequent inundation of these low lying areas can cause commercial losses through blocked access and lost production. As such it will be important to identify in detail these impacts and put in place infrastructure, mitigation and compensation measures that offset impacts under defined environmental flow conditions. A program of works to address access issues relating to managed environmental watering events should also deliver some benefits to farming businesses during times of natural inundation.

It is also recognised that easing constraints will not result in more frequent watering of wetlands and vegetation communities higher up in the floodplain - above the acceptable height of managed environmental flow events. As such it will be important for governments to consider complementary measures such as the use of alternative water delivery infrastructure and farm based and landholder led environmental watering initiatives, to deliver a more comprehensive and effective environmental solution.

With the science and information around managed environmental watering continuing to develop, it will also be important for governments to exercise a cautious and adaptive approach to ensure that management of environmental water portfolios result in positive environmental gains and not unintended negative impacts.

When the Basin CMS overview was completed by the Murray Darling Basin Authority in 2013, it identified the key areas in the Basin where constraints management could best be used to create environmental watering efficiencies. The Yarrawonga to Wakool Junction reach is one of these key areas. A process of investigation and consultation for the period from 2013 to 2024 was outlined. Impacts on riparian landholdings and public infrastructure were identified, along with possible mitigation strategies.

A Draft Yarrawonga to Wakool Junction Reach Report and an annual report on the progress of investigations and consultation were published by the MDBA in December 2014. A final Reach Report was published in July 2015.

The final draft report and annual report proposed that investigation of flows in the range between 50,000ML/day and 65,000ML/day at Tocumwal should continue. It also concluded that community feedback and concern over flows above 77,000ML/day[2] meant that flows at this height could not be achieved. As a result, Basin Governments made a decision to reduce the upper limit for further investigations into constraints management to 65,000ML/day at Tocumwal.

[2] This is the identified minor flood height in the Yarrwonga to Wakool Junction reach of the central Murray.

Further investigation of this upper limit of flows for Basin Governments was met with a clear and vocal response from the Edward Wakool Constraints Advisory Group, who considered that the their objection to flows above 40,000ML/day at Tocumwal had been misrepresented to Governments by the MDBA, voicing their loss of confidence in the future of the process to provide a fair and balanced outcome.

In recognition of the need to improve community involvement and engagement, the NSW Government intervened and took control of project management of the Yarrawonga to Wakool community engagement and concept development process in late 2015, with a view to restarting it to deliver more effective and responsive community consultation and engagement. An important step in this process was the formation of a Landholder Reference Group (LRG).

As a result of discussions with the LRG, this concept proposal is based on investigation of an environmental flow footprint equivalent to a maximum regulated flow limit up to 30,000ML/day below Yarrawonga (total flows). This is a level that affected landholders believe could be effectively mitigated. The intention of this new approach to consultation is to build functional long-term relationships with affected riparian landholders, involving them in the development of the CMS proposal and, significantly, in the development of the mitigation measures required to ensure there are no unacceptable impacts from the proposal.

Whilst all Basin Governments are looking at developing business cases for constraints management and other SDL Adjustment projects, there is a strong recognition by the NSW Government that this project proposal for the Yarrawonga to Wakool reach will mark the commencement of a decade-long process of consultation, detailed project planning and implementation. At this point, the project remains at a concept stage.

2.2 The Yarrawonga to Wakool Reach

The Yarrawonga to Wakool Reach encompasses the mid-Murray downstream of Yarrawonga Weir to the Wakool junction including the Edward, Wakool and Niemur Rivers (see Figure 1). Other important creek systems contained within this reach include the Tuppal, Bullatale, Native Dog, Gulpa, Colligen, Yallakool Gunbower and Merran Creeks. The rivers in this reach, along with their associated creeks and floodplain systems make up one of the most significant environmental landscapes within the Basin.

Key water delivery infrastructure and regulated flow offtakes within the reach include Yarrawonga, Torrumbarry and Stevens Weirs, Gulpa Creek, Edward and Wakool Rivers and the Koondrook-Perricoota inlet and Hipwell Road cutting (Gunbower).

The Yarrawonga to Wakool reach consists of a broad, flat floodplain, interconnected through a network of anabranching flood runners and creeks. The hydrology of the system is complex and higher flow and flood events are highly variable. It is often stated by river operators and riparian landholders that “no two floods are the same”, although there are known patterns of flood risk. The variability is related to the number of large tributaries that can provide inflows to the reach including the upper Murray and Billabong Creek in NSW, the Kiewa, Ovens, Goulburn, Campaspe, Loddon and Avoca Rivers in Victoria and the complex interactions between the connected creeks, flood runners and vast floodplains within the Edward-Wakool River system. The duration of flow events generally increases to the west due to the interaction of tributary inflows and the nature and shape of the floodplain.

This reach supports several important wetland systems including the Ramsar listed Barmah-Millewa Forest and the Gunbower-Perricoota-Koondrook Forest, as well as the Werai group of forests and Thule Lakes. The reach environment provides important breeding habitats for native birds, fish and frog populations, as well as linkages for migratory and nomadic birds and small mammals moving through the landscape. The Edward-Wakool system also plays a crucial role in providing drought refuge for native fish, frogs and birds and helping post drought recovery of native species.

Land use is dominated by agriculture, with more than 1,700,000 ha dedicated to dryland farming and grazing enterprises and more than 300,000ha of irrigated agriculture. Murray Irrigation Limited, one of the largest privately owned irrigation corporations, is located in the area, along with smaller irrigation schemes

including Moira, Merran Creek, Cadell, Bama and Bringan Trust, Irrigated agriculture makes a significant contribution to the regional economy.

There are four NSW Local Government areas within the reach including Federation, Berrigan, Murray River and Edward River Councils in NSW and four in Victoria, including Moira, Campaspe, Gannawarra and Swan Hill.

2.3 Current constraints

Current operating arrangements (as at October 2015) establish maximum rates for regulated flows downstream of Yarrawonga. At any time when flooding of the Barmah-Millewa Forest is considered undesirable (generally through the summer months) the maximum regulated release from Yarrawonga Weir is limited to 10,600ML/day (the channel capacity of the Murray River above Picnic Point) to prevent water entering the forest. This flow rate is indicative. River managers consider the dynamic nature of the river channel and how it changes over time and during the irrigation season manage for the least losses possible. The releases at Yarrawonga are calibrated so the Picnic Point gauge is kept at a height that indicates flows should not be entering the Barmah Millewa forests. At times when inundation of the forest is desirable (generally winter/spring), controlled releases from Yarrawonga Weir may be increased to a level agreed to by Basin Governments. Flows above 18,000ML/day at Tocumwal are known to affect riparian landholders interrupting property access and overtopping low-level crossings.

The Basin Officials Committee (BOC) has currently agreed to a temporary operational target flow range downstream of Yarrawonga of 15,000ML/day (which can be increased to 18,000ML/day under certain conditions, including adequate notice and consultation with all affected landholders).

There are also operational and natural constraints in place for areas such as the Wakool River, Yallakool Creek, Colligen Creek, Niemur River, Edward River below the Murray River offtake regulator and Stevens Weir, the Koondrook Perricoota flood enhancement scheme outlets into Barbers and Thule Creeks into the Wakool River, the Bullatale Creek, Gulpa Creek and Gunbower Creek/National Channel. These are generally set to maintain the efficient flow of water and to avoid impacts to landholders and environments like the Werai Forest.

This Concept Proposal also includes the downstream constraints that exist below the Perricoota-Koondrook Forest. The Forest is the subject of a stand-alone SDL Adjustment project. However, the limited flows currently permitted downstream of the forest under the current licenced operating conditions, mean that the benefit of the Perricoota-Koondrook environmental works completed as part of The Living Murray (TLM) Initiative, cannot be fully realised until mitigation of the downstream impacts of increasing flows is adequately addressed. A more detailed outline of the constraints relating to the Perricoota-Koondrook Forest is provided in Appendix 1 (page 33).

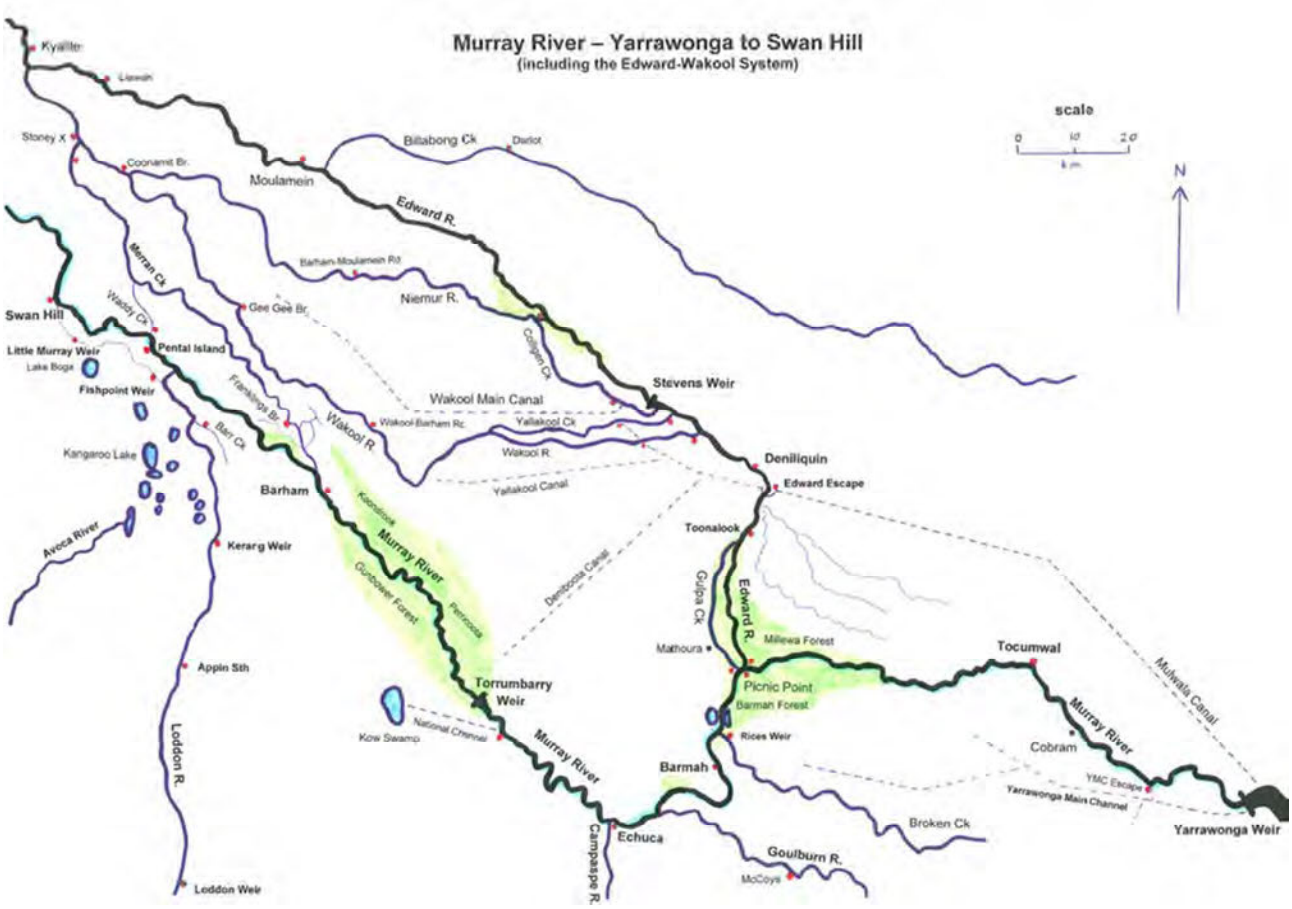


Figure 1 Rivers and creeks in the Yarrawonga to Wakool Junction Reach

3 Description of the measure

3.1 Objectives

The objectives of relaxing operating constraints within the Yarrawonga to Wakool Junction Reach include:

- achieving commercial, environmental and socio-economic benefits;
- ensuring that unacceptable third party impacts are identified and effectively mitigated;
- ensuring that managed environmental flows are safe, practical and achieve the greatest environmental benefit with the least possible water; and
- achieving better local and regional environmental outcomes through the provision of higher managed environmental flows.

3.2 Flow heights, duration, frequency, seasonality

This project concept proposal explores the potential for relaxing the current flow constraints up to an equivalent maximum regulated flow limit of 30,000ML/day below Yarrawonga.

An outline of how a 30,000ML/day at Tocumwal translates through key points in the Yarrawonga to Wakool reach, along with the associated gauged flow heights and estimated travel times is in provided in Table 1 (note – this is a modelled scenario and actual flows and heights will vary depending on antecedent floodplain conditions.).

Table 1 Relative Flows and Gauged Heights Equivalent to a 30,000ML/day flow at Tocumwal

Location	Gauge	Flow peaks at each gauging station relative to a flow of 30,000Ml/day at Tocumwal (409202) (ML/day) *	Flow peaks at each gauging station relative to a flow of 30,000Ml/day at Tocumwal (409202) (m)	Travel Times (from Tocumwal) (Days)
River Murray	Yarrawonga D/S (409025)	31,000	3.9 m	**n/a**
River Murray	Tocumwal (409202)	30,000	4.4 m	**0**
River Murray	Barmah (409215B)	17,000	4.5 m	**2**
River Murray	Torrumbarry D/S (409207)	33,333	7.0 m	**3**
River Murray	Barham (409005)	24,000	5.7 m	**5**
River Murray	Swan Hill (400204)	22,667	3.7 m	**7**
River Murray	Wakool Junction (414200)	30,000	6.8 m	**8**
Edward River	Deniliquin (409003)	11,833	a (n/a)	**5**

Edward River	Stevens Weir (409023)	8,333	4.6 m	**6**
Edward River	Liewah (409035)	6,333	4.8 m	**17**
Niemur River	Barham-Moulamein Rd (409048)	5,667	5.0 m	**16**
Wakool River	Deni-Wakool Rd (409072)	1,667	3.4 m	**11**
Wakool River	Stoney Crossing (409013)	13,667	5.2 m	**26**
River Murray +Goulburn River	McCoy's (405232) + Barmah (409215)	36,700	n/a	**n/a**
River Murray +Goulburn River+ Campaspe River	McCoy's (405232) + Barmah (409215) +Rochester (406202)	44,360	n/a	**n/a**

Notes:

- These flow rates were used to match corresponding inundation or flood footprints by CSIRO in the development of RiM-FIM modelling for this reach.
- Travel times sourced from Water NSW's CAIRO operating system, but may vary depending on flow rates.
- If the target flow rate is set at Yarrawonga D/S, rather than at Tocumwal as per the MDBA analysis, the peak flow rates at downstream sites will likely reduce by a small amount from those shown in Table 2.
- Any future operational delivery of the flows in Table 2 will be subject to operational variance.

When developing watering events, environmental water managers consider the volume of available environmental water and respond to prevailing conditions which dictate environmental watering requirements. The Yarrawonga to Wakool Junction reach may not be the sole driver for Murray environmental watering in all years; priorities may vary in line with downstream floodplain or river channel requirements that may be the target for managed environmental flow events.

Events are likely to occur in the period between July and the end of November, with a preference for early season events if suitable unregulated flow triggers occur on which to supplement events using environmental water.

A hydrograph representing a model environmental flow event at Yarrawonga is provided in Figure 2. This hydrograph is based on the actual flows in 2004; this event followed three low to moderate flow years. There were moderate, late winter and early spring flushes which reached over 30,000ML/day for approximately one week during September 2003. The managed flow release modelled in Figure 2, shows what can be done at release levels of 30,000 ML/day and below. The modelled releases address the need to provide a flush of some duration on the back of three relatively low flow years.

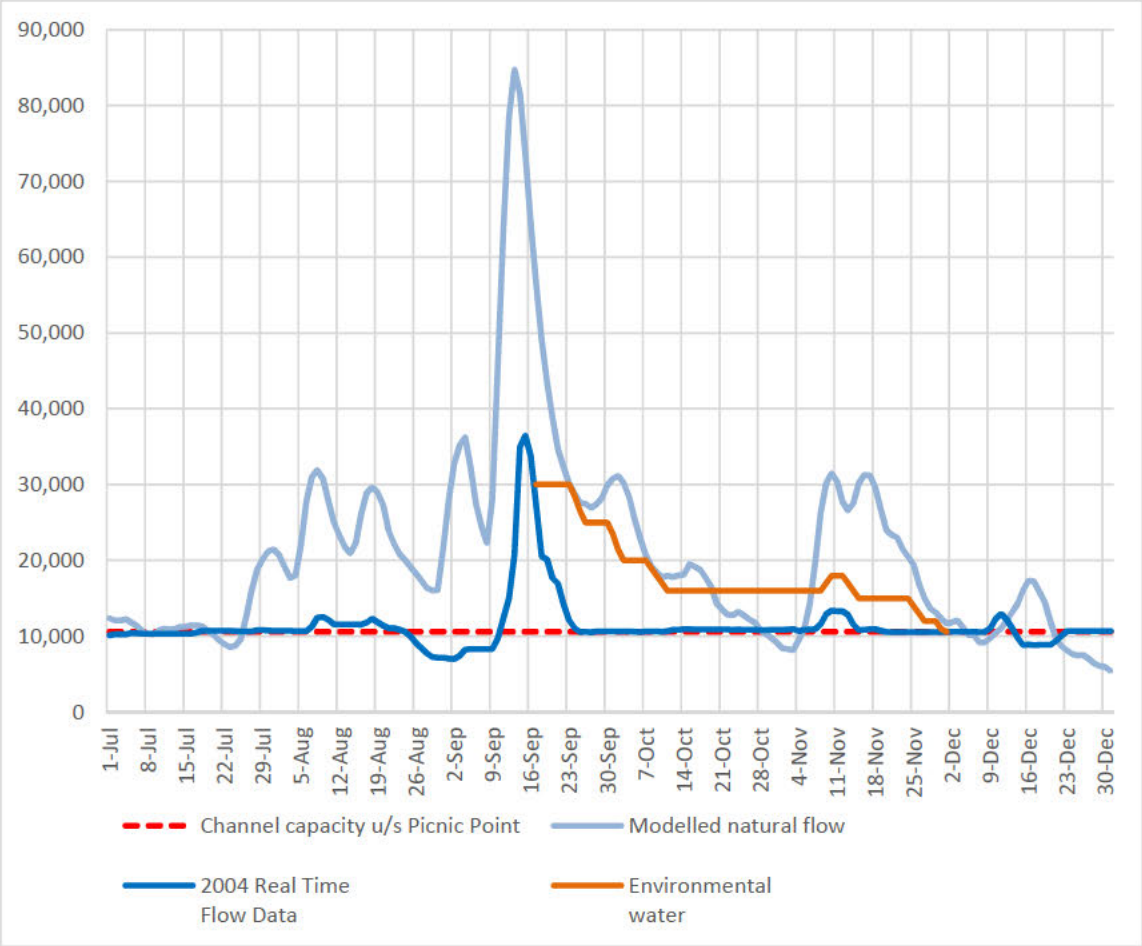
The project also proposes investigating the relaxation of flow constraints through the Perricoota-Koondrook Forest up to a flow target of 6,000ML/day. This flow target is described separately to a managed flow event at Yarrawonga, as the outflows from the forest are likely to be generated through a managed flow event in the Goulburn River system. These flows will need to be coordinated with managed flow events past Yarrawonga, and the impact on the reach below the forest needs to be more fully understood prior to governments or community agreeing to easing of flow constraints below the forest.

Similarly, ecological objectives and desired flow targets must be identified for the Gulpa Creek and Edward-Wakool system (specifically for the Edward River, Wakool River, Yallakool Creek, Colligen Creek and the Niemur River).

The approach to relaxing flow constraints proposed includes working with landholders, State Government agency personnel and other affected stakeholders to observe and trial flows, gradually increasing above the current threshold of 15,000ML/day below Yarrawonga during the winter and spring months. This will be coupled with the investigation and implementation of practical mitigation strategies that would allow the passage of managed flows, without unacceptable third party risks, up to a maximum regulated flow limit of 30,000ML/day downstream of Yarrawonga.

A more detailed description of the hydrology of proposed future managed flow events is provided in Appendix 1 (page 33).

Figure 2 Hydrograph showing a model managed environmental flow event downstream of Yarrawonga compared to the actual and modelled natural flows in 2004 (the orange line shows how regulated flows could be used to extend the height and duration of a natural flow peak)



Reader Note – Flow rates

The target flow rates in this Concept Proposal refer to flow rates downstream of Yarrawonga Weir, and do not refer to flows at Tocumwal. Flow rates at the two sites are similar under wet conditions, but not identical—in general, a given flow rate downstream of Yarrawonga Weir equates to a slightly lower flow rate at Tocumwal. The flow rates between Yarrawonga and Tocumwal can vary significantly if the antecedent floodplain conditions are dry.

Inundation impacts and cost estimates in the Yarrawonga-Wakool area drew on information which was generated with reference to both the Tocumwal and downstream of Yarrawonga Weir gauges. Inundation maps (i.e. the areas modelled as inundated at specified flow rates, which informed the assessment of effects and/or impacts of higher flows) were generated with reference to the Tocumwal gauge, while hydrological data (i.e. frequency, timing and duration of flows) were generated with reference to downstream of Yarrawonga Weir. This means that inundation mapping will correspond to a slightly higher flow than that actually targeted operationally, and this means impacts and cost estimates will be (slightly) more conservative.

For practical purposes the over-estimate for inundation mapping is not likely to materially affect the information described in this report

3.3 Environmental Benefits Associated with Higher Managed Environmental Flows

Relaxing flow constraints to allow for higher and more frequent managed environmental flow events will enhance the reconnection of the lower floodplain with the rivers and creeks that sustain them. The expected environmental outcomes resulting from relaxing flow constraints to allow targeted environmental flows up to a maximum regulated flow limit of 30,000ML/day below Yarrawonga include:

- Enhanced growth and reproduction of vegetation communities;
- Increased diversity of plant and animal species;
- Increased support for bird and native fish breeding;
- More effective transfer of carbon and nutrients from the floodplain to river systems to energise food webs;
- More frequent flushing out sediments, salts and alkaline water from the deeper holes in the river system.

The floodplain ecosystems that exist within the Yarrawonga to Wakool reach consist of three of the largest red gum and box wetlands in southern Australia, including the Barmah-Millewa Forest, the Gunbower-Koondrook-Perricoota Forest and the Werai Forest. These forest areas contain a diverse range of wetlands types including red gum, black box, open grasslands, swamps, marshlands, reed beds and lakes and billabongs. Maintaining this diversity of ecosystems types is an important objective for environmental managers.

In addition to these well recognised forest areas, the reach supports over 3,000 permanent and ephemeral wetland and creek systems, many of which exist on private land.

The height, timing, frequency and duration of managed environmental water events will vary and depend on natural cues, such as unregulated flows from the tributaries to the reach to trigger commencement.

A detailed description of environmental benefits derived from managed environmental flow events made possible by relaxing constraints is provided in Appendix 2 (page 41).

3.4 Potential Adverse Environmental Impacts

Relaxing flow constraints provides water managers with greater flexibility to achieve environmental benefits. It is well recognised by environmental water managers that there are risks associated with managed environmental flow events that may result in adverse environmental outcomes, including hypoxic (blackwater) events, the spread of pest plants and animals including carp and increased bank erosion.

The risk of adverse impacts can be reduced by appropriate planning, conducting flows in the earlier winter spring period to avoid periods of higher temperatures, and ensuring a gradual recession of flows to reduce erosion. It will also be important to ensure flushing flows are available at critical points through the system to mitigate salinity and the potential for hypoxia. Although this strategy principally focusses on higher

flows, summer and autumn low flow scenarios are a priority for the reach to minimise the risk of adverse environmental outcomes including the deterioration of refuge areas and water dependent animals.

In relation to the spread and potential for carp breeding events, the primary aim of managed environmental events is to strengthen the resilience and recruitment of native plants and animal populations to offset the impacts of Carp.

As managed environmental water event planning and delivery is constantly developing, particularly at the scale being investigated in this proposal, it is important for governments to exercise a cautious and adaptive approach, learning from both positive and negative outcomes from each event, and engaging landholders and community in monitoring and evaluation of impacts and outcomes.

It is acknowledged that the Basin Plan will result in the movement of water away from some areas of the catchment and the increase in frequency and duration of watering for others. It will be important to track the impact at a landscape scale to ensure that benefits are felt across the catchment and not just in the lower floodplain reaches and ecological communities. This proposal includes the funding and development of a program of monitoring to establish a reach-scale baseline which can be tracked and evaluated over time, to help guide the improvement of future environmental watering events as well as the development of complementary, non-flow measures.

3.5 Accountability and Evaluation of Environmental Outcomes

Landholders and communities want assurances that constraints management and higher and more frequent managed environmental flows will deliver the outcomes promised by governments. It will be important to identify clear lines of responsibility and accountability for the delivery and management of environmental flow events, as well as monitor and evaluate the benefits and any negative impacts that arise as a result of managed environmental flows.

A budget of $10Million has been included in this concept plan to establish a condition baseline of the Yarrawonga to Wakool reach, against which future environmental flow regimes can be evaluated. This will include sites across the floodplain environment and in adjacent ecological communities so that the impact of the change in watering regimes can be effectively monitored and analysed. It will also engage landholders along the reach in its implementation. A more detailed design of a monitoring and evaluation program will be completed in the next stages of project development.

4 Impacts, Mitigation and Cost

4.1 Third party impacts

Investigation and study of the nature and extent of impacts resulting from relaxing flow constraints and increasing the height, frequency and duration of managed environmental flows has been undertaken by the MDBA. A number of studies that document the extent, potential mitigation and associated costs have been completed and are listed in Table 2. This work has involved mostly desk top assessment with some limited in-field verification.

It should be noted that the studies that relate to the scale of impact and the cost of mitigation on private agricultural land are not accepted by the members of the Landholder Reference Group as sufficiently accurate to allow informed decision making at either a regional or local scale. DPI Water has undertaken to conduct a new study of the cost of mitigation once a more accurate estimate of impact of higher managed flows is available. For the purpose of this concept plan, and in the absence of any other available information, the MDBA commissioned studies have been adopted as a starting point for regional based costing, with additional budget items and contingencies included. These costs will need to be tested over the coming 6 to 9 months with more detailed investigation at a sub-reach and across a representative sample of individual properties. The Landholder Reference Group has been invited to participate in the design of this process.

DPI Water undertook a peer review, using local experts in land valuation and agricultural economics in May 2016 in association with GHD and their study of mitigation and costs relating to agricultural land. Overall the review established that the GHD methodology was broadly appropriate for establishing an upper end estimate of cost, although there were concerns over the accuracy of the hydrology under a new environmental flow regime.

A workshop with a small group of the LRG members was also held with GHD in June 2016. This highlighted some specific areas of concern relating to some of the assumptions made and potential under-costing and did little to build confidence in the original costing methodology used.

An overview of the method used in the costing studies commissioned by the MDBA is provided in Appendix 3 (page 57).

Table 2 Completed Impact, Mitigation and Costing Studies Relevant to the Yarrawonga to Wakool Reach

Subject	Author	Date of Report	Reference
Private Agricultural Land	GHD	Final Report – Yarrawonga to Wakool Reach	GHD (2016)
Public Infrastructure	AECOM	11 May 2016	AECOM (2016 a), AECOM (2016 b)
Levees	AECOM	6 April 2016	AECOM (2016 c)
Specialist Activities	Jacobs	17 May 2016	Jacobs (2016)
Design, Approvals and Works Supervision	Jacobs	16 October 2015	Jacobs (2015)

The basis for much of the assessment of impact in the Yarrawonga to Wakool reach to date is a series of inundation or flow footprint maps, produced for the entire reach by the MDBA at flows of 20,000, 35,000 and 50,000ML/day at the Tocumwal gauge. It is acknowledged that there are many factors which can influence the relationship between flow height and the area inundated, including how wet the catchment is (the antecedent conditions) and physical changes in the river and floodplain. Where possible the

inundation maps have been based on data generated after a wet event, to try and represent the largest extent of flooding possible.

The flow footprint maps were reviewed by the Edward Wakool Constraints Advisory Group in a series of 12 meetings along the reach in early 2014 (MDBA 2015). These meetings established that while there were some areas of agreement, landholders generally felt that the maps were too inaccurate to support decision making at either a regional or local scale. The continued use of these maps to support the subsequent costing studies remains an ongoing point of contention.

At best the inundation maps provided by the MDBA to date only provide an indicative overview of the geographic extent of total impact across the reach at a regional scale. They are not considered accurate at a local or farm scale. It will be important to investigate better mapping processes, particularly through the observation of natural flow events to support the detailed design and costing phase of the project.

Observation and monitoring of natural flow events supported by a more expansive and intensive network of flow gauges will be an important area of ongoing investment and research to better understand the behaviour of flows at all levels in this reach.

The MDBA used the flow footprint maps as a basis for a desktop assessment of how flows would affect agricultural land, townships and public infrastructure, large-scale irrigation infrastructure, native vegetation and wetlands across the reach. Notwithstanding the concerns expressed in the accuracy of the inundation maps, the addition of local knowledge and experience provided by landholders, local government and state government agency staff resulted in the identification of the following main potential third party impacts related to relaxing flow constraints in the Yarrawonga to Wakool reach:

- temporary land severance during periods of inundation
- loss and damages to agricultural land (crops, tolerant pastures, vulnerable pastures, horticulture) through inundation as well as an increase in grazing pressure from native animals seeking refuge from inundated public reserves over extended periods.
- costs, damages and losses to farm infrastructure (tanks, troughs, pumps, fences)
- farm management costs (weed control, animal health, clean up and farm planning)
- costs and damage to public infrastructure (roads, tracks, culverts, bridges, levees landscaping)
- costs and damage to specialist activities (forestry, caravan parks, quarry, abattoir, club/sports court, access to residential/ rural residential land).

A summary of the scale and extent of impact created by easing flow constraints at 35,000, 40,000 and 50,000 ML/day is provided in Appendix 4 (page 60). (Note - This work has been produced by the MDBA and there is considerable landholder concern over the accuracy of the mapping and the assumptions on which it is based. It will be important to generate a more accurate picture of the extent and scale of impact through monitoring natural flow events that move through the reach.)

4.2 Positive commercial, environmental and socio-economic outcomes

Improving the connectivity of floodplain ecosystems with the rivers that support them will deliver some commercial and socio-economic benefits for the region, although it is acknowledged that the shift of water away from irrigation production to environmental end use through government buy-backs in particular, has had negative socio-economic consequences in many of the communities in this Yarrawonga to Wakool reach.

Upgraded farm infrastructure will improve access to all areas of properties during naturally occurring high flows, adding value to the farm asset. Private irrigation operators will have opportunities to generate additional income by delivering environmental water.

Other benefits include:

- potential for some grazing benefit as a result of short duration inundation events, honey and forestry production benefits in floodplain forests

- strengthening native fish populations, leading to increased local and regional economic activity from recreational fishing, and
- further reduction in river salinity levels and other improvements in water quality parameters.

These commercial, environmental and socio-economic outcomes have not been included in the final costs of mitigation contained in this proposal.

More detail on these additional economic and socio-economic benefits is provided in Appendix 5 (page 66).

4.3 Mitigation

The community accepts that if funding is sufficient, effective mitigation measures can be put in place for increased in-channel flows and inundation of the lower reaches of the floodplain. Their main concern remains that unintended, adverse consequences, in particular the increased risk of flooding events occurring on top of managed environmental flows, may not be adequately mitigated. Further study into increased flooding risk will need to be undertaken to better understand this important element of potential impact.

Mitigation options that have been discussed with community representatives include:

Infrastructure to protect assets and establish/maintain access:

- Replacing low-lying crossings on private land with permanent structures that enable access during both regulated and unregulated flows. Those structures would be built to allow access during higher flows levels than those planned for the CMS. These crossings would need to allow passage of farm machinery, consider fish passage and meet floodway planning requirements.
- Works to fix existing minor flooding issues and offset increased frequency and duration of inundation on private and public land, including road upgrades, bridge improvements and upgrading, relocating existing or building new flood control structures, including levees.

Financial compensation for costs and damages:

- Negotiated agreements (easements, compensation payments, event based payments, other) with riparian landholders and private businesses (e.g. caravan parks) that will compensate for environmental flows inundating privately owned parts of the floodplain).
- Arrangements with private and public infrastructure owners (e.g. Councils) to fund the upgrade works required to create, reinstate, maintain access under a higher flow regime.
- The consideration of an environmental insurance or other perpetual fund that could be drawn on when managed flows create impacts outside an agreed magnitude.

Information and notification systems:

- Information systems that give communities advance notice of environmental flows so that preventative steps can be taken well before water arrives.
- Observation of naturally occurring flow events and gradually increasing planned flows to test for effects on communities before permanent changes to rules around constraints are agreed to.
- Operational strategies and improved hydrological information to manage the risk of flows being higher than intended.

Additional impacts and mitigation strategies will need to be investigated in detail during the detailed design and cost phases of project development and all will require more detailed on-ground assessment, design and cost analysis and assessing against legal requirements before any program of implementation could be commenced.

Use of alternative infrastructure to supplement environmental watering events:

The potential to deliver water to targeted sites within the Yarrawonga to Wakool reach using existing or purpose built infrastructure has been raised as a possible complementary option to constraints management as part of the project development process. For example, Murray Irrigation Limited has indicated that their existing water delivery infrastructure would have the capacity to deliver environmental water throughout the Yarrawonga to Wakool system, with some capital upgrades to their escapes.

The use of alternative delivery infrastructure is not intended to create a greater impact on any part of the Yarrawonga to Wakool reach than would be experienced under the equivalent flow footprint associated with a 30,000ML/day flow downstream of Yarrawonga. It will be important to better understand any issues around compounding impacts associated with using MIL infrastructure to deliver environmental flows on those areas of the reach below the MIL escapes. In addition, the timing of and total flow volumes and heights, duration and frequency of managed environmental flows through the reach from Yarrawonga and through MIL's infrastructure would need to be carefully coordinated so as not to create third party impacts in excess of those agreed to.

However, the use of irrigation infrastructure may produce additional environmental benefits to wetlands and ecological communities higher up in the floodplain, remote or cut off from the floodplain that will not experience the benefits associated with higher environmental flow events. Use of irrigation delivery infrastructure may also help to offset negative third party impacts associated with higher managed flow events.

More detail on the potential to use Murray Irrigation Limit's infrastructure to complement flow relaxation in the Yarrawonga to Wakool reach is provided in Appendix 8 (page 81).

4.4 Mitigation Cost

Studies to better understand the regional costs of mitigation measures have been undertaken for the MDBA over the past two years (see Table 2). These studies fell into two broad groups – commercial impacts on farms and other businesses within the floodplain and public infrastructure.

The data sets used to assess impacts and costs for major infrastructure such as public bridges, culverts and roads was considered to be of a high standard and accepted as supplied.

Datasets used to identify the extent of impact of inundation and interrupted access, crossings and other farm based infrastructure were not accurate at a local level, and the farm based costing methodology used broad regional and sub-regional scale assumptions to develop costings for key elements of a package of commercial compensation measures.

DPI Water commissioned further work into the assumptions, units of cost and cost contingencies used to develop the farm based figures, including a review of the methodology and information using an expert panel and discussion with a small number of members of the Landholder Reference Group.

Generally the peer review using local experts in land valuation and agricultural economics supported the methodology used in the original costing studies, however there were reservations associated with the accuracy of the hydrological information provided to the consultants.

The Landholder Reference Group members expressed reservations relating to some of the cost assumptions, in particular the:

- Elevated flooding risks;
- Length of time of foregone grazing in native pastures;
- Cost of weed control;
- Cost of farm based infrastructure – particularly crossings to provide access to land cut off by inundation;

- Area of interrupted access;
- Impact of total grazing pressure from native animals on areas adjacent to the inundated area.

In addition, the LRG expressed concerns that without a clear picture of the timing, frequency and duration of future environmental flow events, it was not possible to either estimate the nature and extent of impact, or provide even defensible estimates of mitigation costs.

To allow for potential underestimates of impact and cost, even in a cursory way, additional budget items and contingencies have been included in the budget in this version of the Concept Proposal. These are explained in more detail in Appendix 6 (page 68).

It is acknowledged that the information gathered on costs was intended to be used to calculate preliminary catchment-wide mitigation and compensation costs. As such, this information is not sufficient to support accurate assessments of impacts or mitigation strategies at a local or farm level, which will require property by property assessment in the next phases of project development.

A renewed approach to costing impacts and mitigation will be commenced once more accurate information on the extent of impact and the timing, frequency and duration of future environmental flow events is available.

In all cases cost contingencies have been applied at each stage of the costing exercise. As an additional level of contingency to offset inaccuracies in the extent of impact and the cost of mitigation, it is proposed that the costs of mitigation at the 50,000ML/day flow footprint be used as a starting point for budgeting in this Concept Proposal.

In summary, mitigation strategies that were costed at a regional scale included:

Infrastructure to protect assets and establish/maintain access:

- Infrastructure works on farms (upgrade crossings, bridges, upgrade internal tracks, reposition pumps) – estimated the number of properties where infrastructure works may be required and the cost of representative engineering works.
- Capital works on public infrastructure (property access upgrades, specific public infrastructure).
- Works on levees (overtopped and flood controlling).

Financial agreements to offset costs and damages:

- Commercial Landholder Agreements on private land to include compensation to offset the costs associated with loss of agricultural production such as loss or damage to pastures, loss or damage to crops, reduction in productive land value, increased livestock husbandry costs, fencing costs, clean-up costs, costs of moving pumps and effects of interrupted access.
- Financial Agreements with Local Councils for the costs associated with the reinstatement and repair of public infrastructure – up front financial agreement to cover the future costs of road rehabilitation, replacement of culverts, impacts on landscaped areas and increased costs associated with operational responses associated with flood preparations, for example, road closures, alternative traffic arrangements.
- Commercial Agreements with specialist activities (forestry, caravan parks, sporting grounds including the cost of easements and infrastructure options.

The community has expressed concerns about how easements affect land title and there has been interest in investigating alternative options that provide a more flexible approach to financial agreements, such as the payment of event based compensation, an environmental access grant or environmental rental, or other similar mechanisms. These options will need to be further developed and costed during the detailed planning and design phases from late 2016. For this stage of project development, the cost of establishing easements or other forms of enduring landholder agreements is considered to provide an accurate approximation of the scale of costs these more flexible approaches might generate. However, there may be additional costs associated with event based payments and an appropriate mechanism to

establish the basis of an ongoing funding source will need to be investigated in the next stages of project development.

In addition there are other mitigation strategies that will need to be investigated and costed as part of the next phase of project development including the inclusion of legal and business advice to landholders as part of the detailed on farm assessment and negotiation of landholder agreements, the specific costs of capital infrastructure upgrades downstream of the Perricoota-Koondrook Forest and the potential delivery of environmental water using Murray Irrigation Limited infrastructure. At this stage the costs of these additional items have been estimated and added into the global budget.

A summary of total estimated costs at each of these flow ranges is provided in Table 3.

An outline of the cost estimates of mitigation and program management produced to date by the MDBA and the independent studies it has commissioned, for flows of 35,000, 40,000 and 50,000 is provided in Appendix 6 (page 68).

An outline of the key assumptions, caveats and contingencies attached to the costing data is provided in Appendix 7, (page 77).

Table 3 Estimated total costs associated with increasing maximum regulated flow levels (source MDBA)

Cost category		35,000 ML/d Total ($m)	40,000 Ml/d Total ($m)	50,000 ML/d Total ($m)
Costs of mitigation measures	Easements and associated negotiation costs for private agricultural land[3]	22	20	29
	Infrastructure on private agricultural land	9	9	11
	Operational response measures – public infrastructure operators	3	4	3
	Capital works on public infrastructure[4]	2	2	2
	Reinstatement of public infrastructure	13 to 16	22 to 26	16 to 21
	Works on levees	4 to 5	4 to 5	5 to 6
	Arrangements with specialist activities	2	2	2 to 11
Potential additional infrastructure implementation costs (Jacobs 2015)		7 to 21	9 to 29	12 to 41
Potential program management costs		15 to 23	15 to 23	15 to 23

[3] Easement costs are based on an assumption that land suffering from interrupted access has 513% of the area of the land suffering from inundation. This assumption is based on a sample of 3 properties and is considered a high estimate. If the assumption regarding inundated access is reduced to a lower percentage (200%) easement costs are lower.

[4] Includes public road access

Cost category	35,000 ML/d Total ($m)	40,000 Ml/d Total ($m)	50,000 ML/d Total ($m)
Additional contingency for landholder agreements (production losses, increased costs of business)	15.5	15.5	15.5
Additional costs associated with capital works on farms.	71.9	71.9	71.9
Additional costs associated with capital works below Perricoota-Koondrook Forest	9.01	9.01	9.01
Additional costs for expert advice to landholders and negotiation costs associated with Landholder Agreements	38.9	38.9	38.9
Additional costs associated with use of Murray Irrigation Infrastructure	12.5	12.5	12.5
Additional costs associated with modelling, monitoring and community consultation (2016/17).	1.2	1.2	1.2
Ecological Monitoring (including establishment of a baseline)	10	10	10
TOTAL ($m)	**262.01**	**279.01**	**306.01**

Note – all costs are expressed net of taxation.

5 Community and stakeholder response

5.1 MDBA consultation 2013-2015

As part of the pre-feasibility analysis undertaken by the MDBA from 2013 to 2015, a program of stakeholder consultation with riparian landholders, local councils, government agencies and irrigation corporations was carried out. The Edward-Wakool Constraints Advisory Group was formed to represent the interests of landholders and a range of public land managers including forestry and national park interests and Murray Irrigation Limited. This group became a focus for MDBA consultation. The MDBA reported (MDBA, 2015) that some 16 community meetings were held involving more than 200 individual community members. In addition, 11 meetings were held with local Councils and further meetings were convened with state government agencies and Murray Irrigation Limited.

The key messages, concerns and issues documented from these meetings included:

Economic

- Loss and damage to their businesses created by increased frequency of inundation;
- Increased risk of flooding through natural flow events occurring on top of managed flow events;
- Loss of access to areas of their property for extended periods;
- Increased costs of carrying out a business on the floodplain;
- Devaluation of their land;
- Concern that there isn't sufficient funding to mitigate impacts adequately;
- Legacy issues related to existing floodplain structures such as block banks and crossings;
- Adverse impacts on tourism due to reduced access to forests and beaches;

Accountability

- Lack of trust in government's ability to manage mid to high range flow events – there was considerable concern expressed for flow ranges greater than 40,000ML/day at Yarrawonga;
- Lack of a clear line of responsibility for liability if a flow event results in unexpected impacts;
- The need for more landholder engagement and involvement in monitoring the environmental outcomes of environmental flows;
- Concern over the cumulative impacts and potential elevated flooding risk resulting from the easement of constraints in river reaches above Yarrawonga.

Environment and biosecurity

- Increased mosquito borne diseases such as Ross River Fever and Murray Valley encephalitis.
- Potential for negative environmental impacts including hypoxic (black water) events, increased carp populations, acid sulphate soils, increased bank erosion and weed infestation;
- Increased cost of weed management;
- The environmental benefits of irrigated agriculture have been ignored as have the impacts from removing water from one part of the landscape and redirecting it elsewhere – the sum total is not all positive.

A more detailed list of community feedback, issues and concerns is provided in Appendix 9 (page 83).

In response to community concerns over the proposed height of environmental flows and the general approach by the MDBA, the MDBA-led consultation stalled in 2015. The NSW Government restarted the community engagement process with a view to focussing on flows in the Yarrawonga to Wakool reach at levels that were safe, practical and do not create unacceptable third party impacts, that could be considered by landholders and affected communities.

This project Concept Proposal is a direct result of this renewed approach to constraints management in the Yarrawonga to Wakool reach. The proposal acknowledges that much of the community effort and feedback to date remain relevant, and where possible this will be incorporated within the project development process. The renewed consultation approach is aimed very firmly at achieving not just

positive environmental outcomes, but mitigating economic and socio-economic impacts, and creating socio-economic benefits where possible.

In addition to consultation relating to relaxation of constraints at Yarrawonga, there has also been a long history of consultation around the operation of The Living Murray (TLM) works in the Koondrook-Perricoota Forest. The works within the forest and the objective of more effective forest watering has broad community support. There is also strong support for an increase in the downstream flow limit as it is widely recognised that the works are largely ineffective or can only be operated with significant risk under the current constraints. The community advisory committee set up to advise government on the Koondrook-Perricoota Project (KPA) has recommended that the works not be operated until the downstream flow limit is lifted and third party impacts are effectively understood and addressed.

However, as in other areas of the reach, mitigation of third party impacts is a sensitive issue below the forest, with diverse views on how this should be managed, particularly with respect to water supply infrastructure. A coordinated approach to consultation that is sensitive to particular issues specific to localised areas within the Yarrawonga to Wakool reach will be critical to progressing the project in the next phase.

5.2 DPI Consultation February to July 2016

As part of restarting the Yarrawonga to Wakool Constraints Management Project, a Landholder Reference Group (LRG) was convened by NSW DPI Water. The Group is chaired by a local landholder, Michael Hughes. Many of the members of the original Edward-Wakool Constraints Advisory Group are members of the new Landholder Reference Group, and collectively they have provided an important set of informed community views and opinions into the process, as well as a level of continuity.

The LRG has been the key source of landholder and community input to the Concept Proposal since February. The group has been instrumental in setting a maximum regulated flow limit of 30,000ML/day below Yarrawonga for investigation, and has provided valuable feedback on the types and scale of mitigation strategies that will be required to offset landholder impacts created by higher managed flow events.

The LRG has highlighted that the lack of accurate information on the magnitude of impact and the future hydrology of managed flow events has created a vacuum in which negotiations are likely to fail. They value highly the development of farm based maps that can accurately represent the area of inundated land and area of interrupted access.

The LRG expressed the view that to succeed, constraints management will need to include:

- The provision of sufficient funding to cover the full cost of mitigation of all unacceptable third party impacts – the budget must fit the problem, not the solution fit the budget;
- The development of appropriate policy and protocols relating to private property access and treatment of legacy floodplain structures;
- The provision of suitable support and advice for landholders to fully understand their legal rights and how they can gain the most beneficial outcomes from the mitigation package available; and
- Sufficient time and resources to properly engage communities and landholders to create local solutions that will leave an enduring and positive legacy - CMS should adopt the principle of “localism”.

DPI has also met with Councils in the reach to discuss the progress of the CMS and provide information on the next stages of project development.

5.3 Beyond July 2016

5.3.1 Business Case Development

Basin Governments have agreed to provide additional time to finalise business cases which support investment in SDL Adjustment projects. This means that for the Yarrawonga to Wakool Junction CMS the NSW Government has additional time from August to November 2016 to conduct additional investigation

and consultation around the impacts, and mitigation and compensation strategies associated with relaxing flow constraints.

It is proposed that this period of business case development will include:

- Resources and support for the Landholder Reference Group to design a fresh start to identifying appropriate mitigation strategies and mitigation costs on private agricultural land, including where appropriate, landholder-led case studies;
- Clearer definition of the CMS measure across the Yarrawonga to Wakool Junction reach;
- Small group consultation and discussion around the extent and nature of impact and the principles of a program of mitigation and compensation;
- One on one discussion with Councils and affected businesses located in the floodplain.
- Provision of information on constraints management generally to the broader reach community.

It is also proposed by DPI Water that an interagency project group will be convened to coordinate and integrate the CMS with other environmental water planning processes and ensure integrated planning across reaches and states.

5.3.2 Detailed Design and Planning Phase

Whilst Basin Governments are still working through the detail of the SDL Adjustment process, it is expected that beyond 2016, the project will move to a detailed design and planning phase, involving a significant program of ongoing engagement with affected riparian landholders, businesses and local councils. Affected stakeholders will be engaged in the development of program design and the way that mitigation packages are created and implemented.

There will be important further work to develop the detail around the project relating to:

- detailed property by property assessments of the impacts and changes to inundation patterns – safety, timing, height, frequency, duration. Those property assessments would inform three things – risk management, impact mitigation and associated costs, and compensation payable to landholders.
- building an equitable and fair framework for the delivery of mitigation measures and compensation, including the nature of Landholder and Council Agreements
- ensuring that, for the duration of the CMS, there will be sufficient funds available for impacts to be mitigated and fair compensation to be paid
- river operating protocols, processes and risk management
- legal treatment of floodplain structures
- investigations into impacts, and detailed design, planning and costing of mitigation works and measures at a farm level.

Overall project development and detailed planning and design are expected to take until 2017-18. During this time affected properties will be assessed individually using specialist advisors engaged by landholders and paid for by government to assist them to determine the extent of impact and create acceptable packages of mitigation and commercial compensation.

During business case development and detailed project planning and implementation phases, Basin Governments must work to build stronger working partnerships with landholders and local communities. Rebuilding trust will require transparency, information sharing and agreement on acceptable flow levels. Effective consultation and engagement strategies will be identified and implemented, including the ongoing role for a Landholder Reference Group.

Observation and monitoring of natural flow events and trialling of small to moderate managed environmental flow events will yield quantitative information to inform increased flows within the reach. The role of riparian landholders will be important in observation and information gathering relating to the extent and distribution of flows and inundation, and positive and negative impacts over time. They will

need to be resourced to do this and there will need to be information systems built to receive and manage the data and information generated.

The key principles of engagement developed as part of this Concept Proposal will need to be extended by governments responsible for project management throughout the detailed planning and implementation phases. Some of these principles include:

Building partnerships and trust:

- Our stakeholders need continuous evidence that the relative governments hold communities' interests first and foremost, and that they are committed to generating commercial, environmental and socio-economic benefits from all MDB projects.
- Project and business case development should reflect a partnership between government and community.
- Processes must focus on rebuilding and maintaining trust and confidence.

Acknowledge past effort and achievement:

- The work previously undertaken by landholders and community should be recognised as provide a starting point for discussion.
- Past effort and improvements in environmental health need to be acknowledged.

Participatory and evidence based:

- Consultation and engagement should be collaborative with appropriate notification and timeframes, a two way conversation, transparency and monitoring of effectiveness along the way.
- Decisions should be based on fact and data.
- Monitoring, reporting and evaluation of projects should involve community and landholders.

6 Project risks

A detailed assessment of risk and risk mitigation strategies has been undertaken in consultation with the Landholder Reference Group and NSW Government agencies. A summary of the key risks and mitigation strategies is provided in Table 4. A high level analysis of risks, mitigation and residual risks is provided in Appendix 10 (page 86).

Table 4 Key Project Risks and Risk Mitigation Strategies

Nature of Risk	Mitigation Strategies	Residual Risk
Deprivation of land, access to land temporarily severed, additional costs to farm businesses, land values reduced as a result of managed environmental flow events. Managed environmental flows inflict additional costs, damages and losses to public infrastructure, private irrigation delivery infrastructure and businesses operating in the floodplain.	Mitigation is designed with adequate buffers and contingencies to offset both managed environmental flow events and unplanned consequences. Provide independent expert advice to landholders relating to impact, mitigation and compensation. Compensation Agreements includes consideration for all farm based risks associated with managed environmental flow events. Construction of crossings, bridges and culverts on private and public lands with adequate height to mitigate risk. Reinstatement and maintenance costs where construction considered unnecessary. Early warning and notification systems put in place. Improved catchment instrumentation and forecasting. Real time information to assist with tracking of managed flow events. Probability of increased flood risk as a result of CMS modelled, understood and effectively communicated. River operators exercise judgement based on operating rules and previous experience.	Low to Medium
Insufficient funding available for mitigation of and compensation for managed environmental flow events.	Full range of compensation options identified and independently costed by experts. Suitable compensation options and costings presented to Commonwealth Government for funding. Inclusion of adequate cost contingencies.	Medium
Downstream impact from use of alternative delivery infrastructure to deliver managed environmental flow events.	Effective consideration and coordination of flows from a range of sources. Mitigation strategies consider the impact of flows compounded downstream of irrigation escapes.	Low
Lack of accountability and responsibility for impacts of managed environmental flows.	Identify and make public operational roles, responsibilities and liabilities associated with managed flows.	Low
Stakeholders lose confidence and disengage from the CMS	Timeframes for project planning and delivery need to	Low

process.	be realistic, communicated well and met. Governments engage stakeholders in a collaborative and inclusive way. Governments need to be transparent in their dealings and in the provision of information. Compensation mechanisms are fair, equitable and commercially driven to offset unacceptable impacts of higher managed environmental flows. Development of a compensation framework involves local input and ownership. Landholders must be given the resources to manage risk in a way that benefits their business. Relaxation of constraints is only implemented when adequate mitigation is in place. Communication and engagement processes are effective.	
Ecological outcomes not achieved.	Ensure objectives are explicit and measurable. Maintain and strengthen effective governance arrangements around the planning, implementation and evaluation of environmental flows. Investigate alternative, complementary physical and operational strategies to multiply the effectiveness of environmental watering events. Provide transparent reporting and review.	Low
Unintended environmental outcomes result from managed environmental flows, eg fish deaths due to hypoxia, carp breeding, acid sulphate soils, weeds and erosion	Gain a greater understanding of the causes and triggers associated with unintended and native environmental outcomes. Design the timing, frequency and duration of flow events to minimise negative outcomes, including low flow strategies for summer and autumn. Complement flow events with operational and physical reduction strategies for pest plants and animals.	High
Project delays and inability to deliver the project within budget results in ineffective mitigation of managed environmental flow events.	Ensure planning and implementation timeframes are realistic, and build in site specific contingencies, adequate time for permits and approvals and individual landholder and stakeholder negotiations. Ensure policies are in place to deal with issues such as legacy structures[5], private land entry protocols. Design a process of landholder agreements and compensation that has local input and ownership.	Low to Medium

[5] These are structures in the floodplain and across water ways that have been in place for lengths of time but which may not be legally compliant according to contemporary regulations.

	Apply a test of fairness and reasonableness to the allocation of compensation. Ensure the principles relating to mitigation and allocation of compensation are sound and locally agreed. Build in adequate cost contingencies and have costings undertaken by experts. Ensure governance structures are robust, accountable and focussed. Engage the services of skilled project managers and project staff.

7 Future Project Phases

7.1 Project proponent

The NSW Department of Primary Industries – Water will be the project proponent.

7.2 Sustainable Diversion Limit Resource Units

This measure will involve works and measures in the following Sustainable Diversion Limit resource units:

- NSW Murray (SS14), and
- Victorian Murray (SS2)

When combined with the Hume to Yarrawonga and South Australian River Murray constraint measures, it will also involve:

- South Australian Murray (SS11).

7.3 Eligibility for Commonwealth funding

NSW confirms that this is a new project, additional to those already included in the benchmark assumptions under the Basin Plan. Pending a final decision to proceed with this project, its implementation is expected to:

- remove or ease a physical or other constraint on the capacity to deliver environmental water to the environmental assets of the Murray Darling Basin;
- allow environmental water to be used more effectively; and
- be designed, implemented and operational within agreed timeframes.

The project is not part of a 'pre-existing' Commonwealth funded project and has not already been approved for funding by another organisation, either in full or in part.

If the project proceeds to implementation is it expected that it will be funded in its entirety by the Commonwealth Government.

7.4 Project timeline and key task areas

To ensure that communities are appropriately consulted, and the proposal is well understood, the next stages of project development will need to include further refinement of impact of easing constraints, mitigation strategies and costs of mitigation as well as design of a program of compensation. There are policy issues to be resolved that relate to treatment of legacy structures within the floodplain, and the actual process with which compensation agreements will be negotiated and recorded.

DPI Water will work with landholders, stakeholders and the LRG to identify the most appropriate processes and organisational structures to support a government and community partnership, capable of identifying and progressing local solutions to increase the effectiveness of managed environmental watering events and effectively mitigating against any third party impacts. This partnership approach will include developing the most effective way of administering and applying mitigation and compensation packages, including using existing government agency structures, outsourcing, engaging the services of private delivery partners, creating a purpose built delivery agency or a combination of these.

While Basin Governments are yet to confirm the SDL Adjustment process, it is expected that this will continue up to November 2016 when a more detailed project outline will be required by Basin Governments.

A period of detailed planning and design will need to be undertaken throughout 2017 and 2018 and involve farm by farm assessments and negotiation of agreements. There will also be assessment of impact and mitigation at a local Council level and associated with impacted businesses within the floodplain.

An indicative project timeline is provided in Appendix 13 (page 103). Each of the key stages of project planning is discussed in further detail below.

7.4.1 Development of supporting principles, protocols and policies

A number of policy areas require further development before a final suite of mitigation strategies can be implemented. Some of these are already under review and development but most will require further study and consultation, including:

- Adapting existing protocols to guide private property access for detailed farm assessments, monitoring of flow heights and evaluation of environmental outcomes;
- Treatment of floodplain works and historical floodplain structures; and
- Further exploration of alternative landholder agreement mechanisms.

7.4.2 Community engagement and consultation

Ongoing engagement and consultation with riparian landholders, Local Government and other project stakeholders will be an essential inclusion during detailed planning, design and implementation phases. It is expected that a program of engagement, consultation and communication will be developed for commencement in August 2016 and consider:

- the future role of the Landholder Reference Group, and the most appropriate way to engage stakeholders, including landholders at all levels of project development and management;
- road testing of mitigation and compensation strategies using a selection of farm case or sub-reach studies that are landholder led;
- engagement of landholders at a property by property level;
- engagement with Local Councils to deliver best value for money mitigation works; and
- communication of key project outcomes and progress to the broader communities within the reach.

Systems that involve riparian landholders in the observation and monitoring of impacts and benefits of both natural and trial flows should be developed further. Information systems capable of storing and retrieving community and landholder generated information should be considered. The cost of ongoing consultation must be included in the project budget from 2016 to 2024.

7.4.3 Detailed assessment and selection of mitigation strategies

The NSW Government wants to ensure adequate mitigation of third party impacts to allow the delivery of environmental flows unimpeded within any boundaries that are agreed to. Mitigations must also deliver good value for money. The LRG has outlined that landholders want mitigation strategies that are commercially focussed to offset any production losses over time, damages and establish access to conduct their farming businesses. Additionally, owners of public infrastructure want to ensure that their ratepayers are not negatively impacted by the cost of maintaining access or repairing infrastructure developed as a result of higher managed environmental flow events.

Whilst investigations into mitigation strategies have focussed on the establishment of easements and infrastructure, there is a range of alternative mitigation options that landholders and NSW government agencies have identified for further consideration.

Areas for further investigation to more accurately assess the extent of impact, the nature and scope of mitigation options and more accurate costings area provided in Table 5.

Table 5 Recommended further work to assess impacts, mitigation options and costs

Issue	Further work that is required
Inundation footprint	Knowledge of the inundation footprint needs to be generated to allow informed decisions to be made. This would involve: • Developing new, and/or and refining existing inundation models • On-ground monitoring and assessment of actual flow events, involving local stakeholders (e.g. monitoring and measuring flows over specific properties) • Incorporation of aerial photography and satellite imagery of actual flow events and analysis of this with ground truthing.
Definition of the measure	Definition of maximum regulated flow limits across the reach, frequency and duration
Cost of impacts and mitigation strategies on agricultural land.	Design and implement a new approach to costing of impacts and mitigation strategies on agricultural land to develop whole of program costs.
Compensation to mitigate impacts at a farm, business and Council level	Development of a fair and equitable compensation framework, including a set of agreed principles, stakeholder engagement and negotiation at a sub-reach and individual level, provision of information and expertise to support landholder decision making, methodology to guide negotiations and costs, legal arrangements and payment arrangements.
Proposed operating regime	Future environmental watering and/or river operation decisions could provide more specificity regarding the future environmental flow regime (height, timing, duration, frequency at key locations within the reach)
Improved monitoring and forecasting	Development of more intense monitoring and rainfall/runoff forecasting to better inform behaviour of environmental flow events, and learn from natural and past events.
Public infrastructure (e.g. roads, crossings)	On-ground assessment of impacts on assets will inform negotiations with managers (e.g. councils) regarding best value for money mitigation.
Alternative Delivery Infrastructure Options	Investigate the potential for delivery of environmental water to targeted sites using MIL infrastructure. Utilisation of the designed capabilities of the Koondrook - Perricoota Flood Enhancement Scheme

Issue	Further work that is required
Detailed design of program implementation model	Identify, design and cost potential delivery models that will include: • Implementation of detailed design and costing • Management and allocation of funding • Landholder and stakeholder engagement and support, • Agency coordination and engagement • Implementation of legal agreements • Delivery, monitoring and evaluation of the project (works, governance, procurement, value for money).

The selection of mitigation strategies should include a range of options from least cost to higher cost options to ensure that:

- affected parties are no worse off
- CMS flows deliver positive commercial, environmental and socio-economic outcomes
- mitigation and compensation measures align with other government precedents.

Considerable time and effort will be required to establish and manage relationships with affected landholders and other stakeholders, gather details relating to impacts on individual properties, agree on principles relating to selection, scope and costing of mitigation measures, and negotiate legal and other administrative arrangements.

7.4.4 Design of funding program for mitigation and compensation

An important consideration in the detailed planning stage will be how funding for mitigation works and measures will be allocated. There is concern amongst riparian landholders that funding will not be allocated fairly and equitably and that the program will create "winners and losers" between riparian landholders. An important principle in designing a program of mitigation will be that all impacts are equally worthy of consideration. The project is committed to ensuring that affected landholders, Councils and businesses have equitable access to the mitigation measures and compensation measures for their property. Mitigation measures must be commercially realistic, verifiable, fair and reasonable and meet the needs of floodplain businesses.

It will be important to establish the total scope and location of mitigation works to ensure that sufficient funding is able to be secured, prior to any funding being allocated. Implementation will need to be staged and where possible, economies of scale generated. Project costs will need to be accelerated to accommodate any time lags between design and implementation.

The inclusion of local knowledge and strong governance will be essential to ensure that the implementation and investment program is practical and commercially focussed at a local scale, although this will need to be consistent with existing government regulations, standards and policies in relation to design of works, contractual and legal arrangements and procurement.

It will important that all landholders and floodplain businesses have access to legal and business related advice to assist them to negotiate a package of commercial compensation and infrastructure that is tailored to their business requirements and optimises social and economic outcomes. This will be costed as part of the detailed design and planning phase of the project.

An overview of the proposed project governance arrangements is provided in Appendix 11 (page 97).

7.5 Implementation Program

The finalisation of legal agreements with landholders, riparian business owners, and Councils containing appropriate commercial mitigation packages, will only commence once:

- all outstanding policies and protocols are in place;
- detailed investigation and negotiation of agreements have been completed; and
- accurate costings have been established.

It is expected that these issues will be dealt with from August 2016 through to the detailed planning and design phase of the project in 2017 and 2018.

Implementation of operational constraint relaxation will only occur after adequate mitigation measures and strategies are in place. The approach to flow relaxation will be incremental, with flow heights and durations gradually increased as the opportunities for managed environmental flows arise. Implementation will be a process of learning by doing, with the impacts and effectiveness of mitigation strategies carefully monitored before higher flows would be permissible.

7.6 Governance Arrangements

Once agreement has been reached to progress the Constraints Management Strategies in NSW, overall project governance and project management arrangements will be established by the NSW Government, in consultation with landholders and stakeholders, to minimise the risk to participants and investors. Given the scale of the potential investment it will be important to establish a strong governance framework, together with an effective management structure that effectively represents the interests of all stakeholders and supports the development of local ownership and direction to project implementation. The development of governance and management structures and processes will be the subject of ongoing discussion between the NSW Government and the LRG over the next six months. A number of possible governance and management structures are provided in Appendix 11 (page 97).

The planning and implementation of managed environmental flow events are coordinated through existing inter-agency and interstate committees, with responsibility assigned to the appropriate NSW Government agencies. An outline of the planning and operational process is provided in Appendix 12 (page 100).

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Appendix 1 Hydrology of Future Managed Flow Events

A1.1 Targeted Flows up to 30,000ML/day at Yarrawonga

Flows of 30,000ML/day already occur in the Yarrawonga to Wakool reach; however, they don't occur as often they used to. For example based on the long term average of 107 years of flow rate data (MDBA 2015):

- flows at 20,000 ML/day (Tocumwal) currently occur on average about 3 times a year; in pre-regulation conditions, flows at this rate used to occur on average 4 times a year
- flows of 35,000 ML/day (Tocumwal) used to be reasonably frequent (3 times a year), but now occur about once a year;
- flows of 50,000 ML/day (Tocumwal) used to occur 14 times in 10 years on average, but now occur naturally 8 times in 10 years; and
- flows of 77,000 ML/day (Tocumwal) used to occur 6 times in 10 years, but now occur naturally only 3 times in 10 years.

It should be noted that the long-term average frequencies described above are for events of any duration. It is well understood that it is not possible to return these systems to pre development flow heights and frequencies, and that this Concept Proposal is only targeting flows up to 30,000ML/day at Yarrawonga for investigation. However, a move toward greater frequency and higher flow rates, whilst working with communities and landholders to mitigate commercial impacts, would provide a significant environmental benefit.

The pre-feasibility work completed by the MDBA (MDBA 2015) shows that flow rates below 50,000ML/day at Tocumwal are contained wholly within the floodway network, and flows between 20,000 and 35,000ML/day are generally contained within the channels of rivers and creeks, except for the floodplain forests and wetlands and a small section along the Niemur River.

By comparison, flow rates above 50,000ML/day were reported to provide overland flows in a number of places in the reach.

Different watering patterns can achieve different outcomes. Low flow rates can be used for long durations (e.g. months) if the objective is to provide base flows in rivers, and to fill up or maintain low-lying wetlands and billabongs, and to deliver for end-of-system objectives. Mid-range flow rates of medium duration (e.g. weeks) could be used in addition, to support in-river processes such as facilitating fish breeding, increasing survival, migration and access to food through connecting floodplain habitat. If the risks could be managed and mitigated and there was landholder and community support, higher flow rates could be used for short durations (e.g. days) to fill wetlands higher on the Edward-Wakool floodplain or to contribute to downstream environmental outcomes.

It is difficult to predict the exact timing of when higher flows may occur, as they will be highly dependent on the weather and seasonal characteristics. However, it is possible to discuss potential scenarios that could be examined in future work. The following sections describe two hypothetical scenarios, based on previous investigations for this reach (from MDBA, 2015). All flow rates described are at Tocumwal.

1. Low flow events — 10,000–20,000 ML/day

In terms of lower flow rates, it is probable that these flows could be expected, and desired from an ecological perspective, to be delivered in most years. Durations would likely vary from weeks to months to align with particular ecological objectives, for example to support fish or bird breeding activity, or to fill wetlands. Water could also be delivered in very dry periods to support drought refuges. Timing is likely to follow a winter–spring pattern.

Flow events of this size could be wholly made up of regulated water. However, adding regulated water to unregulated 'natural' events, or freshes, would help achieve this aim more efficiently. If *only* regulated

water was to be used, this could be delivered either by using water held by environmental water holders and/or by adding onto deliveries of consumptive water.

An example of managed flows in the vicinity of 20,000 ML/day[6] was the 2013/14 flow trial where the recession of a flush of some 44,000 ML/day was managed for reduction or tapered draw down for two objectives; to benefit the environment of the Barmah Millewa forests and to determine what infrastructure was affected by these levels. Flows of 18,000 ML/day were maintained at the beginning of October 2013 for approximately 9 days, were then lowered to 15,000 ML/day for one and a half months and finally lowered to a summer operational height of 10,000 ML/day.

2. Low to mid-sized events — 20,000–50,000 ML/day

Flows in the range of 20,000–35,000 ML/day could be expected, and be desired for ecological purposes at least 1 in every 2 years on average, depending on seasonal conditions. These flows would meet very specific ecological objectives, such as periodic watering of the Barmah–Millewa Forest. At these flow rates, duration may be shorter than at lower flow rates; however, the timing is more likely to follow a winter–late spring pattern. It is likely that these flows would be made up of unregulated inflows from the Ovens and Kiewa rivers, combined with regulated releases from the upper storages.

Flows above 30,000ML/day are not being explored in this Concept Proposal, however, hypothetically (for the purpose of providing information and comparison) flows of 35,000–50,000 ML/day would need to be less frequent on average than events at lower flow rates. Those types of flow rates would be linked to specific environmental objectives. Timing of these types of events would likely be strongly linked to natural flow events from the Ovens and Kiewa rivers.

Case Study – 2005 Barmah-Millewa Flood Event

During 2005 two flow peaks were triggered by unregulated flows from the Ovens and Kiewa Rivers. Both events produced similar peaks of approximately 30,000ML/day downstream of Yarrawonga. To complement the unregulated flows, environmental flow releases sourced from the Barmah-Millewa Environmental Water Allowance (BM EWA) were made commencing in the last weeks of October 2005. The release from the Yarrawonga Weir was gradually increased from 9,000 ML/day to 22,000 ML/day. During the early weeks of November the flows from Yarrawonga were managed to mimic inflows into the system and were decreased and increased and then decreased again until a gradual draw down plateaued at 15,000 ML/day into December. Throughout December the drawdown was managed so that regular summer season flows were maintained at approximately 10,000 ML/day into 2006.

Releases of the BM EWA continued through until February 2006 to support waterbird breeding that had resulted in the Gulpa Creek system. During that time the river operators tried to mimic how a natural event would behave. Just over 500GL of environmental water was used to extend the flooding of the forests and support waterbird breeding and native fish outcomes. Given the amount of water used in this event, it should be noted that the release of the BM EWA also provided downstream benefits, such as environmental flows across the South Australian border.

Whilst all events will be different, the 2005 event contains some key learning such as what happens when flow rates of that magnitude are released and particularly, how the dry and wet conditions of the floodplain influences flow rates and heights. The first flood peak (August-September) inundated a very dry floodplain, whilst the second peak (November) inundated a floodplain that had been wetted up by the preceding event. A comparison of flow heights recorded in September and November 2005 can be traced through the system (refer Table 6) and illustrates the influence of pre-existing conditions.

[6] Flows rates are from Yarrawonga.

Table 6 2005 Barmah Millewa flood event - wet dry comparison (Source: DPI Water Hydsys Database)

Location	August-September 2005		November 2005	
	Flow (ML/d)	Height (m)	Flow (ML/d)	Height (m)
Murray R. @ Yarrawonga	30,752	3.82	30,084	3.76
Murray R. @ Tocumwal	26,715	4.09	28,441	4.29
Goulburn R. @ McCoys Bridge	15,181	6.72	4,358	3.26
Murray R. @ Torrumbarry	19,993	5.17	15,119	4.24
Edward River Offtake	2,115	2.78	2,194	2.82
Gulpa Creek Offtake	764	2.97	994	3.19
Edward R. @ Toonalook	5,348	4.85	7,081	5.32
Bullatale Creek U/S Edward R.	343	1.13	854	1.67
Edward R. @ Deniliquin	NR	2.77	NR	3.02
Edward R. @ Stevens Weir	3,694	2.89	6,249	3.91
Edward R. @ Moulamein	3,443	2.75	3,392	2.73
Billabong Ck @ Darlot	757	N/A	1,259	N/A
Wakool R. Offtake	145	1.00	124	0.93
Wakool R. @ Wakool-Barham Rd Bridge	454	1.62	455	1.63
Wakool R. @ Stoney Crossing	1,588	0.84	2,624	1.10
Yallakool Ck Offtake	514	2.49	460	2.39
Colligen Ck Offtake	244	0.86	238	0.89
Neimur R. @ Barham-Moulamein Road Bridge	1,036	3.05	2,541	3.96

Other stream and river influences

The Murray Yarrawonga to Wakool system is not fully descriptive of the very complex interplay of the contributing anabranches and other rivers that affect the system's behaviour. Observation has informed river managers that the Goulburn River in Victoria, which enters the Murray above Torrumbarry Weir, can "hold up" flows from the Murray itself and where these flows influence the Murray they in turn can hold up Wakool and Edward River outflows. The relationship between flows in the Goulburn River and the impact on that area of the reach below the Koondrook-Perricoota Forest needs to be more clearly understood. Similarly, the potential impact of easing constraints in the Hume to Yarrawonga reach above the current operating limit of 25,000Ml/day on elevated flood risk below Yarrawonga needs to be carefully considered.

Other rivers and creeks are important, for example, the Billabong Creek and the Loddon River also impact on system behaviour. A recent example occurred in 2010/11 where the Loddon River played a major role in river heights and flows that affected the Merran Creek summer flood, and the Billabong Creek to the north affected flows out of the Edward River past Moulamein (DPI Water Hydrometric Data).

Within their capabilities to manage, river operators and environmental water managers are continually striving to improve how they identify and work within these factors that affect flow behaviour and water quality. Experience suggests that a cautious approach to managing environmental flow events is prudent.

Characteristics of a "typical" environmental managed flow event

While there will always be year to year variability of managed environmental flow events, some of the likely hydrological features may be generalised along the following lines:

The **timing** for a managed event up to 30,000ML/day at Yarrawonga would ideally occur in winter to spring (June to November), not during the summer irrigation season. This matches the time of year when rain and unregulated tributary flows typically occur throughout the region and in upstream catchments. It is also when floodplain plants and animals need the water most, and, if managed correctly, can provide benefits to downstream environments throughout the Murray.

Whilst a managed flow event of the **magnitude** of 30,000Ml/day could be generated using stored environmental water, it is more likely to be generated by releasing held environmental water to extend the height and duration of a naturally occurring fresh out of the unregulated tributaries.

The hydrograph in Figure 3 provides an example of how a managed environmental flow could be used to extend the duration of a natural fresh. In the hydrograph:

- The light blue line represent modelled natural flows
- The dark blue line represents real flow data
- The red line represents how a managed release of environmental water could be used to taper the recession of a natural peak flow between 30,000 and 10,000ML/day.

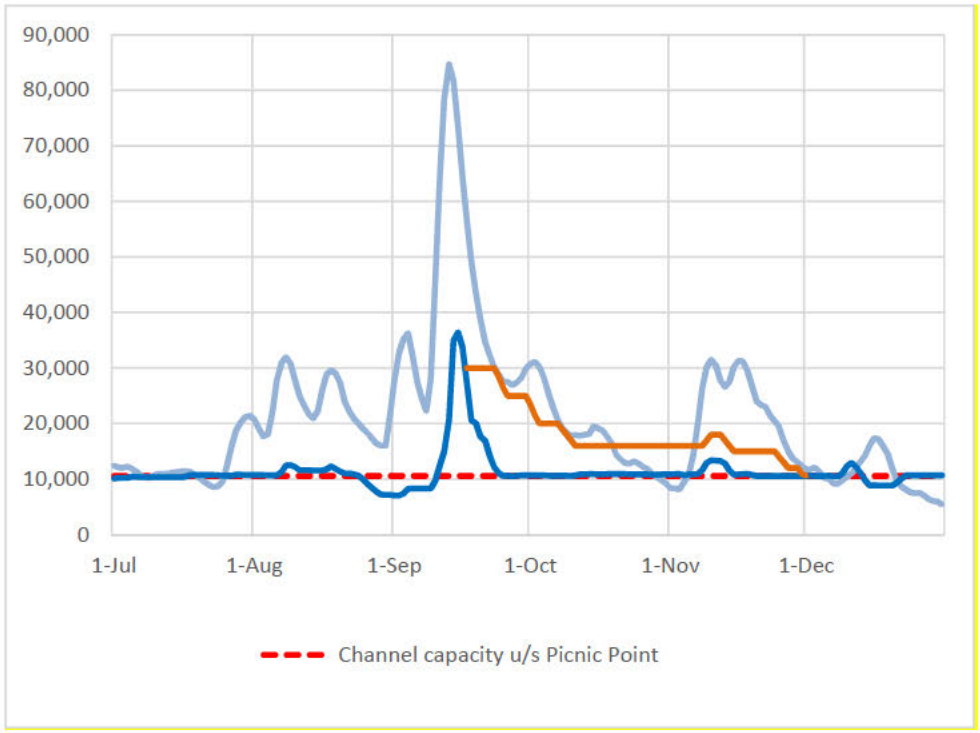


Figure 3 Hydrograph showing an model managed environmental flow event compared to the actual and modelled natural flows in 2004.

A1.2 Targeted Flow of up to 6,000ML/day through Koondrook-Perricoota

Further information on the management of environmental water at Koondrook-Perricoota can be found in the Koondrook-Perricoota Environmental Water Management Plan
http://www.mdba.gov.au/publications/mdba-reports/koondrook-perricoota-environmental-water-management-plan

Location and hydrology

The Gunbower-Koondrook-Perricoota Forest is located on the Murray River downstream of Torrumbarry Weir, between Moama and Barham (Figure 1). It is made up of three separate forests, the Gunbower Forest on the southern side of the Murray River in Victoria, and the Koondrook and Perricoota on the northern side of the river in NSW. The Gunbower-Koondrook-Perricoota Forest has a total area of approximately 50,000 ha, and the Koondrook-Perricoota portion is about 32,000 ha.

Flow of floodwater through Koondrook-Perricoota Forest is dominated by the Burrumbarry-Barber Creek system and flows to this system are sourced naturally from Swan Lagoon downstream of Torrumbarry Weir. Water enters the site in the southeast, via the two inflow effluents to Swan Lagoon, when flow in the Murray River exceeds about 18,000 ML/day (DECC, 2008). Outflow from the forest occurs primarily via Thule Creek, about halfway through the Forest, and through Barber, Calf and Cow Creeks at its western end. During large floods, water also drains out of Axe and Pothole Creeks and floods into adjoining private properties (MDBC, 2007; Wyatt, 1992).

Barber Creek and Thule Creek are tributaries of the Wakool River. The Wakool River joins the Murray River about 360 km downstream of the Forest.

Objectives and works

Basin Plan, The Living Murray and site ecological objectives can be achieved in the Koondrook-Perricoota forest by delivering a flow regime through the forest comprising flows up to 6,000ML/d, for up to 100 days, during the period July to November. Without works, these flows can only be achieved by delivering mid-sized flows (around 32,000ML/day) downstream of Torrumbarry Weir.

During 2011-2013, infrastructure was constructed in the Koondrook-Perricoota Forest under The Living Murray works program to restore the health of the Koondrook-Perricoota icon site. The works direct water from the Torrumbarry weir pool through the wetland and forest ecosystems to supplement natural high flows or floods. The works enable diversion of up to 6,000ML/d into the forest without raising the weir pool above normal operating level. The works also allow flows out of the forest to be contained and controlled to manage downstream impacts.

Existing constraints

The structures are capable of diverting 6,000ML/day from the Torrumbarry weir pool through the forest. This flow is sufficient to achieve the ecological objectives for the icon site. However, flows of this magnitude create third party impacts downstream of the forest. In order to eliminate third party impacts, the works include regulators on the outflow points from the forest, and a levee to retain water within the forest. Operation of the works is subject to an Approval issued by the NSW Government. The Approval currently limits outflows to 250ML/day via the Barber Creek (none via the Thule Creek) to avoid third party impacts.

Limiting the release rate from the forest causes water to back up within the forest whenever the inflow rate (minus infiltration and evaporation) exceeds the allowable release rate. This constrains the inflow rate and/or the period for which the inflow rate can be sustained, jeopardising the achievement of the objective of the works. Furthermore, backing up water within the forest due to outflow constraints leads to the development of a ponded area into summer, contained by the downstream levees. This is a substantial departure from the natural flood extent pattern and creates a raft of adverse ecological outcomes.

The contribution of the works to Basin Plan objectives will be vastly improved if operating constraints can be lifted to permit natural, unimpeded through-flow.

Relaxed constraints

This Concept Plan targets a maximum regulated flow limit of up to 30,000ML/day below Yarrawonga for investigation. This equates to a flow of 33,000ML/day downstream of Torrumbarry Weir, if the Goulburn and Campaspe flow assumptions developed by the MDBA modelling (RiMFIM) are adopted. Flows of 33,000ML/day downstream of Torrumbarry Weir will naturally direct approximately 6,700ML/day through the Koondrook-Perricoota forest. This flow is sufficient to achieve the management objectives at the site.

The 30,000ML/day flow downstream of Yarrawonga is expected to be targeted 3-4 times in 10 years between July and November. The frequency and timing target aligns well with Koondrook-Perricoota objectives. However, targets downstream of Yarrawonga include a peak duration of 7-10 days, well short of the 100 day management objective at Koondrook-Perricoota. Furthermore, water delivery objectives include a number of smaller, more frequent events that may not be achieved from Yarrawonga releases.

Operation – managed operation of the Koondrook-Perricoota Flood Enhancement Works

Relaxed constraints below the Koondrook-Perricoota Forest will enable more flexible delivery of flows via the Koondrook-Perricoota forest flood enhancement works. The delivery of such flows is dependent on water being available in the Torrumbarry Weir Pool.

Enabling water to be delivered to the Torrumbarry Weir Pool via easing constraints at Yarrawonga will provide greater opportunity to use both Goulburn River and Murray River sourced environmental water through the forest.

Managed releases into the Koondrook-Perricoota forests will result in outflows into the mid-Wakool River and its tributaries. It is important to consider these outflows as they may compound the effects of flows

entering the Wakool system from the Edward River upstream, increasing the extent of the inundation footprint.

With this in mind, delivery would occur under three broad scenarios:

1. Release of flows up to 30,000ML/day downstream of Yarrawonga, creating short periods of overbank flow (up to 6,700ML/day) through the Koondrook-Perricoota forest.
2. Extend the duration of overbank flow peaks to up to 100 days by operating the flood enhancement works to deliver up to 6,000ML/day after overbank flow ceases.
3. Delivery of flows via the works to achieve smaller, more frequent inundation events.

Scenario 1 does not involve operation of the works, and would be delivered from concurrent releases from Yarrawonga (up to 30,000ML/day) and the Goulburn River. Frequency would depend on targets elsewhere in the reach. Flows would occur downstream of the Koondrook-Perricoota forest in the Thule, Calf and Cow/Barber Creeks and the Barber Overflow, and would connect with Torrumbarry releases in the Wakool River.

Scenario 2 is an extension of Scenario 1 and involves extending the period of flow through the forest by operating the works. Total expected frequency of events this size and greater would be 3-4 years in 10, including unmanaged floods. Delivery would target Red Gum forest objectives, as well as fish and connectivity objectives. Flows would occur downstream of the Koondrook-Perricoota forest in the Thule, Calf and Cow/Barber Creeks and the Barber Overflow, and would connect with concurrent flows in the Wakool River. Downstream flows would occur for an extended period of time, beyond the period of flow downstream of Yarrawonga.

Scenario 3 would occur without specific releases from Yarrawonga. The works would be operated to deliver inflows between 2,000ML/day and 6,000ML/day to create a variety of smaller, more frequent inundation events targeting a variety of ecological outcomes in the forest including wetland vegetation, waterbird breeding and resident native fish. Smaller flows would be up to 9 years in 10. Outflows would be variable but would generally include at least some discharge into the Barber and Thule Creeks. Not all events would necessarily connect with the Wakool River.

Appendix 2 Environmental Benefits and Outcomes

A2.1 Environmental benefits within the Yarrawonga to Wakool Reach

Ecological values of the Barmah-Millewa Forest

The Barmah and Millewa Forests are the largest River Red Gum forests in Australia. They cover approximately 66,000 ha of floodplain along the Murray and Edward Rivers between Tocumwal, Echuca and Deniliquin. The Barmah Forest (29,500 ha) is located on the Victorian side of the River Murray and Millewa Forest (36,500 ha) on the New South Wales side. The Forests consists of a wide variety of ecosystem types including:

- swamps and marshes in the lower areas that are frequently flooded, where water can pond;
- rushbeds surrounding the swamps and marshes, and generally in wetter areas;
- lakes and billabongs which are generally deeper water environments and are important in providing feeding areas for large colonial nesting waterbird breeding events;
- open grassland plains, including large plains of Moira grass, which, when flooded, provide highly significant breeding and feeding habitats for colonial nesting waterbirds such as egrets, herons, spoonbills and marsh terns;
- river red gum (*Eucalyptus camaldulensis*) forest (the largest area remaining in Australia) of various types and health, depending on inundation, with the lower areas supporting larger and denser red gum forest; and
- black box (*Eucalyptus largiflorens*) woodland in the high, drier zones.

There are a number of streams that divert water from the main stem of the Murray River into the Barmah-Millewa floodplain. These streams provide important seasonal habitat for a range of aquatic fauna, particularly fish. Through-flow at critical times maintains aquatic habitat and provides fish passage between sites within the forest and wetlands and to the Murray River. Freshes in spring trigger spawning in many species and, by providing access to adjacent flooded wetland habitat, provide nursery habitat for juveniles.

Through-flow also maintains water quality. Blackwater events occur from time to time in Barmah-Millewa forest and have resulted in fish kills. River red gum trees lining the watercourses depend on creek water to maintain their health. At high sustained flows, trees lining the watercourses provide nesting habitat for waterbirds.

The extent of key floodplain vegetation communities within the area are outlined in Table 7.

Table 7: Key floodplain vegetation communities within the Barmah-Millewa forest.

Vegetation type	Barmah (ha)	Millewa (ha)	Total area (ha)
Giant rush (*Juncus ingens*)	531	2,667[a]	3,198
Moira grass (*Pseudoraphis spinescens*)	1,535	774[a]	2,309
River red gum forest (with a flood-dependent understorey)	16,617	26,181	42,798
River red gum woodland (with a flood-tolerant understorey)	9,711	4,002	13,713
River red gum/yellow box/grey box/black box woodland	1,063	2,919	3,982
Total	29,457	36,543	66,000

Ecological Values of the Gunbower- Koondrook-Perricoota Forest

The Gunbower and Koondrook–Perricoota Forests cover approximately 51,000 ha of the River Murray floodplain downstream of Torrumbarry Weir, between Echuca and Barham. Gunbower Forest is a floodplain system of the Murray River located in northern Victoria on the southern bank of the river between Torrumbarry and Koondrook and covers approximately 19,000 ha. The northern bank of the river is occupied by the Koondrook-Perricoota Forest which covers around 32,000 ha. Combined, Gunbower and Koondrook-Perricoota forest forms the second largest river red gum forest in Australia.

Gunbower Forest and Koondrook–Perricoota Forest differ in structure. Gunbower Forest has more permanent and semi-permanent wetlands, partly as a result of a lower commence-to-flow threshold, and also because of its different geomorphology. Gunbower's wetlands are interconnected by a series of flood runners, and surrounded by river red gum (*Eucalyptus camaldulensis*) forest, river red gum woodlands and black box (*E. largiflorens*) and grey box (*E. moluccana*) woodlands. Koondrook–Perricoota Forest is predominantly a river red gum forest, dissected by intermittent flood runners. Black and grey box woodlands fringe the river red gum forest on the higher, less frequently flooded areas. The site is also known to support nesting waterbirds when inundated with significant numbers of birds recorded between 2000-06 (Harrington and Hale 2011). The extent of key floodplain vegetation communities within the Gunbower and Koondrook–Perricoota Forests are outlined in Table 8.

Table 8: Habitat types and areas for Gunbower and Koondrook-Perricoota Forest.

Habitat types	Gunbower (ha)	Koondrook–Perricoota (ha)	Total area (ha)
Permanent wetlands	382	0	382
Semi-permanent wetlands	992	1,700	2,692
River red gum (flood-dependent understorey)	8,423	19,000	27,423
River red gum (flood-tolerant understorey)	4,509	7,000	11,509
Black box woodland	3,126	4,000	7,126
Other	1,768	300	2,068
All types	19,200	32,000	51,200

(Murray-Darling Basin Authority, 2012b)

Ecological Values of the Werai Forest

The Werai Forest covers an area of about 11,000 ha and comprises the northern portion of the NSW Central Murray State Forest Ramsar site, listed in 2003 (GHD, 2009). Werai Forest comprises the greatest extent of river red gum forest and woodlands in the Edward-Wakool System while also containing significant areas of reed beds and other low-lying wetlands that provide suitable waterbird breeding habitat.

The rivers and their associated floodplains and wetlands support a diversity of habitats for a range of aquatic and terrestrial species, including over 20 significant species (Hale & SKM, 2011a). These systems also play a significant role in supporting a high proportion of native fish species, especially through providing habitat suitable for recruitment. The area also provides critical drought refuge habitat for threatened species such as Murray cod (*Maccullochella peelii,* listed as Vulnerable), trout cod (*Maccullochella macquariensis*, listed as Endangered), Eel-tailed catfish (*Tandanus tandanus*) and silver perch (*Bidyanus bidyanus*, listed as Critically Endangered) (Hale and SKM, 2011).

The reach provides habitat for significant waterbird breeding events of hundreds of wetland birds including colonial nesting waterbirds, such as Nankeen night herons (*Nycticorax caledonicus*), egrets and cormorants – if sufficient wetland inundation is achieved (Hale and SKM 2011).

Reconnecting the floodplain with rivers, wetlands and creeks has a range of benefits for native fish and the river and wetland systems that support them. Increased flows will also support the recovery, growth and reproduction of vegetation (Murray Darling Basin Authority 2014a).

This proposal would help to deliver a more natural watering regime which would contribute to restoring floodplain vegetation. Improving riparian health through a more natural wetting and drying cycle would also help improve bank stability and reduce erosion.

What impact has river regulation had on flows?

Increased regulation has resulted in less variability of in-stream flows, reduced flood frequency, a reduced area of extent, and changes in duration of overland flows (Green, 2001). Small and mid-sized flows that used to connect the rivers and creeks to the floodplain and its wetlands are now captured in dams.

While the MDB system exhibits a high level of variability over the long-term, as a result of dams, natural inundation of flood country has been reduced. For example, at Tocumwal, there has been a 30% reduction of small flow events of 20,000 ML/day and a 50% reduction in their duration. Mid-sized flows have also changed; there has been a more than 40% reduction of flows of 50,000 ML/day and a 50% reduction in their duration. The story is similar at Deniliquin, with a 20% reduction in flows of 5,000 ML/day and a 50% reduction in their duration. Flows around 18,000 ML/day have also reduced in frequency by 50% and a 54% reduction in duration.

What will managed environmental flows above 15,000ML/day at Yarrawonga achieve?

Recent experience (since 2011/2012) using environmental water and working cooperatively with Water NSW, landholders and others, has shown that managed flows through the Edward Wakool system results in fish movements when cued properly. Trial environmental flow events were negotiated with landholders and the river operators and the outcomes were monitored in the short and long term. Whilst it is difficult to say that specific flows on a particular date resulted in a certain number of fish being spawned, the consensus is that the Edward-Wakool system, along with the Millewa forests exhibited positive outcomes from these flow events, particularly for fish communities.

Floodplain vegetation inundation is often used as an indicator of river health. Areas riverine vegetation are enlivened by water, building links between the river and other parts of the floodplain, strengthening its diversity and resilience. Whilst it's not as simple as "more is good" and factors like temperature, seasonality and natural cues are important, the opportunity to link the floodplain to the rivers is one way that healthy systems are maintained.

The importance of the Millewa-Edward-Wakool area is recognised by environmental water portfolio managers to the extent that, during the Millennium Drought, areas of refuge for fish and other aquatic species were supported with water from environmental accounts. The maintenance and improvement of the area as well as the maintenance of its connection with the rest of the Murray River system is enhanced by flexible water management and operation.

The Barmah Millewa Forests and the river and floodplain environments of the Wakool System are intricately connected to the Murray River downstream of the central Murray region. Connected by waterways, the central Murray provides broad environmental inputs to the length of the Murray upstream as well as far as the Lower Murray floodplains and Riverland. Increased flexibility in the ability to release environmental water would result in improved local and regional outcomes for native fish, waterbirds and wetlands. It would also contribute flows to ensure 'all-of-system' outcomes.

Whilst flows above 30,000ML/day are not being investigated as part of this concept proposal, based on flood inundation modelling conducted by the MDBA (MDBA 2015) flows at:

- 20,000 ML/day (at Tocumwal) represents flows just above the current regulated flow constraint
- 35,000 ML/day (at Tocumwal) represents flows that would readily reach targets for the Barmah–Millewa Forest and upper reaches of the region
- 50,000 ML/day (at Tocumwal) represents flows that would begin reaching a number of disconnected wetlands and ephemeral creeks in slightly higher parts of the landscape and along the system for its entire length. Disconnected wetlands and creeks which may benefit from these flows include Tuppal, Cockrans, Jimaringle and Gwynnes Creeks

Reconnecting the floodplain with rivers, wetlands and creeks has a range of benefits for floodplain dependent fauna and in particular native fish. Increased flows will also support the recovery, growth and reproduction of various vegetation communities.

Whilst the NSW Government acknowledges the impacts on landholders at higher flow levels, Table 9 shows a basic analysis of the area (in hectares) of wetland and floodplain vegetation that is estimated to be inundated by the above flow levels.

The area inundated was calculated using the Murray River Floodplain Inundation Model (RiM-FIM) inundation footprints prepared for the Yarrawonga to Wakool Reach. Analyses were prepared using inundation footprints compared with vegetation (Cunningham et al. 2013 and the National Vegetation Information System — NVIS 4.1) and wetland (Australian National Aquatic Ecosystem wetlands database) data for the Basin. The results are indicative at this stage however, increased flows show considerable increase in area inundated for targeted wetlands and native vegetation.

Table 9 Area of wetlands and flood-dependent native vegetation that would be inundated at the flow rates being studied for the Yarrawonga Weir to Wakool Junction reach (both public and private lands)

Flow rate (Tocumwal, ML/d)	Red gum woodlands (ha)	Red gum forests (ha)	Black box (ha)	Shrublands (ha)	Wetlands (ha)
20,000	14,000	13,000	6,000	<1,000	18,000
35,000	33,000	26,000	13,000	1,000	23,000
50,000	46,000	32,000	18,000	2,000	25,000
65,000	62,000	38,000	30,000	4,000	28,000

(Murray-Darling Basin Authority, 2014a)

Different flow thresholds have different effects on native vegetation and wetlands, depending on the location of the wetland or vegetation in the landscape. Figure 4 shows that the increase in area of wetlands and red gum forest begins to level out at flows around 35,000 ML/day, whereas the area of vegetation communities higher in the floodplain such as red gum and box woodlands continues to increase beyond 50,000 ML/day.

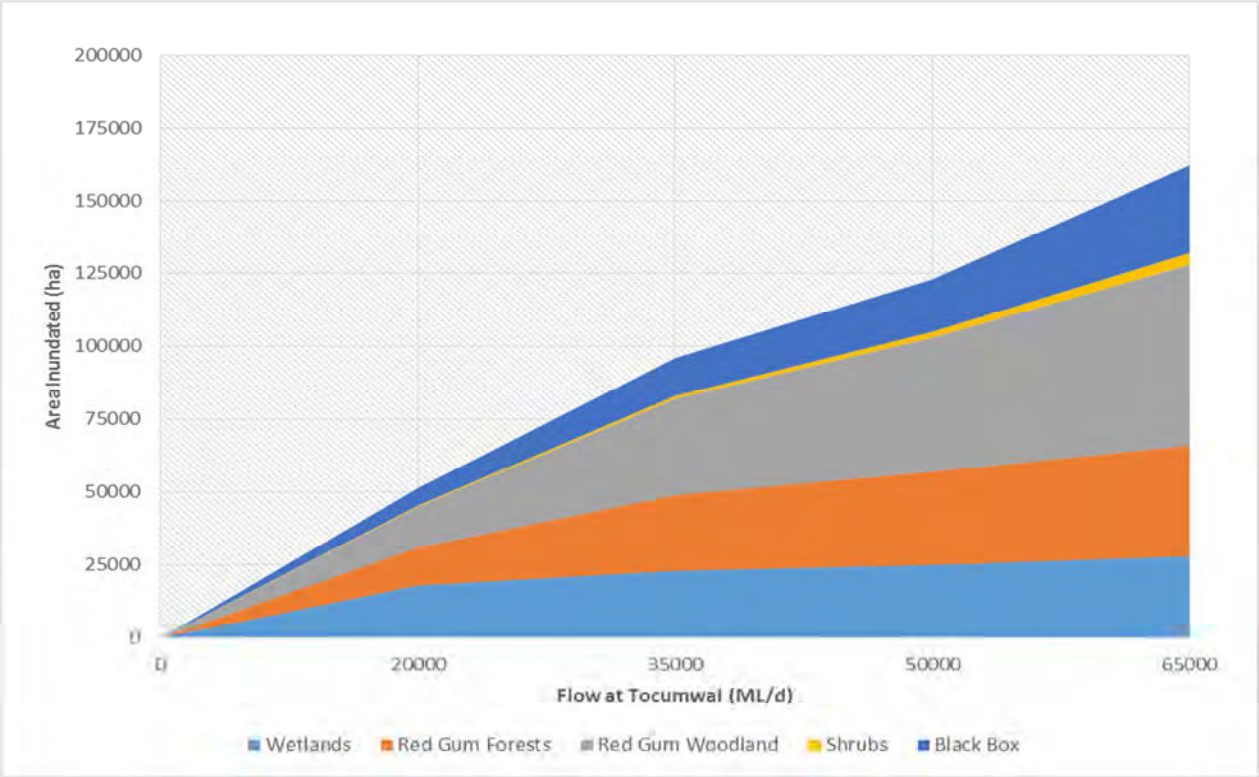


Figure 4 Comparison of the area of wetlands and food-dependent native vegetation inundated by different flow rates (Data from Murray Darling Basin Authority 2014(a))

There is a strong link between vegetation type and frequency of inundation. Black box is higher in the floodplain because it can tolerate less frequent inundation than red gum woodlands. In turn, some wetlands, flooded grasslands/meadows and flooded gum areas are intolerant of prolonged dry conditions. Inasmuch as individual areas are important, diversity in the landscape is also important for those species that rely on a variety of vegetation types for their survival. For example, some species use certain habitats in which to feed and other habitats to breed and nest. Some vegetation areas rely on pollinators from others and so on. This diversity also helps to support towns and populations that benefit from the environment of the floodplain and the rivers running through, connecting it all together.

With increased flows, additional velocities are also achieved adding another layer of variation into a system. The 2004-2005 flood event which involved two additions of the Barmah Millewa Environmental Water Allocation, was shown to be beneficial to Golden and Silver Perch and Murray and Trout Cod (King, A.J., Tonkin, Z. and Mahoney, J. 2007). The rates of flow in other Murray systems (for example, the Lindsay River) have been shown to affect Murray Cod movement and spawning behaviour. Additionally, a variation in flow rates can scour the deeper holes and clean the beds of rivers and streams in parts of the system that would otherwise accumulate saline or acidic water and allow silt to deposit. The Lower Wakool and Niemur Rivers are reaches where flush pulses can export high levels of saline water and allow for freshening of these river environments.

What will target flows of 6,000ML/day into the Koondrook-Perricoota Forest achieve?

An increase in the flow that can be delivered through the forest, up to 6,000ML/d, would permit inundation of target ecological communities for up to 100 days, without retaining water within the forest levees. This would have substantial beneficial ecological impacts. These are described briefly below, together with conditions to optimise them.

Vegetation

There is significant evidence that the vast majority of vegetation communities within the Koondrook-Perricoota floodplain are in less than optimal condition as a result of reduced flood frequency and duration (GHD 2009; FNSW, 2008). The TLM works have been designed to improve the ecological condition of the forest communities and as such, there are many predicted benefits from operation of the works to their full potential.

The MFAT (MDBA, 2009) provides an indication of the optimal inundation durations and timing for the three dominant forest vegetation communities. A comparison of these with the predicted inundation regime indicates that large areas of the forest would be provided with an almost optimal hydrological regime (Table 10) indicating that very large areas of forest would be provided with beneficial inundation durations.

Table 10 Areas of forest community predicted to be inundated for optimal and tolerance durations.

Community	MFAT inundation preferences (MDBA, 2009)	Approximate area (ha) of community predicted to be inundated (DHI, 2008) to match preferences	Approximate percentage of area of community in the Forest (%)	Total area in the Forest (ha)
Black Box woodland	Optimal: 30 – 60 days	590	13	4,463
River Red Gum Woodland	Optimal: 30 – 150 days	1,800	34	5,280
River Red Gum Forest	Optimal: 30 – 250 days	10,000	51	19,742
Floodplain marshes*	Any inundation favourable.	1,217	75	1,622

* The 'optimal' and 'tolerance' range for floodplain marshes varies with plant species composition. However, any inundation is likely to be beneficial.

Expected responses to inundation by forest vegetation communities include:

- Trees and Shrubs (Lignum, Black Box, River Red Gum):
  - Increase in leaf area and canopy condition (possibly flush of epicormic growth);
  - Increased root growth;
  - Flowering and seed production; and
  - Germination of seedlings of tree species (on wet soil following flood recession).
- Germination of wetland plants from the seed bank (during inundation);
- Replenishment of seed bank with wetland plant species (on recession of flood); and
- Increase in diversity and productivity of inundation tolerant and dependant plant species.

From ; MDBA, 2009; Alderidge, 2006.

Waterbirds

Beneficial impacts to waterbirds are anticipated relating to both breeding and foraging habitat. Waterbird nesting requirements for species previously recorded breeding within the Forest indicate that the vast majority of birds require inundated woody vegetation to a minimum depth of 30 cm for 3 to 4 months. Modelling indicates that over 9,000 hectares of woody vegetation would be inundated to a depth of greater than 30 cm and some 4,000 hectares would remain inundated for over four months. A spring / summer

flood event not only would provide optimum timing for waterbird breeding within this inundated area, but due to increased temperatures and therefore productivity, require less of a lag time for waterbird breeding events to commence (MDBA, 2009).

Foraging habitats for waterbirds are based on food preferences, bill shape and morphology and size of the waterbird. Wading species of birds generally require inundated foraging areas with a water depth of < 30 cm. At peak operating potential, approximately 7,000 hectares of the Forest would be inundated to a depth of < 30 cm. This would include large areas under canopy as well as smaller, open areas, providing for feeding and foraging of a number of waterbird species (including international migratory wading species).

Deeper areas on the floodplain and in the channels provide foraging habitat for dabbling ducks and diving species of birds such as cormorants, gulls and terns. At peak inundation, over 5,000 hectares would be inundated to a depth of > 1m, providing foraging habitat for a number of water bird species. Feeding and foraging would be enhanced by the pulse of productivity expected upon inundation.

Native fish

Understanding of native fish use of flooded wetland habitats is in its infancy in Australia. However, evidence from some empirical studies and monitoring of environmental watering at Barmah-Milawa, Hattah Lakes and Chowilla Floodplain have indicated that a number of species benefit from floodplain inundation, either directly by using the inundated habitat on the floodplain or indirectly by increased productivity in the river channel following the release of carbon from the floodplain surface.

A number of native fish are known to use inundated floodplain habitats and it is likely that the increased productivity in the floodplain following inundation is beneficial to some native fish species. The role of the floodplain in providing spawning habitat is less certain and the results of research in comparable floodplain systems in Victoria has indicated that there is little difference in spawning and recruitment in native fish in years of flood as opposed to years when water remains within the river channels.

However, results from Barmah Forest indicate that the floodplain, channels and wetland habitats within the forest system are important for native fish and a diversity of habitats is the key to maintaining native fish diversity. The operation of the works would inundate a number of habitats within the system, including channels and waterways, open water bodies, floodplain wetlands and marshes and inundated forest areas as well as a significant amount of woody debris in localised areas. This would provide a diversity of habitat for both spawning and foraging of native fish.

Other fauna

Evidence from other environmental watering events at icon sites on the Murray River such as Hattah, Chowilla and Barmah have indicated that reinstating a wetting and drying cycle can result in benefits for aquatic biota such as frogs and freshwater tortoises. Increased abundance and diversity of frogs, tortoises, yabbies and crustaceans was recorded at Chowilla three months after inundation and increased abundances of tortoises and frogs were observed in Hattah Lakes following environmental watering.

Proposed inundation is likely to result in suitable habitat for the nine frog species that have been recorded in the forest. The majority of native, wetland frogs in south-eastern Australia prefer inundated vegetated habitat for breeding and foraging. Flooding of the forest would result in approximately 1,000 hectares of inundated shallow marsh, which should provide suitable habitat for frog breeding.

Inundation would result in increased productivity and watering of a large area (approximately 17,000 hectares) of the Koondrook-Perricoota floodplain. This would not only provide increased resources and habitat for aquatic and wetland dependant flora and fauna, but should result in flow on effects to terrestrial species. This has been demonstrated in other comparable areas, such as the increase in the diversity and abundance of bush birds in Barmah Forest following environmental watering. The increase in productivity with an increase in flower, fruit, seed and insect resources on the floodplain has the potential to benefit a wide range of species through the food web.

Flow-through benefits

Achieving inundation associated with 6,000ML/day inflows without ponding would have significant system-wide ecological benefits including:

- A natural flood distribution pattern, limiting inundation of non-target types;
- Excellent modelled water quality parameters, including low likelihood of hypoxic blackwater;
- Unhindered connectivity for fish from the Wakool River to the forest via the Barber and Thule creeks and through to the Murray River via the inlet regulator fishways;
- Avoiding creation of additional carp breeding habitat associated with ponding on the floodplain;
- Limiting drowning of Red Gum germinants and understorey species by maintaining a natural depth profile;
- Maximising germination of understorey species and River Red Gums by completing the recession by early summer;
- Providing the capacity to vary flow rates in downstream systems to minimise geomorphological impacts; and
- Transport of carbon and other nutrients via natural mechanisms to benefit downstream systems.

Water requirements for key environmental assets in the Yarrawonga to Wakool Reach

The ecologically relevant flow thresholds identified in the following sections are based on the objectives of the Basin Plan integrated with local knowledge. However, these flow levels will only be pursued insofar as flow levels are safe, practical and create no unacceptable third party impacts.

Flows required to support the Barmah-Millewa Forest

The regularity, extent, duration and seasonality of flooding within the forests are governed by flow in the Murray River contributed to by the Murray, the Ovens and Kiewa rivers as measured downstream of Yarrawonga Weir. Relatively small changes in topography also influence the distribution and depth of flooding and under certain circumstances the Campaspe and Goulburn can “hold up” floods with their flows into the Murray downstream of the forests. Generally speaking water passes over the floor of the forests as sheet flow in large floods, and flows through the forests predominantly as creek flow during smaller flood events.

Barmah–Millewa Forest is dissected by many ‘effluent’ streams, the largest of which are the Edward River and Gulpa Creek. Key effluents start to flow depending on the level of flow in the Murray River.

Information used to assess environmental water requirements and objectives as part of developing the Basin Plan suggests for the Barmah Forest that Gulf Creek begins to flow at 3,500 ML/day, Boals Creek at 6,000 ML/day and Smiths and Tullah Creeks begin to flow once flows exceed 9,500 ML/day. For the Millewa Forest channel capacities for the Gulpa Creek and Edward River are 350 ML/day and 1,600 ML/day respectively. The Toupna Creek begins to flow at 3,500 ML/day at the Mary Ada Regulator and 7,000 ML/day at the Pinchgut Regulator. Toupna Creek flows will enter the Towrong Creek and Bullatale Creek (via the Aluminy Creek) from around 12,000 ML/day with the Mary Ada Regulator open. Murray River flows > 20,000 ML/day enter eastern Millewa and the Aratula Creek via the Low Sandy effluent channel. Mid-range Murray River flows (with all forest regulators open, including Mary Ada and Pinchgut) will eventually deliver flows into the Tootalong Creek and Cornalla Creek systems, which will ultimately flow into the Edward River via Winter Creek, Gerapna Creek and the Wild Dog Creek. Other ecologically relevant flow thresholds (downstream of Yarrawonga Weir) for the forests include:

- 35,000 ML/day is the minimum flow to inundate River red gum forest, open wetlands and provide a sufficient one metre depth across the Moira grass plains, and provide effective flows to transfer dissolved organic carbon, nutrients and plankton into the main river channels (Water Technology, 2009);
- 50 days of flows greater than 15,000 ML/day from mid-spring result in a high probability of breeding attempts by ibis, spoonbills, herons and egrets in the forest (Overton, Colloff, Doody, Henderson, & Cuddy, 2009). These flow thresholds are broadly consistent with (Leslie, 2001), which identified 18,330 ML/day with Victorian Department of Sustainability and Environment (2008), recommending a slightly high threshold of 20,000 ML/day;
- flows of 35,000 ML/day inundate most River red gum forest with flood-dependent understorey and return flows from the floodplain to the main river channels. Higher flows up to and in excess of 60,000 ML/day are needed to inundate River red gum/Black box woodland located at higher elevations on the Millewa floodplain (Water Technology, 2009).
- Flows > 900 ML/day for at least 30 days (if re-watering the forest after a drying regime) from the Gulpa Creek offtake are required over mid-winter to early spring to fill Gulpa Creek wetlands (Reed Beds Swamp, Coppingers Swamp and Duck Lagoon) and allow flows to enter Moira Forest (and Moira grass plains) via Coolamon Creek. Flows of this magnitude are also required to flush Gulpa Island using Deadmans Creek, Campbells Creek and McCartneys Creek. McCartneys Creek flows will ultimately discharge into the Edward River. These early season flushing flows can be an important method in helping to reduce the chances of hypoxic blackwater events occurring late in the season if higher flows are experienced.
- Edward River offtake flows > 1,800 ML/day are required to fill St Helena Swamp and Black Swamp (significant colonial nesting waterbird sites). Flows of this magnitude will also enter the Little Edward (anabranch) and fill the Duffy's Lagoon and White Swamp area of the forest.

Flows required to support key elements of the Edward-Wakool system

Some of the ecologically relevant flow thresholds and durations and the associated expected environmental objectives/outcomes for the Edward-Wakool River System are:

- Up to 6,000 ML/day at Stevens Weir (generally at least 4 metres at Deniliquin) over mid-winter and early spring for significant flooding of reed beds and low-lying River red gums in Werai Forest (Green & Alexander, 2006);
- Up to 4,500 ML/day at Moulamein to provide low-level floodplain inundation to transfer DOC, nutrients and plankton into the main river channel;
- Up to 800 ML/day in the Yallakool Creek and up to 200 ML/day in the Wakool River (from the offtake) over mid-winter and early spring to create bank-full flows for in-stream vegetation and transfer dissolved organic carbon, nutrients and plankton into the main river channel;
- Up to 1,000 ML/day in the Wakool River (at Barham) to provide dilution for flows entering the main river channel from the Thule Creek, Barber Creek and Yarrein Creek, and other ephemeral creeks;
- Exceed 1,600 ML/day over mid-winter and early spring at Stoney Crossing to flush deep saline holes in the lower-Wakool River;
- Up to 1,500 ML/day over mid-winter and early spring in the Niemur River (at Barham-Moulamein Road Bridge) to provide low-level River red gum floodplain inundation to transfer DOC, nutrients and plankton into the main river channel, and provide dilution for flows entering the river from the Cockran-Jimaringle creeks, and other ephemeral creeks.

Flows required to support the Gunbower- Koondrook-Perricoota Forest

Flows begin to enter Gunbower Forest from the Murray River via a number of effluent streams, with the lowest flow threshold at Shillinglaws Regulator on Yarran Creek, which commences to flow at 13,700 ML/day at Torrumbarry. Key ecologically relevant flow thresholds (expressed at Torrumbarry) for the forest include:

- Flows < 18,000 ML/day (downstream of Torrumbarry Weir) begin entering low level offtakes to the Koondrook Perricoota on the Murray. Flows can be managed into the Gunbower and Perricoota-Koondrook forests using water delivery infrastructure from the Torrumbarry Weir pool.
- Return flows from Perricoota-Koondrook (via either Thule Creek or Barber Creek) should be coordinated with receiving flows in the Wakool River to ensure sufficient dilution for water quality purposes if required and manage flows below the agreed flow constraint level, which is particularly relevant to the Bookit Island section of the Wakool River

A2.2 Environmental benefits downstream of the Yarrawonga to Wakool Reach

Key environmental assets downstream of the Yarrawonga to Wakool reach that would benefit from relaxation of constraints include the Hattah Lakes and the Riverland-Chowilla Floodplain. Together with relaxation of constraints in the Hume to Yarrawonga and Lower Murray reaches, this measure will assist in delivering overbank watering events to help achieve the Basin-wide outcomes identified in Table 11.

Table 11 Summary of environmental outcomes at whole-of-Basin level (Murray Darling Basin Authority, 2011).

Habitat areas	General outcome across the Basin
Riparian or 'streamside' habitats	The ability to reinstate more frequent and variable 'bank-full' events which will maintain healthy streamside vegetation such as river red gums and river cooba.
Permanent and semipermanent wetland habitats close to the major rivers	The ability to reinstate more frequent and variable flow regimes to provide healthy wetland habitats and support the role that these systems play in the productivity of the river system more broadly - for example providing breeding and feeding habitats for birds and fish, and carbon/nutrient inputs to support instream productivity.
Low level floodplain habitats	The ability to reinstate more frequent and variable flow regimes to water low level floodplain vegetation communities such as red gum forests and woodlands, to maintain the health of these communities and the important role they play in the broader productivity of the Basin's rivers.

A2.3 Alignment with Existing Plans, Strategies and Environmental Objectives

When combined with relaxed flow constraints in other reaches of the Murray River and tributary systems, implementation of the Yarrawonga to Wakool CMS would contribute to pursuing the enhanced environmental outcomes of Schedule 5 of the Basin Plan, in particular (2)(f) and (2)(g):

> "(f) providing opportunities for environmental watering of an additional 35,000 ha of floodplain in South Australia, New South Wales and Victoria, improving the health of forests and fish and bird habitat, improving the connection to the river, and replenishing groundwater; and
>
> "(g) Achieving enhanced in-stream outcomes and improved connections with low to middle level floodplain and habitats adjacent to rivers in the southern Murray-Darling Basin." (Commonwealth Government of Australia, 2012).

The Basin-wide Environmental Watering Strategy, identifies maintaining vegetation, wetlands and waterbirds as important outcomes and identifies overbank flows, with water volumes greater than the channel capacity, as important to "recharge wetlands and important for floodplain vegetation, fish and waterbirds, as well as productivity." In addition, the Basin-wide Environmental Watering Strategy also identifies the importance of using environmental water to mimic natural patterns as this is "most likely to produce desired environmental responses" (Murray Darling Basin Authority, 2014c).

This measure would also align with the river flows and connectivity outcomes identified in the Basin-wide Environmental Watering Strategy, specifically:

> "Improved connectivity with bank-full and/or low floodplain flows by 30–60% in the Murray, Murrumbidgee, Goulburn and Condamine–Balonne." (Murray Darling Basin Authority, 2014c).

In addition this measure can assist in restoring connectivity between the River Murray and its surrounding floodplains, also identified as one of the 2014-15 environmental watering priorities:

> "Connectivity in the River Murray System: improve riparian, littoral and aquatic vegetation (e.g. *Ruppia tuberosa*) and native fish populations by increasing ecosystem connectivity through coordinating water delivery in the River Murray system." (Murray Darling Basin Authority, 2014).

This measure would help to achieve several of the Commonwealth Environmental Water Holders (CEWH) environmental water delivery objectives, outlined in the following tables. These objectives have been developed with existing constraints in place, and may expand if constraints could be relaxed.

The objectives are presented for water availability scenarios. The scenarios refer primarily to the amount of environmental water that is available in a given year, thus determining the environmental watering objectives (Cooling and SKM, 2012). When water is scarce it will be used to maintain ecosystem viability, and when water is abundant it will be used to promote long-term ecosystem health and increase the size and resilience of populations (Cooling and SKM, 2012).

Environmental water is used most efficiently when building on natural flows (Cooling and SKM, 2012). Environmental water availability scenarios are not entirely independent of ambient flow conditions. It is most likely that environmental water reserves will be low when river flows are low, and that higher flows will already be occurring in years when environmental water reserves are high. Given this, the following tables describe median to wet water availability scenarios.

Commonwealth Environmental Water Holder Environmental Water Delivery Objectives – Yarrawonga to Tocumwal and Barmah-Millewa Forest (Ecological Associates, SKM 2011)

Environmental Asset	Objectives	
	Median Water Availability Scenario	**Wet Water Availability Scenario**
Watercourses	• achieve multiple fish spawning events • inundate organic debris, reduce summer blackwater risks and export organic matter to Murray River (including the Gulpa Creek and Edward-Wakool systems) • support waterbird nesting in riparian trees (i.e. maintain nesting and foraging habitat for colonial nesting waterbird species such as the egrets, herons and cormorants).	• process and export organic matter and support fish breeding. • support waterbird nesting in riparian trees (i.e. maintain nesting and foraging habitat for colonial nesting waterbird species such as the egrets, herons and cormorants).
Giant Rush Wetlands	• initiate and support breeding by a variety of waterbirds such as ibis, swans, spoonbills, bitterns • provide additional habitat for fish, frogs, yabbies and turtles • maintain a mosaic of open water and rush/reed bedsconnect wetlands via watercourses and provide recolonisation/dispersal opportunities within the forest for aquatic fauna • maintain vegetation structure and prevent river red gum encroachment.	The same objectives as those sought under the Median Scenario.
Moira Grass Plain	• maintain moira grass growth and vegetative reproduction • provide nesting and foraging habitat for waterbirds such as egrets, herons, grebes, terns • provide adequate water depth and flood frequency to restrict invasion of giant rush and river red gums into moira grass plains. • Allow fish to return to permanent habitat on the flood recession.	The same objectives as those sought under the Median Scenario.
Red Gum Forest	• maintain river red gum growth • inundate organic debris, reduce summer blackwater risks and export organic matter to Murray River. • Allow fish to return to permanent habitat on the flood recession.	The same objectives as those sought under the Median Scenario, plus: • maintain river red gum reproduction • inundate terete culm sedge community • provide feeding locations for waterbirds

Commonwealth Environmental Water Holder Environmental Water Delivery Objectives - Edward-Wakool system (Hale and SKM, 2011)

Environmental Asset	Objectives	
	Median Water Availability Scenario	**Wet Water Availability Scenario**
Permanent, semi-permanent regulated rivers and creeks (>1,000 km) Reed Bed Creek Wetlands (Werai Forest)	• Maintain water quality within channels and pools. • Reduce the frequency and magnitude of blackwater events, by preventing the accumulation of litter in channel and on bars and benches. • Prevent stratification in shallow pools and provide sufficient water to dilute any water quality impacts associated with breaking stratification of deep pools. • Maintain inundation of wetlands connected at pool level to minimise exposure of ASS. • Promote productivity to maintain food webs and ecosystem function for in-channel flora and fauna. • Maintain connectivity between main channel and low lying wetlands as well as billabongs and backwaters. • Provide fish passage and allow biota to complete flow driven critical life cycle processes such as spawning, seed setting and dormant stages. • Maintain extent and health of reed bed vegetation • Promote successful breeding of waterbirds with short breeding cycles.	• The same objectives as those sought under the Median Scenario plus: • Reconnect refuge holes • Promote productivity to maintain food webs and ecosystem function for in-channel flora and fauna.
River red gum forests located in Werai and Niemur Forests Black Box woodlands and ephemeral wetlands and water courses around Cockran & Yarrien Creeks and Poon Boon Lakes		• Maintain health of river red gum forests and woodlands. • Promote productivity to maintain food webs and ecosystem function for in-channel flora and fauna. • Maintain connectivity between main channel and floodplain. • Maintain health of Black Box woodlands, and ephemeral creeks and watercourses.

Commonwealth Environmental Water Holder Environmental Water Delivery Objectives – Gunbower Forest (Cooling and SKM, 2012)

Environmental Asset	Objectives	
	Median Water Availability Scenario	**Wet Water Availability Scenario**
Gunbower Creek and Forest watercourse	• maintain aquatic habitat to support local fish populations • maintain passage at fishways in winter and spring • support fish breeding. • Provide sustained connection between Gunbower creek and the forest to allow movement of fish • maintain riparian vegetation health • provide dispersal opportunities for fish between the river, forest and Gunbower Creek • support breeding by some waterbirds along watercourses and temporary wetlands • process and export organic matter and reduce blackwater risks.	The same objectives as those sought under the Median Scenario.
Permanent and semi-permanent wetlands	• maintain aquatic habitat for fish, invertebrates, turtles and birds throughout the year • inundate fringing reedy vegetation to promote breeding by fish, frogs, turtles and waterbirds • provide open water habitat for breeding waterfowl • support breeding by colonial nesting waterbirds with a requirement for a short period of inundation in fringing river red gum including ibis, darter and spoonbill • connect wetlands via watercourses and provide recolonisation/dispersal opportunities within the forest for aquatic fauna • maintain vegetation structure and prevent river red gum encroachment.	The same objectives as those sought under the Median Scenario plus: • support breeding by colonial nesting waterbirds with a requirement for a long period of inundation in fringing river red gum including egret and heron
River red gum and Black box communities	• maintain growth of river red gum trees • promote aquatic plant growth in understorey including Moira grass, milfoil and spike sedge • support post-flooding productivity of river red gum understorey • provide waterbird feeding habitat • inundate organic debris, reduce summer blackwater risks and export organic matter to Murray River • allow fish to return to permanent habitat on the flood recession • Within Black box communities maintain tree health and understorey productivity and composition.	The same objectives as those sought under the Median Scenario.

Commonwealth Environmental Water Holder Environmental Water Delivery Objectives – Koondrook-Pericoota Forest (Hale and SKM, 2011)

Environmental Asset	Objectives	
	Median Water Availability Scenario	Wet Water Availability Scenario
permanent and semi-permanent wetlands as well as River red gum and Black box communities	• Maintain and enhance channel and wetland habitats: • Maintain extent and improve condition of river red gum forests. • Promote successful breeding of waterbirds (short life cycle e.g. waterfowl). • Provide fish passage through existing fishways located at and inside the forest • Maintain extent of swamp wallaby grass. • Prevent excessive build-up of organic matter on the floodplain surface to minimise impacts to receiving waters.	The same objectives as those sought under the Median Scenario plus: • Maintain extent and improve condition of river red gum woodlands. • Maintain the health of black box woodlands. • Promote successful breeding of waterbirds (long life cycle e.g. colonial nesters).

Appendix 3 Summary of methodology used to assess extent of impact and cost of mitigation

The MDBA commissioned the following studies into the extent of impact and cost of mitigation in the Yarrawonga to Wakool reach:

Subject	Author	Date of Report	Reference
Private Agricultural Land	GHD	Final Report – Yarrawonga to Wakool Reach	GHD (2016)
Public Infrastructure	AECOM	11 May 2016	AECOM (2016 a), AECOM (2016 b)
Levees	AECOM	6 April 2016	AECOM (2016 c)
Specialist Activities	Jacobs	17 May 2016	Jacobs (2016)
Design, Approvals and Works Supervision	Jacobs	16 October 2015	Jacobs (2015)

A brief description of the methodology used in each study is provided below. All costing studies were based on frequency data from two hydrological model runs – 50,000ML/day and 65,000ML/day at Yarrawonga. Costs for 35,000 and 40,000ML/day were based on extrapolated flow data provided by the MDBA.

Private Agricultural Land - GHD (2016)

- Based on inundation maps and hydrological modelling supplied by MDBA (inundation maps assumed to over-estimate area inundated and hydrologic modelling provided an overestimate of the number of opportunities available for managed environmental watering events.
- Divided the reach into eight sub-reaches provided by MDBA.
- Land use based on data from Australian Collaborative Land Use and Management Program (ACLUMP).
- Aggregated land use into 4 categories – Grazing Tolerant Pasture, Grazing Vulnerable Pasture, Crop and Horticulture.
- Overlaid cadastral data to determine property details. The number of properties is considered an overestimate resulting from isolated small pixels occurring in the modelled data which are being interpreted as individual properties.
- Costing based on whole of reach estimates, not accurate at an individual property scale.
- Visited 3 farms in the reach to test assumptions.
- Assumed that for every ha of inundated land there is 5.13ha of interrupted access (based on farm visits).
- Assumed that the areas of interrupted access are higher production value than inundated land.
- Adjusted stocking rates, crop production yields, and agricultural land worth for each land use within each sub-reach.
- Costed loss of production for each land use for each sub-reach for flow events less than 7 days duration and more than 7 days duration, as well as additional costs to business eg clean up, fence repair, moving pumps, additional livestock husbandry costs, weed control, reestablishment of vulnerable pastures.
- Costed every event identified by the hydrological modelling across a 114 year period, in today's dollars (considered to be significantly higher than the actual number of managed flow events likely to occur under actual conditions).

- Applied published gross margins and expressed reduction in production and increased costs as a reduction in gross margin to arrive at a percentage equivalent to the "degree of affectation".
- Applied the degree of affectation against the agricultural land worth of the sub-reach and land use type.
- Infrastructure costs including crossings, culverts, raising of tracks, erosion control and pump raising were based on an allowance of $50,000 per farm for all farms experiencing a level of inundation greater than 10 ha.
- Assumed a cost of negotiation with individual landholders and provision of farm advice to landholders based on a representative group approach.
- Peer reviewed outcomes with local experts.

Public Infrastructure – AECOM (2016)

- Based on inundation maps and hydrological modelling supplied by MDBA (inundation maps assumed to over-estimate area inundated and hydrologic modelling provided an overestimate of the number of opportunities available for managed environmental watering events.
- Based on stakeholder consultation, identified three response measures to address impacts on public infrastructure:
  - Asset reinstatement: rectification work undertaken following an environmental flow to reinstate the asset to a similar condition and function to that in place prior to the environmental flow;
  - Operational response: actions taken by the asset owner to manage the environmental flow prior to, during or post the event;
  - Capital works: work undertaken to improve an assets ability to maintain functionality during an environmental flow so as to avoid the need for asset reinstatement work.
- Created "moderate" and "high" costs for each flow scenario with the high cost providing an allowance for the level of uncertainty.
- Considered costs for events less than 7 days duration and greater than 7 days duration.
- Built on the work done as part of the pre-feasibility study with the quantity of impact and costs modified as a result of revised modelling and stakeholder consultation which identified new response measures, new asset types and costing assumptions.
- Study focussed on impacts to sealed roads, unsealed roads, tracks, bridges, culverts, fords, landscaped areas and sole access to properties.
- The cost was calculated on the marginal difference between the existing flow range and the modelled flow range for each scenario, over a 30 year period.
- Costs are expressed in present value.

Levees – AECOM (2016 c)

- Existing reports and GIS data layers were reviewed to determine the extent and quality of all available levee data.
- While some data was accurate most was inaccurate and in some cases non-existent.
- There was little data available on levee condition.
- A customer built GIS tool was produced to allow the high quality topographical LiDAR data to be used as a basis for digitising the location of existing levees.
- Levees on both public and private land were identified.
- Levees were categorised as overtopped, flood controlling, earthen, unsealed road or track, sealed road or track, public and private.
- Potential levee failure mechanisms and deterioration modes were linked to environmental flow events less than 7 days duration and more than 7 days duration.
- In the absence of age and condition data, levees were assumed to be constructed since the 1950s and considered in the last 30 to 40 year period of their expected life.
- Levee reinstatement costs have been estimated for a 30 year period.

- No regular maintenance costs were included in the costs.
- The cost of undertaking levee condition inspections on public land was identified and estimated as an annual cost over 5 years.
- Costs were assumed to be evenly spread over the 30 year period.
- Assumed that expenditure commences in 2017 and concludes in 2046.
- All costs have been escalated at 2.68% per year.
- All costs are expressed in present value.
- Response measures were broken down into itemised tasks and expressed as a $/m cost.
- Costs such as repair, widening, restoration, replacement, vegetation removal, traffic management and temporary traffic diversion were included.
- Contingencies were applied where costing uncertainties existed.

Specialist Activities – Jacobs (2016)

- The specialist activity types included in the study included residential property, tourism and recreational assets (caravan parks, river based businesses, cafes, cellar doors), primary industry excluding broad acre agriculture, dairy and orchards (quarries, aquaculture, forestry).
- Case studies were undertaken on a number of representative businesses.
- Desk top assessment using GIS to determine businesses potentially affected.
- Costs were calculated for clean-up, turf repair, access track repair, daily rate business losses and infrastructure options, including construction of new levees and raising access tracks.
- Costs were estimated over the difference between the current number of flow events and the number of modelled events over a 30 year period.
- Costs were escalated at a rate of 2.68% and presented in present value.
- At the 50,000Ml/day flow range in the Yarrawonga to Wakool reach the study identified 9 residential, 4 tourism and recreational, and 2 primary industry assets that were potentially impacted.

Appendix 4 Summary of Impacts

Source of Information : MDBA (Derived from inundation mapping, cadastral information and assumptions made in the costing studies conducted by GHD, AECOM and Jacobs). The extent of impact will be further investigated in the next stages of project planning and design. It is expected that more accurate inundation maps will be generated from observations of natural flow events as and when they occur.

Impact		35,000 scenario		40,000 scenario		50,000 scenario		Proposed Mitigation Activity
		NSW	VIC	NSW	VIC	NSW	VIC	
Inundation of agricultural land	Number of properties affected[7]	1,353	101	1,455[8]	131[9]	1,395	118	Affects negotiation and legal costs
		Total 1,454 across both jurisdictions		Total 1,586 across both jurisdictions		Total 1,513 across both jurisdictions		
	Cropping	665 ha	246 ha	751 ha	284 ha	836 ha	320 ha	Landholder Agreements
	Tolerant pasture	12,521 ha	75 ha	13,456 ha	293 ha	17,007 ha	656 ha	
	Vulnerable pasture	2,997 ha	162 ha	3,177 ha	183 ha	3,842 ha	197 ha	
	Horticulture	1 ha	12 ha	1 ha	14 ha	1 ha	20 ha	

[7] Affected properties were identified as those on private agricultural land that were subject to inundation (based on modelling) within any part of the property boundary. "Property" means an area of land subject to private tenure and delineated as such in the relevant state land/property register. The "number of properties" is I kely to be different to the "number of landholders" as one property may have multiple owners, and one landholder may own multiple properties. The individual costings reports for each reach provide more information on the number of properties with inundation extents categorised by size.

[8] The number of properties assessed for the 40,000 ML/day analysis is not comparable to the numbers assessed for the other flow rates. This is because the 40,000 ML/day inundation layer had a degree of "noise" (i.e. intermittent pixels showing inundation, outside the main inundation extent) which resulted in a relatively larger number of properties being counted as affected by inundation, even though this inundation was assessed as minimal (<1 hectare). The reported property numbers are therefore partly a function of this discrepancy in the inundation layer.

[9] See note 2 above

Impact		35,000 scenario		40,000 scenario		50,000 scenario		Proposed Mitigation Activity
		NSW	VIC	NSW	VIC	NSW	VIC	
	Total area affected	16,183 ha	496 ha	17,385 ha	774 ha	21,686 ha	1,193 ha	
Impacts on farm infrastructure	Haysheds, silos, livestock yards	Landholder consultations were not completed for 35,000 and 40,000 scenarios. It is assumed that impacts would be of a similar nature to for the 50,000 scenarios.				Generally located off the floodplain however some individual properties impacted.		
	Pumps					Pumps of main significance as other structures generally are located away from the floodplain. These need to be removed when a high flow is anticipated. Depending on location and type of pump, this can result in a significant increase in management time.		Infrastructure/ Landholder Agreements
	Fences					Flooding could result in a build-up of debris along fences and weaken their structure and reduce longevity.		Landholder Agreements

Impact		35,000 scenario		40,000 scenario		50,000 scenario		Proposed Mitigation Activity
		NSW	VIC	NSW	VIC	NSW	VIC	
Farm management issues	E.g. animal health, weeds, clean up and farm planning					Range of impacts including increased costs of mustering, weed control		Landholder Agreements
Interrupted access[10] to private agricultural land	Area of land (200% interrupted access)	32,366 ha	992 ha	34,810 ha	1,550 ha	43,372 ha	2,386 ha	Combination of Landholder Agreements and new or upgraded bridges and crossings
	Area of land (513% interrupted access)	83,014 ha	2,542 ha	89,288 ha	3,975 ha	111,265 ha	6,103 ha	
	Affected private bridges	On-ground property assessment required to develop estimate. 304 properties were assessed as having inundation of >10 ha and are considered more likely to have affected bridges and crossings.		On-ground property assessment required to develop estimate. 327 properties were assessed as having inundation of >10 ha and are considered more likely to have affected bridges and crossings.		On-ground property assessment required to develop estimate. 389 properties were assessed as having inundation of >10 ha and are considered more likely to have affected bridges and crossings.		
	Affected private crossings							

[10] GHD generated impact and cost estimates for two assumptions regarding the level of interrupted access: a scenario where the area of interrupted access was assumed to be 200% of the area inundated, and a scenario where the area of interrupted access was assumed to be 513% of the area inundated. The higher 513% assumption was based on a limited sample of three properties and is considered to be a high estimate. It compares to a ratio of up to 82% assessed during the prefeasibility phase, calculated from a sample of 32 properties). The 200% represents an intermediate point between the 80% and 513% assumptions.

Impact		35,000 scenario		40,000 scenario		50,000 scenario		Proposed Mitigation Activity
		NSW	VIC	NSW	VIC	NSW	VIC	
Damage to public infrastructure	Sealed roads	3,903 m	387 m	4,141 m	396 m	4758 m	397 m	Reinstatement activities
	Unsealed roads	7,423 m	1,694 m	9,057 m	1,970 m	13396 m	2577 m	
	Tracks	305,292 m	4,718 m	370,236 m	5,194 m	472743 m	7879 m	
	Shared user paths	666m	46m	719 m	91 m	880 m	131 m	
	Culverts	77	2	83	3	93	5	
	Bridges	40	5	41	5	43	6	
	Landscaping	26ha	17ha	28ha	35ha	31 ha	46 ha	
	Other							
Significant impacts on public infrastructure	Isolated Property Access road upgrades	Isolated Property Access road upgrades – assuming 1% of impacted properties require 100m of unsealed road upgrade		Isolated Property Access road upgrades – assuming 1% of impacted properties require 100m of unsealed road upgrade		Isolated Property Access road upgrades – assuming 1% of impacted properties require 100m of unsealed road upgrade		Raise road

Impact		35,000 scenario		40,000 scenario		50,000 scenario		Proposed Mitigation Activity
		NSW	VIC	NSW	VIC	NSW	VIC	
	Community Levee for Residential Properties in Cobram Street, Tocumwal[11]	1		1		1		Up to 1 metre high levee, and up to 150 metres long.
	Ferry Crossing at Speewa Punt Road	nil	1 crossing	nil	1 crossing	nil	1 crossing	Upgrade ferry crossing
Impacts to overtopped levees	Earthen and Road (sealed and unsealed) Levees	30.56km	8.03km	38.5km	8.6km	46.5km	11.9km	Capital response measures
Impacts to flood control levees	Earthen and Road (sealed and unsealed) Levees	248.2km	47.6km	274.6km	57.7km	313.3km	65.9km	
Impacts on specialist activities	Caravan parks	1	nil	1	nil	2	nil	Commercial Agreements, New Levees, Raised Access Road
	Forestry	nil	nil	nil	nil	1	nil	Purchase additional logging equipment
	Forestry	nil	nil	nil	nil	nil	nil	Easement / Business operation agreement

[11] Inundation modelling identifies potential impacts. Existing town stormwater infrastructure may already be sufficient to prevent impacts.

Impact		35,000 scenario		40,000 scenario		50,000 scenario		Proposed Mitigation Activity
		NSW	VIC	NSW	VIC	NSW	VIC	
	Quarry	nil	nil	nil	nil	1	nil	Commercial Agreements, Easements, Raised Access Roads.
	Abattoir	nil	1	nil	1	nil	1	Commercial Agreements, Easements, Raised Access Roads.
	Club/Sports court	2	nil	2	nil	2	nil	Commercial Agreements, Easements, Raised Access Roads.
	Residential/rural residential properties	6	1	6	1	8	1	Commercial Agreements, Easements, Raised Access Roads.

Appendix 5 Economic and Socio-Economic Benefits of Higher Environmental Flows

Infrastructure benefits

Individual landholders will benefit from flow mitigation measures, such as improving creek crossings and roads, as this infrastructure will also provide benefits during natural flow events that would have happened anyway. Investment to remove, replace or upgrade infrastructure to maintain landholder access during high river flows, and improve flow variability and fish passage, would provide local social, economic and environmental benefits.

Forestry and grazing benefits

There are approximately 383,100 hectares of River red gum within the Riverina Bioregion, and 54.9% (210,500 hectares) of this area is private land. There are unquantified economic opportunities to the region from grazing native pasture, apiculture, and private native forestry on land holdings that benefit from overbank flow events (natural and managed) that deposit water, carbon and nutrients into the soil. Transfer of dissolved organic carbon, nutrients and plankton from the floodplain back to the river systems by mid-sized events also provides benefits to the riverine foodwebs, and native fish in particular.

Improving flow variation, removing barriers to fish movement, improving river-floodplain connectivity and habitat, and transferring dissolved organic carbon (DOC), nutrients, zooplankton and phytoplankton from the floodplains to the river systems to energise food webs is likely to strengthen native fish populations

In 2012, Deloitte Access Economics (DAE) reported the *Benefits of the Basin Plan for the fishing industries in the Murray-Darling Basin*. The report found that in the Murray-Darling Basin from 2010 to 2011 there were 429,857 anglers, a direct expenditure from recreational fishing of $1,352 million and flow-on effects of $375 million, the contribution to the gross domestic product was $403 million, and 10,950 jobs were produced from recreational fishing over this period. According to the report, Murray cod and Golden perch have the highest economic importance, and that a 10% increase in fish numbers would likely increase the numbers of recreational fishers and expenditure by 5%. An industry workshop advised that when valuing the fishing industry the social benefits (for example, mental health benefits) must be included, and that natural amenity and having a variety in fish species add to the enjoyment of recreational fishing (DAE 2012, pp. 39-40).

However, the expected positive impacts of additional environmental water on native fish populations will only be achieved if hypoxic black water events are avoided as far as possible through appropriate timing and coordination of flow events.

Increasing the numbers of visitors to the red gum forests, and improving the quality of their experience, will provide direct economic outcomes for small and regional communities and businesses

Forests NSW (2008) estimated 500,000 visitor days per year to the Riverina River red gum state forests, and the NSW Natural Resources Commission (NRC 2009) reported that in 2008 the eastern central Riverina region received 4.3 million visitors, with 6 million visitor nights. A visitor count in the regional River red gum national parks (using car counters together with survey data measuring ‘people per vehicle’) showed a 23% increase in visitors between 2011-2012 and 2012-2013 and a further 37% increase between 2012-2013 and 2013-2014. According to the survey the average length of stay was 2.52 nights and average nightly spend $172. Therefore, the increase of 54,446 visitors in 2012-2013 is valued at $23.6 million and the further increase of 127,594 when comparing the 2012-2013 and 2013-2014 is valued at about $55.3 million in increased economic value (Tourism Research Australia 2015).

Improving river water quality and health

The 'Regulation Impact Statement – Basin Plan' notes that improvements to river salinity and water quality would have positive social and economic benefits to Basin communities (Australian Government 2012). The lower Wakool River (downstream from Gee Gee Bridge to the confluence with the Murray River) is renowned as a saline groundwater intrusion site where low oxygen zones are formed by chemical stratification during low flow conditions. A flow of 1,570 ML/day at Stoney Crossing is required to flush saline water out of the deepest hole (Green 2000). Flows above 35,000 ML/day (below Yarrawonga) and 5,000 ML/day (below Stevens Weir) are required to provide flushing flows through the Barmah-Millewa Forest and Werai Forest respectively. Flushing flows during mid-winter and early spring are required to dilute tannins and transfer DOC, nutrients and plankton to the main river channels. Blue Green Algal alerts, such as during summer 2016, can be expected to reoccur in the drying system predicted by climate change, i.e. with lower general water availability, and consistently low flows through creeks and rivers with high nutrient inputs. Importantly, mitigation of water quality impacts cannot be reliably achieved without ongoing relief of system flow constraints.

Appendix 6 Estimated costs (as at June 2016) – Note all costs are net of taxation

Source of information: Consultants commissioned by MDBA. Note that all cost estimates below $1 million have been rounded up to $1 million. Other cost estimates have been rounded to the nearest million following normal convention. The totals reflect this rounding.

These costing estimates along with additional budget items included as contingencies will be updated through new costing work to be undertaken by DPI Water, when more accurate information on extent of inundation and the timing, frequency and duration of future environmental flow scenarios is available.

Estimated costs, assuming maximum regulated flow limit of 35,000ML/day

Cost category		New South Wales ($m)	Victoria ($m)	Total ($m)
Costs of mitigation measures	Easements and associated negotiation costs	21	1	22
	Infrastructure on private agricultural land	8	1	9
	Operational response measures	2	1	3
	Capital works on public infrastructure	1	1	2
	Reinstatement of public infrastructure	11 to 14	2	13 to16
	Works on levees	3 to 4	1	4 to 5
	Arrangements with specialist activities	1	1	2
Potential additional infrastructure implementation costs		**6 to 17**	1 to 4	7 to 21
Potential program management costs				15 to 23 [Assume same as for 50,000 scenario]

Cost category	New South Wales ($m)	Victoria ($m)	Total ($m)
TOTAL ($m)	**53 to 68 (excluding program management costs)**	**9 to 12 (excluding program management costs)**	**77 to 103**

Estimated costs, assuming maximum regulated flow limit of 40,000ML/day

Cost category		New South Wales ($m)	Victoria ($m)	Total ($m)
Costs of mitigation measures	Easements and associated negotiation costs	19	1	20
	Infrastructure on private agricultural land	8	1	9
	Operational response measures	3	1	4
	Capital works on public infrastructure	1	1	2
	Reinstatement of public infrastructure	19 to 23	3	22 to 26
	Works on levees	3 to 4	1	4 to 5
	Arrangements with specialist activities	1	1	2
Potential additional infrastructure implementation costs		7 to 25	2 to 4	9 to 29

Cost category	New South Wales ($m)	Victoria ($m)	Total ($m)
Potential program management costs			15 to 23 [Assume same as for 50,000 scenario]
TOTAL ($m)	**66 to 84** **(excluding program management costs)**	**11 to 13** **(excluding program management costs)**	**87 to 120**

Estimated costs, assuming maximum regulated flow limit of 50,000 ML/day

Cost category		New South Wales ($m)	Victoria ($m)	Total ($m)
Costs of mitigation measures	Easements and associated negotiation costs	27	2	29
	Infrastructure on private agricultural land	10	1	11
	Operational response measures	2	1	3
	Capital works on public infrastructure	1	1	2
	Reinstatement of public infrastructure	14 to 18	2 to 3	16 to 21
	Works on levees	4 to 5	1	5 to 6
	Arrangements with specialist activities	1 to 9	1	2 to 11
Potential additional infrastructure implementation costs		10 to 35	2 to 6	12 to 41
Potential program management costs				15 to 23
TOTAL ($m)		**69 to 107 (excluding program management costs)**	**11 to 16 (excluding program management costs)**	**95 to 147**

Notes (that apply to all the above tables)

1. Easement costs are based on an assumption that land suffering from interrupted access has 513% of the area of the land suffering from inundation. This assumption is based on a sample of 3 properties and is considered a high estimate. If the assumption regarding inundated access is reduced to a lower percentage (200%) easement costs are lower.
2. Potential program management costs are assumed to be split equally between NSW and Victoria
3. The range of estimated costs for specialist activities reflects the range from the moderate estimate for easement-focused mitigation options (7% discount rate) to the high estimate for infrastructure-focused mitigation options (7% discount rate).
4. Levee cost estimates are draft only.

Additional Impacts and Costs Included in the Budget

A range of additional budget items and cost contingencies have been identified by agencies and landholders in the process of Concept Proposal Development. These are summarised in Table 12. A more detailed explanation of these budget items are provided below.

Table 12 Summary of Additional Budget Items and Cost Contingencies

Cost category	Total ($m)
Additional contingency for Landholder agreements (production losses, increased costs of business).	15.5
Additional costs associated with capital works on farms.	71.9
Additional costs associated with capital works below Perricoota-Koondrook Forest	9.01
Additional costs for expert advice to landholders and negotiation costs associated with Landholder Agreements	38.9
Additional costs associated with use of Murray Irrigation Infrastructure	12.5
Additional costs associated with modelling, monitoring and community consultation (2016/17)	1.2
Ecological Monitoring (including establishment of a baseline)	10
TOTAL ($m)	**159.01**

Note – all costs are net of taxation

Costs Identified by the Landholder Reference Group:

A review of the GHD costing study by the Landholder Reference Group in June identified areas where the landholders believed the extent of impact and costs associated with mitigation to be underestimated. These included the:

- Length of time of foregone grazing in native pastures;
- Cost of weed control;
- Cost of farm based infrastructure – particularly crossings to provide access to land cut off by inundation;
- Area of interrupted access;
- Cost of crop losses;
- Agistment costs;
- Impact of increased total grazing pressure from native animals relocating to areas adjacent to the inundated area;
- Provision of legal and business advice to landholders to support them in the negotiation of agreements.

To accommodate these potential underestimates the following additional costing contingencies have been included in the budget:

- An additional $15.5Million contingency to account for additional impacts by grazing pressure from native animals, increased forgone grazing and agistment costs $31 Million at 50%.
- An additional $71.9Million to account for increased infrastructure costs associated with properties with at least 50ha of inundated land (250ha of interrupted access), based on $500,000 per structure and 1.25 structures per farm (115 farms).
- An additional cost of $38.9Million to cover the costs of legal and business advice to landholders – based on $100,000 per farm with an area of 10ha or greater inundated (389 farms).

All costs will be further investigated as part of the next stage of project development.

In addition, several areas not included in the original costing studies have been included in the budget. These included:

- Additional costs associated with capital works below Perricoota-Koondrook Forest;
- Additional costs associated with the use of Murray Irrigation Infrastructure to deliver environmental water;
- Additional costs associated with modelling, monitoring and community consultation.

Additional costs associated with capital works below Perricoota-Koondrook Forest:

Impacts and mitigation

The pre-feasibility work completed by the MDBA (MDBA 2015) shows that flow rates below 6,000ML/day through Koondrook-Perricoota forest are contained wholly within the floodway network, and flows below 3,000ML/day are generally contained within the channels of rivers and creeks.

Impacts will be more frequent than the target flows downstream of Yarrawonga, and will be characterised by a range of inundation extents and durations, enabled by the works. Impacts will occur within the forest (to public roads and culverts), along the boundaries and downstream of the forest. Impacts are similar to those experienced elsewhere in the reach and include:

- Temporary land severance during (loss of access) during periods of downstream flows;
- Loss and damages to agricultural land (primarily pastures) arising from inundation downstream and alongside the forest;
- Costs, damages and losses to farm infrastructure including fences and pumps;
- Farm management costs;
- Costs and damage to public infrastructure including bridges and forest roads;
- Costs and damage to specialist activities including forestry activities.

Mitigation options are as per the broader reach and include financial compensation for costs and damages, information and notification, and infrastructure. Infrastructure requirements particular to the impacts associated with flows through the Koondrook-Perricoota forest include the following:

1. An alternative water supply system for regulated licence holders extracting from the Barber Creek.
2. Replacement bridges at Sandy Bridge to maintain access for heavy vehicles and equipment.
3. Refurbishment of the Thule Lakes Regulator to ensure continued management of flows into the Thule Lakes.

Licence holders on the Barber Creek currently utilise legacy structures to access their entitlements. These earth weirs can accommodate only very low flows in the Barber Creek and can no longer be legally reinstated once damaged. Options to replace these structures include one or more low-level fixed crest weir, or piped water supply from the Wakool River and Merran Creek.

Sandy Bridge is in a poor state of repair and has a 10 tonne load limit. Heavy access is via a temporary low level causeway. The causeway is unable to withstand overtopping and is overtopped by all but minimal flows. Replacement of the Sandy Bridge with a structure that can accommodate heavy vehicles

and equipment is required. Consideration of a similar structure on Colenso Park Road may also be required.

The Thule Lakes regulator is located between the Thule Creek and the Thule Lakes, which are opportunistically cropped. It is an old, private structure operated under licence. The structure is used to exclude nuisance (and possibly environmental) flows from the Thule Lakes and to retain water following larger flows. Releases of 30,000ML/d from Yarrawonga will result in flows from the forest impacting upon this structure. This structure may need refurbishment in order to reliably exclude increased flows from the Thule Lakes.

Additional infrastructure costs

Relaxing current operational constraints will enable existing Koondrook-Perricoota TLM works costing $80M to deliver the full suite of environmental outcomes for which they were designed. Raising the downstream flow release limits will substantially improve environmental outcomes within the forest, and will also deliver significant ecological outcomes for downstream systems and improved connectivity for system-wide outcomes.

Preliminary estimates for cost of additional infrastructure downstream of Koondrook-Perricoota Forest are shown in Table 13. These costs are in addition to the mitigation strategies common to the reach.

Additional costs associated with the use of Murray Irrigation Limited infrastructure to deliver environmental water:

The cost of capital upgrades to MIL escapes has been included in the budget. The annual budget for the delivery of environmental water through the MIL channel system has not been included in the budget at this stage.

Additional costs associated with modelling, monitoring and community consultation:

There is a need to create more accurate inundation maps to support detailed farm and businesses assessments, and a requirement to clarify the areas of interrupted access.

Natural flow events will require monitoring and tracking to support a better understanding of the extent of inundation and interrupted access. This will involve aerial monitoring and on-ground verification.

Ecological outcomes of managed flow events, both positive and negative, will require monitoring and evaluation. Monitoring programs should involve local environmental organisations, farmer groups and individual landholders to increase effectiveness and engagement in the future program;

Community engagement will be an ongoing feature of the next phase of project development between July and November, and an intense program of one on one engagement of landholders, floodplain businesses and Councils will be required as part of the detailed design and planning phase between 2017 and 2019.

A budget of $1.2Million for the next phase of project development up to Feb 2017 has been included to cover:

- Further investigation into mitigation and cost of impacts on agricultural land;
- Stakeholder consultation;
- Monitoring of natural flow events;
- Creation of inundation maps.

It is assumed that the existing Program Management budget of $15 to 23Million will cover the costs of stakeholder consultation up to 2024.

An additional budget of $10Million has been allocated for the monitoring and evaluation of managed environmental flow events (including the establishment of a base line for future comparison).

Appendix 7 Assumptions and contingencies associated with the cost estimates

Source of information: MDBA Costing studies and input from the Yarrawonga to Wakool Landholder Reference Group

Issue	Assumption/caveat	Implications for cost estimates
Hydrology (MDBA)	Cost estimates are based on modelled hydrological assumptions provided by the MDBA. The model represented the possible number of opportunities for the delivery of a managed flow event, which is expected to be considerably higher than the actual number of managed flow events likely to actually occur under a future relaxation of constraints.	Expected to result in overestimate rather than underestimate of extent of impact.
Extent of Inundation (MDBA)	Inundation maps were provided by MDBA, based on maps produced by RiMFim. As the majority of events on which the modelling is based relate to a wet catchment, for costing purposes, it has been assumed that the outcomes produced by the model represent a maximum extent of inundation.	Expected to result in an overestimate rather than an underestimate of impact.
Impact on production and additional costs to farming businesses (GHD)	Agricultural land worth, degree of affectation on agricultural gross margins and impacts of higher flows have been generalised in a model created by GHD, based on extent of inundation and hydrological assumptions provided by MDBA. The value of loss and additional costs has been combined in a total cost of purchase of easements. Model assumptions have been ground truthed with a small number of properties in the Yarrawonga to Wakool reach (3 properties) and through consultation with relevant local experts, but by necessity they are still average values across the reach.	Estimates are considered fit for purpose at a reach level but not at a local or property scale. A contingency of 10% has been built into the easement costs. Costs at a flow range up to 50,000ML/day have been included as a further contingency. In the review of the GHD work involving the LRG, several of the cost assumptions were challenged, in particular the cost of weed control, forgone grazing days in native pastures and infrastructure costs to provide access to areas of interrupted access. Additional budget has been allocated to offset these areas of uncertainty.

Issue	Assumption/caveat	Implications for cost estimates
Easements – administrative costs (GHD)	A $5,000 "administration" cost has been assumed per property. These costs include establishing the criteria for calculation of the level of compensation, site inspections and negotiations with land owners and legal costs to include easements on land titles. Based on previous experience in negotiating easements along the Hume-Yarrawonga and Mitta-Mitta regions.	This estimate is considered too low and an additional budget allocation has been provided against this area of the budget.
Infrastructure works on private agricultural land (GHD)	In the context of the timeframes available for the feasibility work, and associated constraints to on-ground consultation with landowners, it was not possible to identify precisely which private crossings or other infrastructure would require works. The number of private crossings, and the nature of works required, has been estimated on a regional basis, drawing on intelligence gathered from sample case study properties.	Estimates were considered by GHD as fit for purpose at regional level but not at a more local scale. Cost estimates reflect an infrastructure-focused approach to addressing interrupted access and such an approach is considered realistic. In reviewing the budget for infrastructure to maintain farm access, the LRG considered the assumptions generated by GHD to be an underestimate of the actual likely cost of crossings, bridges and culverts. As a result the budget against this item has been increased in line with landholder expectations (and based on some representative examples of the types of crossings required in the eastern areas of the reach).
Capital works on public infrastructure (AECOM)	These assets were identified by stakeholders (e.g. councils) and reviewed by engineering experts (AECOM). However, there were practical limitations to the level of detail to which cost estimates could be made for these works.	Cost estimates are considered prefeasibility in terms of accuracy. A contingency of 50 percent has been built in. Estimates are considered more likely to be overestimates than underestimates.
Reinstatement works on public infrastructure (AECOM)	Infrastructure identified through a desktop analysis, supplemented by consultation with stakeholders (e.g. councils). However, there were practical limitations to the level of detail to which the consultation process could consider individual infrastructure items.	Estimates are considered fit for purpose at LGA level but not at a local scale A contingency range of 15 to 60 percent (depending on specific works) has been built in.

Issue	Assumption/caveat	Implications for cost estimates
Works on levees (AECOM)	Desktop assessment only. Insufficient data and time meant it was not feasible to consider levees through a detailed on-ground assessment.	Cost estimates are considered prefeasibility in terms of accuracy. A contingency range of 40 to 120 percent (depending on specific works) has been built in. Estimates are considered more likely to be overestimates than underestimates.
Specialist activities eg caravan parks, sporting grounds (Jacobs)	Identified through a desktop analysis, supplemented by selected case studies from which costs have been extrapolated.	Estimates are considered fit for purpose at catchment level but not at a more local scale, or for individual activities (or categories of activity). A contingency of 100 percent has been built in. Estimates are considered more likely to be overestimates than underestimates.

Contingencies were added through a two stage process. Firstly, consultants added a level of contingency to their *base cost* estimates for easements, infrastructure, levees, and specialist activities. Secondly, contingencies were added in the form of *additional infrastructure implementation costs* to cover design, approvals and/or site supervision, where these potential costs were not already considered.

Tables A7-1and A7-2 summarise contingencies that were added. Contingencies for specific infrastructure items varied depending on those items, and this is reflected in ranges in the table.

Table A7-1: *Moderate* cost contingency assumptions

Source of cost estimates	GHD	GHD	AECOM	AECOM	Jacobs	MDBA/States
Base costs	Easements	Private infrastructure	Public infrastructure	Levees	Specialist activities	Program management
Contingency	10 percent Plus other costs (negotiation and advice)	No contingency	15 to 25 percent (new capital typically 25%)	40 to 60 percent	100 percent	Assumes starting from scratch (i.e. no resources already available)

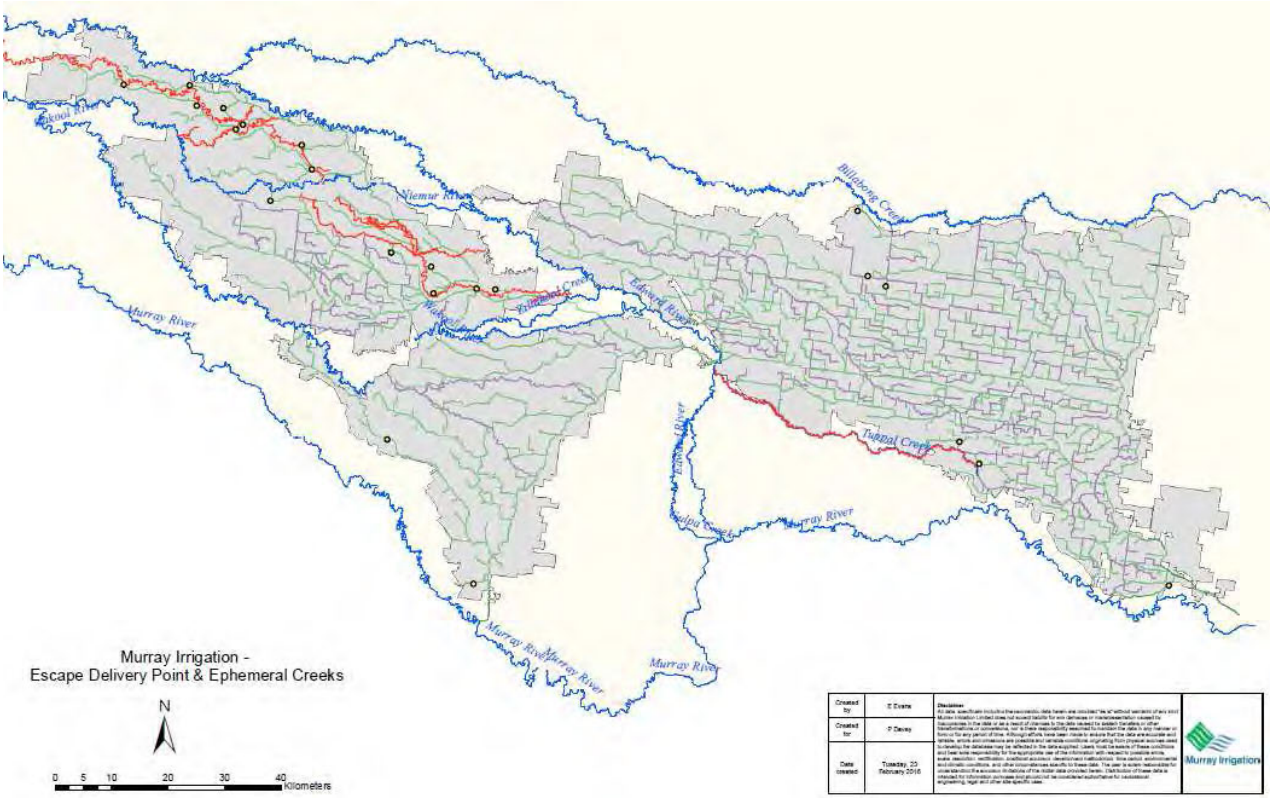
Source of cost estimates	GHD	GHD	AECOM	AECOM	Jacobs	MDBA/States
Jacobs Additional implementation costs	Not added	Additional to above 50 percent (assume bundled approvals)	Added to capital works component 12 to 50 percent	Additional to above 12 percent	Added to infrastructure component 30 percent	Not added

Table A7-2: *High* cost contingency assumptions

Source of cost estimates	GHD	GHD	AECOM	AECOM	Jacobs	MDBA/States
Base costs Contingency	Easements 10 percent Plus other costs (negotiation and advice)	Private infrastructure No contingency.	Public infrastructure 40 to 60 percent (capital typically 50%)	Levees 80 to 120 percent	Specialist activities 100 percent	Program management Assumes starting from scratch (i.e. no resources already available)
Jacobs Additional implementation costs	Not added	Additional to above 160 percent (assume approvals are not bundled)	Added to capital works component 17 to 160 percent	Additional to above 17 percent	Added to infrastructure component 100 percent	Not added

Appendix 8 Potential Utilisation of Murray Irrigation Limited Infrastructure to Complement Relation of Flow Constraints in the Yarrawonga to Wakool Reach[12]

The of the 1,700,000ha in the Yarrawonga to Wakool Junction reach, 748,000ha is covered by the Murray Irrigation network of gravity fed earthen irrigation channels providing stock and domestic and irrigation water to almost 2,400 landholdings and four towns.



There are already environmental watering programs occurring within Murray Irrigation's area of operations. By making further use of existing programs and infrastructure, the SDL offsets to be gained from a combination of the Constraints Management Strategy and targeted environmental water delivery may be greater.

The MDBA estimated the following incremental benefits through increased flow rates at Yarrawonga Weir[13]:

Flow @ Yarrawonga	Outcome	Comment
20,000ML/day	Just above current regulated flow. Flows in channel with low level inundation in Barmah-Millewa Forest.	
30,000ML/day	Readily reach targets for Barmah-Millewa Forest and upper reaches of the region.	Flow level currently being investigated for Constraints Management.

[12] This appendix, provided by Murray Irrigation Limited (MIL) which has membership on the Landholder Reference Group, does not represent NSW DPI Water policy. Its inclusion is beneficial from the overall perspective of understanding potential costs and opportunities and benefits to be gained by the utilisation of MIL infrastructure.

[13] Yarrawonga to Wakool reach Report, MDBA, 2014, p40

50,000ML/day	Begin reaching some disconnected wetlands and ephemeral creeks in higher parts of the landscape including Tuppal, Cockrans Jimaringle and Gwynnes.	OEH currently uses Murray Irrigation infrastructure to deliver to all of these named ephemeral creeks and disconnected wetlands on private property.
77,000ML/day	Over 75 percent of Barmah-Millewa forest and many disconnected wetlands.	A flow rate that is unacceptable to the local riparian landholders and communities.

If local landholders and community accept constraints measures to allow maximum regulated flows up to 30,000ML/day below Yarrawonga, the use of Murray Irrigation infrastructure may provide a means of more efficiently targeting environmental outcomes in specific areas of the reach within the agreed flow footprint, potentially providing a greater SDL offset. This may be particularly effective in watering targeted wetlands higher up in the floodplain, above the 30,000ML/day footprint but able to be supplied through MIL infrastructure without third party impacts.

If MIL infrastructure were to be used to supplement natural flow events, there would be ongoing delivery costs that would need to be met. A current Memorandum of Understanding exists between MIL and the Office of Environment and Heritage. These arrangements allow flexibility for Murray Irrigation to prioritise channel capacity for irrigation customers. Guaranteed access to channel capacity would require some commitment from Government to meet a portion of fixed charges consistent with irrigation customers. While this would be subject to negotiation, an indication of the costs to guarantee capacity access and delivery of 50GL per year would be:

- Delivery entitlement (fixed fees) [redacted]
- Water use fees [redacted]
- Total per annum for delivery of 50,000ML = [redacted]

Outcomes from current watering programs can be improved by upgrading priority escapes to allow increased flows into ephemeral creeks and streams or end of system escapes to return water to the Murray River system.

The NSW Office of Environment and Heritage has identified 14 escapes within the Murray Irrigation area of operation which it considers to be priority escapes for the purposes of delivering environmental flows. Upgrading these escapes will allow improved efficiency and accurate measurement of environmental flows improving accountability for environmental water holders.

Estimated costs to upgrade this infrastructure is:

- Upgrade 14 priority escapes to compliant FlumeGate or SlipMeter [redacted]

The Edward River Escape allows the transfer of up to 2,400ML/day around the Barmah Choke. Exceeding this current capacity at this location has the potential to exceed downstream channel capacities and therefore is not a priority, however, the Murray Irrigation system could complement Edward River Escape flows through the Perricoota Escape which delivers flows back into the Murray River above Torumbarry Weir. The current capacity for this escape is only 200ML/day. This escape could be upgraded with associated channel works. This would allow up to 1,000ML/day through this escape.

- Upgrade Deniboota Channel and Perricoota Escape (approx.) [redacted]

Appendix 9 Community Consultation and Stakeholder Response

Key stakeholder messages, concerns and issues from consultation conducted between 2014 and 2016 are listed below:

Level of Risk:

- The community rejected flows of the order of 77,000ML/day at Tocumwal.
- There is continuing concern for even small to mid-range flows if not mitigated – it was acknowledged that third party impacts occur at flows less than 20,000ML/day at Tocumwal.
- There was broad recognition that the impacts of smaller flows could be managed and mitigated and that these flows could have environmental and community benefits.
- Some landholders supported increasing the height of flows to improve river and floodplain health, as long as the risks could be managed.
- There was considerable landholder concern about flows in the 40,000 to 50,000ML/day range. Submissions to the MDBA in response to the Yarrawonga to Wakool Reach report, from the Murray Valley Private Diverters and the landholder representatives on the Edward Wakool Constraints Advisory Group (Murray Valley Private Diverters, 2015), labelled flows above 40,000ML/day at Tocumwal as “unrealistic and unsafe” due to increased risks associated with local and regional flooding.
- Landholders generally accept that they live on floodplains and accept the risks associated with naturally occurring flood events. They don’t accept the risks associated with managed environmental flows that may exacerbate or compound the risk of a damaging or uncontrolled flood above the historical frequency – investigations into increased flood risk is ongoing work commissioned by the MDBA.
- The community has suggested that a wet catchment is likely to result in a larger flood footprint than a dry catchment – flood modelling should assume a wet catchment.
- The impact of tributary inflows both above and below Tocumwal must be considered – including the impact of backing up flows and multiple rainfall events.
- The community want clarity around which government agencies are responsible for the risks associated with managed flow events and liability for resulting third party impacts.
- Constructed drainage channels designed to direct local rainfall events back to rivers may be impacted by higher river flows resulting in backflow or rainfall inundation to land off the floodplain. This would also be the case for environmental flow events delivered via irrigation infrastructure.
- Trialling of small flow events and “learning by doing” is a way of building confidence that risks associated with managed events can be managed, and confirming the extent of third party impacts.
- The community has raised the risk associated with mobilising acid sulphate sediments in the reach and the need to implement a monitoring and mitigation strategy to deal with this.
- Adaptive management in environmental flow planning and delivery requiring consideration of the broad realm of inputs and effects is required.

Commercial Impacts on Farm Businesses:

- Interruption to land access as a result of higher managed flows may create issues with stock management and animal husbandry, isolate cropping areas, impede movement of equipment

and farm supplies, and issues with emergency management such as for fires. This is a key issue that will require more detailed investigation of extent, scope and mitigation at a farm level. The frequency and duration as well as the height of managed flows are important factors in regard to appropriate mitigation of access issues.

- Prolonged inundation and frequent flooding may lead to loss of production value of pastures or in some cases pasture death. Costs to farming businesses include reduction in stock carrying capacity and pasture reestablishment costs.
- The cost of damage and reinstatement of fence lines was identified as an important issue that will occur with every flow event.
- Devaluation of the value of land due to limits on access and reduced agricultural productivity.
- Landholders believe that the budgeted figure for mitigation and compensation ($200M) for the CMS as a whole is too low.
- They believe that the budgeted figure is inaccurate, lacks detail and that they will suffer substantial commercial impacts as a result.
- Landholders and communities want assurance that, for the duration of the CMS, there will be sufficient funds available for impacts to be mitigated and fair compensation to be paid.
- There was a call for greater transparency and involvement of local landholders and community in the monitoring and evaluation of environmental flows, and the setting of flow targets and watering programs.
- Landholders and communities voiced concern that they cannot adequately assess the impact of management environmental flows on their businesses and lives without understanding the frequency, timing, duration and predictability of these flows into the future.
- Red gum regrowth and the ability to remove and manage these areas within floodways is an issue.
- Maintaining channel integrity through the removal or repositioning of fallen logs and other debris is beyond the scope of landholders to manage.
- The timing of environmental flow events should not compromise irrigation supply at times when channel capacity is limited.
- A greater variation in the height of river flows may create additional work for river pumpers if irrigation and stock and domestic pumps need to be lifted at times of high flows. Additionally very low flows may also create access issues for existing pump sites.

Legal Issues:

- The majority of levees in rural areas are privately owned, and as a consequence the design and construction standards are highly variable. The legislation governing the location and licencing of floodplain structures, including levees differs between NSW and Victoria. Issues relate to the cost of strengthening and extending existing levees, regulation which may prevent the construction of new levees and the treatment of historical levees;
- The treatment of structures in the floodplain, as part of the on-farm assessment of mitigation and funding of new works.
- Legal liability for flows that produce negative environmental outcomes – requires an accountability framework.

Environmental issues:

- The potential negative environmental impacts of higher and more frequent environmental flows should also be identified including increased bank erosion and slumping, increased weed infestation and unintended changes to native vegetation communities and black water events.
- Potential for increased carp breeding events and carp numbers.
- Potential negative impacts on groundwater recharge, particularly in the Wakool area due to increased flooding needs to be better understood.

Community impacts:

- Impacts on public infrastructure such as bridges and culverts, and damage to roads, were identified by local councils.
- Adverse impacts on tourism, including limiting access to beaches and areas of forest for water sports, camping and fishing were identified.
- There is belief/evidence that higher flows will increase the risk/incidence of mosquito borne diseases such as Ross River Fever and Murray Valley encephalitis.

Appendix 10 High Level Risk Analysis

CMS - Yarrawonga to Wakool										
				INHERENT RISK				RESIDUAL RISK		
2	3	4	5	7	8	9	10	11	12	13
Div Risk No	Nature of Risk (Risk Name & Description)	Risk Owner	Risk Factors/Causes of Risk	Consequence	Likelihood	Risk Rating (VH, H, M, L, VL)	Mitigation Strategies to Control Risks (Current Controls/Existing Mitigation Strategies)	Consequence	Likelihood	Risk Rating (VH, H, M, L, VL)
	Impacts to Landholders and Other Stakeholders									
1	Landholder deprived of use of land and improvements as the result of managed environmental flow events.	Landholder	• Insufficient warning of planned events • Insufficient on-farm infrastructure for access and flood protection • Insufficient public infrastructure for access and flood protection • Naturally occurring inundation event made higher/longer by piggy backing managed environmental flow event. • Timing, frequency, duration, height of managed flow events causes land inundation. • Flood risk increased by wet catchment • System failure during management of water release • Compensation is not market value/equitable	Severe	Likely	Extreme	• Mitigation is designed with adequate buffers and contingencies to offset both managed environmental flow events and unplanned consequences. •Gov't to pay for independent advice to landholders relating to deprivation of use of land and improvements • Compensation agreement includes consideration of deprivation of use of land and improvements. • Early warning systems - planned and unplanned events • Effective notification systems implemented. • Improved catchment instrumentation and forecasting • Real time information to assist tracking of managed flow events. • Likelihood of increased flooding with CMS modelled •River operators exercise	Minor	Unlikely	Low

							judgement based on operating rules and previous experience			
2	Access to land temporarily severed as the result of managed environmental flow events	Landholder	• Insufficient warning of planned events • Insufficient on-farm infrastructure for access and flood protection • Insufficient public infrastructure for access and flood protection • Naturally occurring inundation event made higher/longer by piggy backing managed environmental flow event • Timing, frequency, duration, height of managed flow events causes land inundation and limits access • Flood risk increased by wet catchment • System failure during management of water release • Compensation is not market value/equitable	Severe	Likely	Extreme	• Mitigation is designed with adequate buffers and contingencies to offset both managed environmental flow events and unplanned consequences. • Gov't t pay for independent advice to landholders regarding temporary land severance • Compensation agreement includes consideration of severance of land • Construction of crossings, bridges and culverts on farms and public land with a significant buffer. • Real time information to assist tracking of managed flow events. • Early warning systems - planned and unplanned events • Effective notifation systems implemented. •Improved catchment instrumentation and forecasting •River operators exercise judgement based on operating rules and previous experience	Minor	Unlikely	Low

3	Landholders bear additional costs, damages and losses resulting from managed environmental flow events e.g. pest control, pasture re-establishment, fence repairs, levee repairs and maintenance, business management costs, cost of feeding stock and/or agistment.	Landholder	• Insufficient warning of planned events • Insufficient on-farm infrastructure • Insufficient public infrastructure • Naturally occurring inundation event made higher/longer by piggy backing managed environment flows • Timing, frequency, duration, height of managed flow events causes inundation of land and damage to pastures, crops and infrastructure • Flood risk increased by wet catchment • System failure during management of water release • Compensation is found not to be market value/equitable	Severe	Likely	Extreme	• Mitigation is designed with adequate buffers and contingencies to offset both managed environmental flow events and unplanned consequences. •Gov't to pay for independent advice to landholders regarding additional costs of and damage • Compensation agreement includes consideration of additional costs and damage. • Real time information to assist tracking of managed flow events. • Likelihood of increased flooding with CMS modelled • Early warning systems - planned and unplanned events • Effective notification systems implemented. • Improved catchment instrumentation and forecasting •River operators exercise judgement based on operating rules and previous experience	Minor	Unlikely	Low
4	Land value reduced by managed environmental flow events	Landholder	• Purchaser/valuer/commercial partner opinion based on perceptions of risk factors below • Naturally occurring inundation event made higher/longer by piggy backing managed environment flows • Timing, frequency, duration, height of managed flow events inundates land, reducing production and land values • Flood risk increased by wet catchment	Major	Likely	Extreme	• Mitigation is designed with adequate buffers and contingencies to offset both managed environmental flow events and unplanned consequences. •Gov't to pay for independent advice to landholders in relation to reduction in land value • Compensation agreement includes consideration of reduction of land values • Real time information to assist tracking of managed flow events. • Likelihood of increased flooding with CMS modelled • Early warning systems - planned	Negligible	Likely	Medium

			• System failure during management of water release • Compensation paid does not run with title • Compensation is not market value/equitable				and unplanned events • Effective notification systems implemented. • Improved catchment instrumentation and forecasting •River operators exercise judgement based on operating rules and previous experience			
5	Insufficient funding available for mitigation of and compensation for managed environmental flow events	Government	• Inaccurate costings underestimate real cost to mitigate • Compensation paid does not run with title • Compensation not tailored to suit individual farming businesses • Compensation is not market value/equitable • Compensation not calculated to compare different types of compensation eg per-event, one-off, easement etc	Severe	Possible	Extreme	• Full range of compensation options identified • Full range of compensation options independently costed by experts • Suitable compensation options and costings presented to Cwth for funding • Inclusion of adequate contingencies and buffers	Moderate	Unlikely	Medium

6	Downstream landholders impacted by use of MIL and other irrigation delivery infrastructure to deliver environmental water.	Landholders	• Insufficient warning of planned events • Ineffective coordination of flows in river and through irrigation infrastructure • Compounding impacts of river flows and additional flows from MIL escapes • Insufficient on-farm infrastructure • Insufficient regional infrastructure • Naturally occurring inundation event made higher/longer by piggy backing managed environmental flows • Timing, frequency, duration, height of managed flow events inundates private and public land • Flood risk increased by wet catchment • System failure during management of water release • Nobody accountable for event, impacts, liability • Compensation is not market value/equitable	Severe	Possible	Extreme	• Effective government coordination of flows from a multiple of sources. •Compounding impacts downstream of escapes considered in planning a managed environmental flow event. •Mitigation is designed with adequate buffers and contingencies to offset managed flow events, compounding impacts downstream of escapes and unplanned consequences. •Early warning and notification systems • Improved catchment instrumentation and forecasting	Minor	Unlikely	Low
7	Lack of accountability and responsibility for impact of managed environmental flow events.	Government	• Clear roles and responsibilities of government agencies involved in managed environmental flows not allocated and agreed.	Major	Unlikely	High	• Information re lines of accountability for operational liabilities publicly available • Governments to provide advice on roles and responsibilities • Ensure there is appropriate accountability tied to organisations and individual officers responsible for managing environmental flow events and meeting environmental outcomes and targets.	Minor	Unlikely	Low

8	Planned inundation inflicts additional costs, damages and losses on Private Irrigation Infrastructure Operators.	PIIO	• Insufficient warning of planned events • Ineffective coordination of flows in river and through irrigation infrastructure • Compounding impacts of river flows and additional flows from MIL escapes • Insufficient on-farm infrastructure • Insufficient regional infrastructure • Naturally occurring inundation event made higher/longer by piggy backing managed environmental flows • Timing, frequency, duration, height of managed flow events inundates private and public land • Flood risk increased by wet catchment • System failure during management of water release • Nobody accountable for event, impacts, liability • Compensation is not market value/equitable	Major	Possible	Extreme	• Mitigation is designed with adequate buffers and contingencies to offset both managed environmental flow events and unplanned consequences. •Gov't to pay for independent advice to PIIO regarding additional costs of and damage • Compensation agreement includes consideration of additional costs and damage. • Real time information to assist tracking of managed flow events. • Likelihood of increased flooding with CMS modelled • Early warning systems - planned and unplanned events • Effective notification systems implemented. • Improved catchment instrumentation and forecasting	Minor	Unlikely	Low
	Stakeholder Engagement and Support									

9	Stakeholders lose confidence and disengage from the CMS process.	Government	• Implementation phase too long • Poor and ineffective communication • Lack of involvement in the process • Unsatisfactory outcomes • Insufficient coordination between agencies leads to ineffective notification of all stakeholders, inconsistent messages and incorrect information. •Inadequate or ineffective communication of outcomes from watering events .	Severe	Likely	Extreme	• Timeframes need to be realistic and communicated well • Project commitment to stick to timeframes • Project and stakeholders work together with the intention of reaching agreeable outcomes and progressing ahead of schedule whenever possible •Compensation mechanisms are fair, equitable and sufficient to offset unacceptable impacts of higher managed environmental flows •The method of implementing compensation has local input and ownership and allows landholders to manage their own risk by choosing mitigation strategies that are appropriate for their farming businesses, • Communication and engagement processes are effective •Relaxation of constraints only occurs once appropriate mitigation measures are in place •The increase in height and duration of managed environmental flows are incremental to assess that mitigation measures are effective	Minor	Unlikely	Low
10	Community and Government dissatisfaction with the outcomes achieved from managed environmental watering events leading to withdrawal of support and funding.	Government	•Insufficient monitoring and evaluation of each watering event. •Ineffective communication of the outcomes from each watering event. •Managed watering events result in unintended consequences for the environment and key stakeholders. •Managed environmental flow events fail to achieve	Severe	Unlikely	Extreme	• Ensure effective monitoring and evaluation of managed environmental watering events. • Communicate effectively positive and negative outcomes of watering events. • Involved landholders and communities in monitoring and recording outcomes. • Ensure there are clear and stated objectives attached to environmental watering events. • Ensure objectives are	Minor	Unlikely	Low

			environmental objectives.				measurable and effectively communicated. • Provide adequate resources to engage and sustain community and landholder involvement in monitoring and evaluation programs.			
	Ecological Outcomes Not Achieved									
	Ecological outcomes not achieved	Government	• Misforecast of the peak tributary flows means that piggybacking environmental flow event is ineffective (too low) and unable to reach the areas of the floodplain targeted. •Failure to recognised triggers early enough to optimise value of environmental release. •Water order placed too late to be effective. •Timing and duration of managed flow events do not achieve the environmental outcomes targeted. •Volume of environmental water available insufficient to reach and maintain the height and duration of flows required to meet environmental objectives. •Government agencies fail to identify and coordinate all water holdings. •Environmental water release not effective in matching the flow pattern required to optimise environmental outcomes. •Too little or too much water released.	Severe	Possible	Extreme	•Ensure expert input to design and implementation of managed environmental flow events. • Development of operational strategies aligned with achieving target outcomes and minimising risk • Build in an adaptive approach to environmental flows, ensuring that analysis of past events is carried forward to future events. • Ensure objectives are explicit and measurable. • Coordinate the activities of government agencies and holders of environmental water • Build strong and effective governance arrangements around the planning, implementation and evaluation of environmental flows • Investigate contingencies and alternative strategies (physical or operational control) to constraints management to achieve environmental outcomes eg Control measures for carp may include: Physical control: preventing Carp from accessing places to feed or spawn, e.g. closing wetland regulators, installing Carp screens. Operational measures: Drawing down water levels at key times to strand Carp in drying wetlands or	Minor	Unlikely	Low

							floodplains; Providing flow events in winter, which is outside Carp peak breeding season, if the desired environmental outcomes can be met during this time. Timing watering events to match our native fish spawning season to offset the benefits to carp • Ensure transparency and effective communication in reporting outcomes • Conduct periodic and independent reviews			
12	Unintended environmental outcomes result from managed environmental flow events.	Government	• Blackwater events result from ponding environmental flows at time of high temperatures, and insufficient coordination of flushing flows. • Managed environmental flows create conditions conducive to spread and increased breeding of pest species eg carp, lippia, burrs. • Increased bank slumping and erosion. • Environmental flow events result in stranding of fish populations. •Risk of mobilising acid sulphate sediments.	Major	Likely	Extreme	•Gain greater understanding of the cause and triggers relating to undesirable environmental outcomes. • Development of operational strategies aligned with achieving target outcomes to offset potential negative consequences • Design managed environmental flow events to minimise likelihood of unintended outcomes. •Identify the key areas in the reach where unintended outcomes are most likely to occur. • Consideration of physical or operational control and reduction strategies for pest flora and fauna. •Need to implement a monitoring and if required mitigation strategy for acid sulphate sediment.	Major	Unlikely	High

13	Learnings from each watering event ineffective leading to no improvement in outcomes.	Government	•Hydrometric data in insufficient to provide an effective record of the event. •Insufficient resourcing and ineffective system of recording and collection of landholder information. •Insufficient data collected or ineffective data collection methodology leads to inability to evaluate outcomes. •Government agencies fail to share, evaluate and incorporate information and learnings from each watering event into the planning and implementation of subsequent watering events.	Major	Unlikely	Moderate	• Increase the effectiveness of the hydrometric network. • Design and implement an effective system of data collection including government and landholder/community resources. • Design and implement an effective program of evaluation, analysis, reporting and information sharing between government agencies across jurisdictions.	Minor	Rare	Low
	Project Delivery									
14	Delays in project delivery lead to cost overruns and inability to deliver managed environmental flows	Government	• Disputes over funding contracts and landholder agreements. • Natural high flow and flooding events delay construction of floodplain structures. • Disputes over treatment of legacy structures in the floodplain. • Delays associated with attaining necessary permits and approvals.	Major	Possible	Extreme	•Design a process of landholder agreements and compensation roll out that has local input and ownership. •Apply a test of fairness and reasonableness to the allocation of compensation. •Ensure implementation timeframes are long enough to allow for floods and higher natural flows in some/most years. •Develop a consistent policy for the treatment of legacy floodplain structures across jurisdictions. •Ensure implementation timeframes are long enough to allow for assessments to support attaining required permits and developmental approvals	Negligible	Possible	Low
15	Structural failure during commissioning or operation of	Depends on implementation model	Poor design and construction techniques causes structures to fail.	Major	Possible	Extreme	• Ensure adequate design standards for flood plain structures. • Ensure design standards are fit	Moderate	Unlikely	Medium

	floodplain infrastructure prevents the delivery of managed environmental flows.						for purpose (public verses private)			
16	Inability to deliver the project within the budget, resulting in unacceptable risk to the delivery of managed environmental flows.	Government	• Inadequate cost assumptions and estimates. • Ineffective program and project management and insufficient financial controls.	Severe	Possible	Extreme	• Full range of compensation options identified • Full range of compensation options independently costed by experts • Ensure budgets include the costs of any assessments to support attaining required permits and developmental approvals • Inclusion of adequate contingencies and buffers • Implement effective program and project management processes, including adequate financial controls and governance arrangements.	Minor	Possible	Medium
17	Underestimates of costs relating to levees creates budget overrun.	Government	• Inadequate cost assumptions and estimates. • Incomplete extent of public and private levees investigated.	Major	Moderate	High	• Check extent of levees included in costing work undertaken by MDBA • Revise costings to include full extent of existing levees.	Minor	Unlikely	Low

Appendix 11 Possible Governance Arrangements

Should the project proceed, appropriate governance arrangements will be established by the NSW Government to effective stakeholder engagement in decision making is achieved, minimise the risk to investors, ensure appropriate financial controls are in place and the project is delivered on time and on budget.

These arrangements will be consistent with the NSW Public Service Commission rules and guidelines regarding Government Boards and Committees, and the appropriate Victorian equivalent arrangements.

In any future governance model, the **Deputy Director General, DPI Water** will be the project sponsor and have overall responsibility for project delivery. The DDG DPIW will report through to the Minister. In discussions with the LRG a number of governance models have been considered and these are outlined below.

In Model 1:

A **Project Control Group** would be established set and monitor project delivery objectives and to provide high level oversight of financial accountability. It could comprise senior executives from DPI Water and other NSW Government agencies with a responsibility in environmental water delivery, stakeholder representatives or a financial delegate/s of their choosing. The members of this group would contribute a mix of skills and expertise in risk management, financial management and project governance. It may be independently chaired.

A **Technical Advisory Panel**, consisting of technical experts in the areas of hydrology, engineering ecology and river operations, could be established to provide advice to the Project Control Board.

A **Stakeholder Advisory Panel** could be established to create a high level linkage with the areas of the community impacted by constraints management. The panel members would represent the interests of landholders, farming businesses, floodplain businesses and Local Councils from NSW and Victoria.

An experienced **Project Manager** would be appointed to oversee all elements of project implementation. Appropriate **Management Teams** would be formed to provide advice and oversight to implementation on a technical area or geographic basis as required.

Implementation could be through **Sub-reach teams**, established to create local solutions and engage directly with landholders, Councils and floodplain businesses. These teams would be supported by appropriate people and resources.

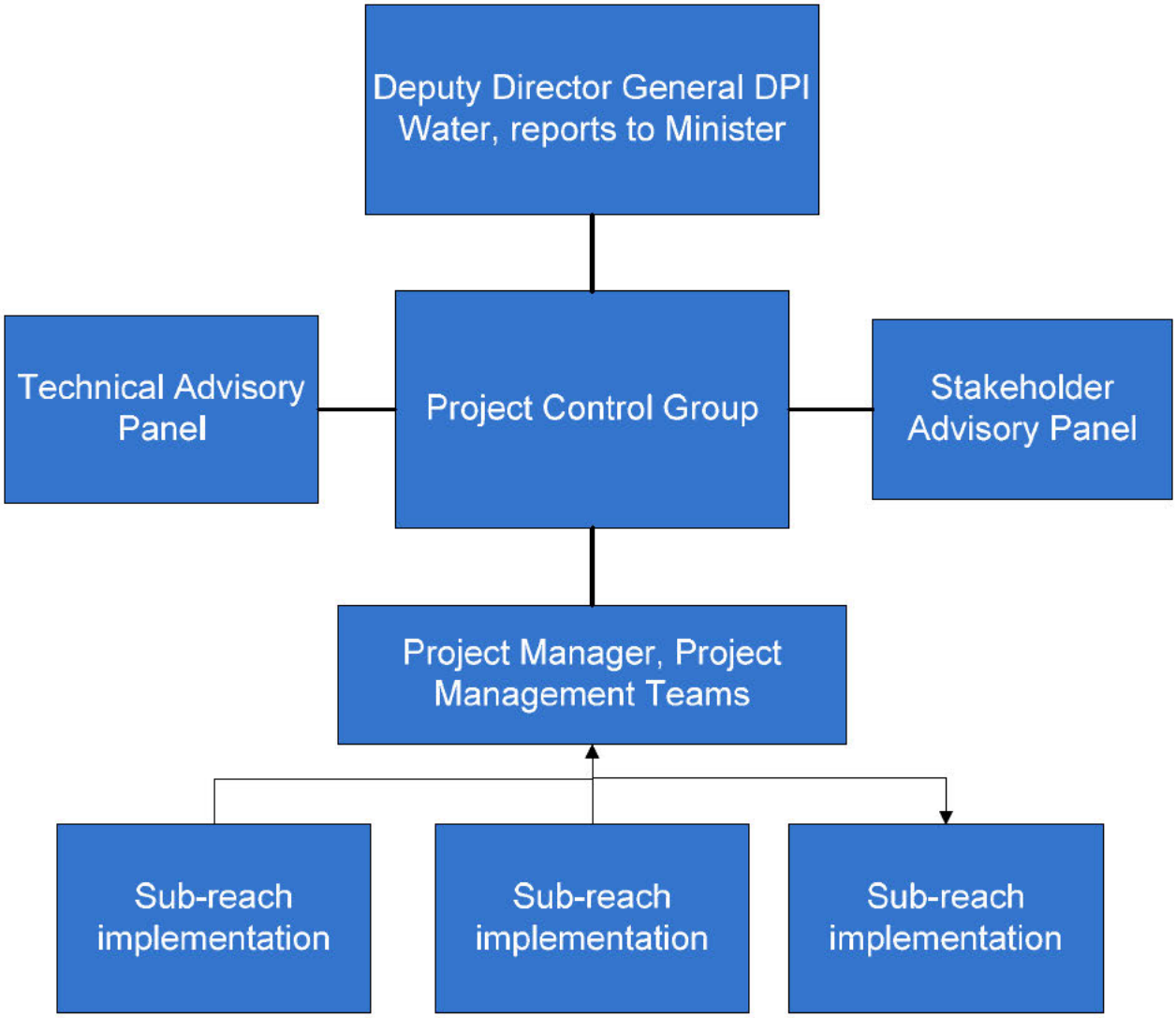
In Model 2:

There is a greater emphasis on the involvement of stakeholders at both the Project Oversight Group and the Management Group level, and the input of local ideas and knowledge to the development and oversight of implementation. This approach is favoured by the LRG.

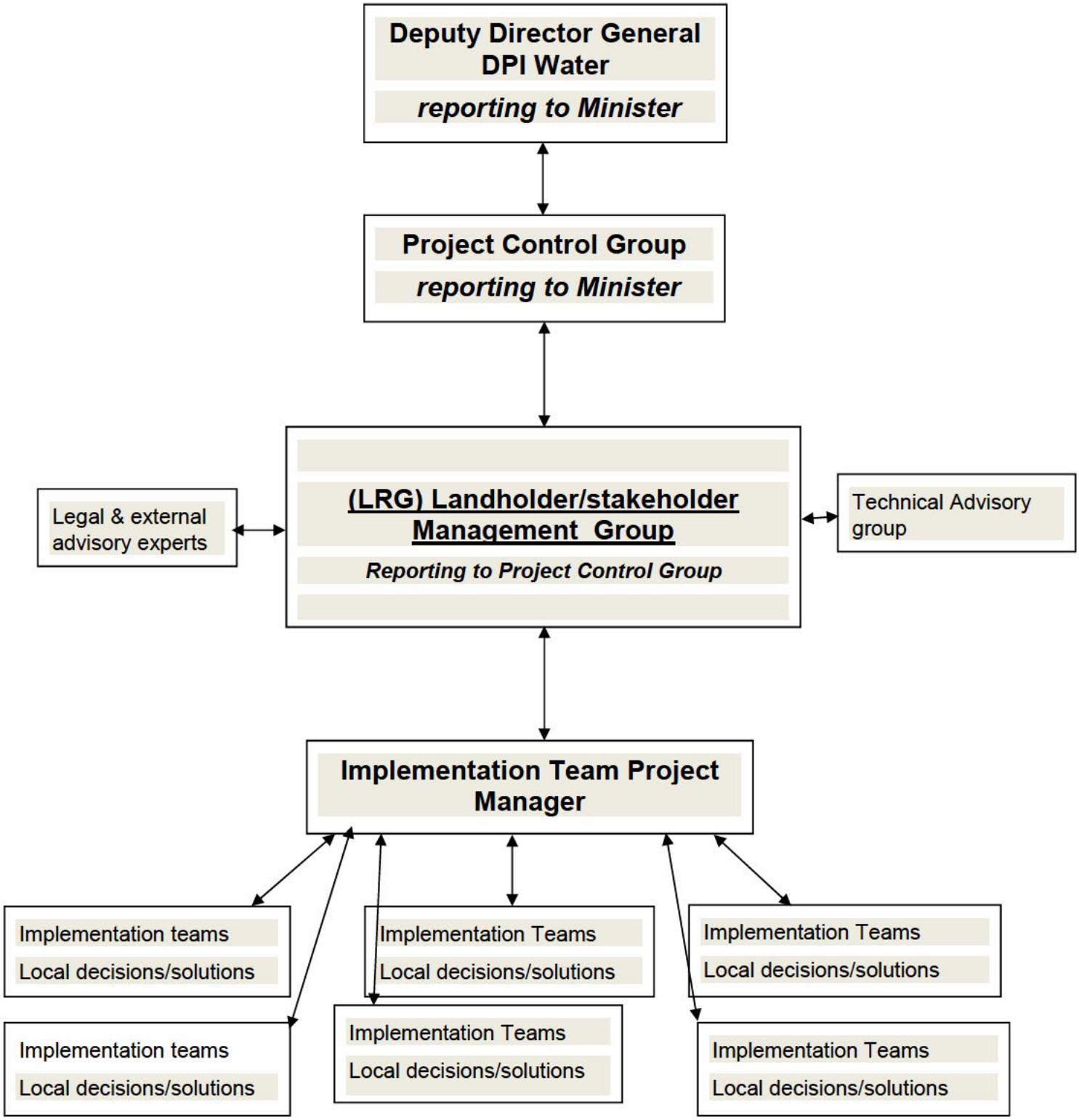
There are similarities between both models in the establishment of a high level “Project Board” structure and a “Project Management” structure with on ground implementation achieved at local or sub-reach level.

The LRG will continue to review examples of governance and management structures, employed in other large natural resource management projects, such as those used in the Murray Land and Water Management Plans, to ensure that an effective combination of governance, accountability, and joint community and government decision making is achieved.

Possible Implementation Model 1:



Possible Implementation Model 2:



Appendix 12 Government Planning and Operational Framework for Managed Environmental Flow Events

Operational Planning Framework for a Managed Environmental Flow Event (maximum regulated flow limit of 30,000ML/day below Yarrawonga)			
	Action	**Responsibility/Lead Agency**	**Timing**
Phase 1 - Preplanning - Annual Plans			
1.1	Basin Wide Annual Watering priorities (informed by the Basin Watering Strategy - MDBA)	States provide to the MDBA	Annual - Autumn
1.2	Environmental Watering Management Plans for each TLM Icon Site.	MDBA with icon site managers (icon site managers align with Ramsar).	Long term
1.3	Annual Watering Plan - NSW (consistent with the Statement of Annual Watering Priorities - CEWH)	NSW OEH working with Southern Connected Basin Environmental Water Committee (MDBA, DPI Water, Vic, SA, CEWHO)	Annual - Autumn
1.4	TLM Icon Site Managers develop watering proposals (Barmah-Millewa, Koondrook-Perricoota)	Icon Site Managers (B-M OEH, GBCMA/ P-K FC NSW, NE CMA)	Annual - Autumn
1.5	CEWO Watering schedules (allocation of water against priorities)	CEWO in consultation with OEH	Continual review
1.6	Basin Officials Committee Approves 30,000ML/event at Yarrawonga (timing, duration, operational aspects)	MDBA Water Liaison Working Group	Autumn meeting
Phase 2 - Event Based Planning (NSW)			
2	Flow Event Management Plans - operational plans (Form A)	NSW OEH	Pre-event

2.1	Identifies Ecological needs and trigger conditions	NSW OEH	Autumn-early winter
2.2	Assess water availability	NSW OEH, CEWO, MDBA, VEWH, DPI Water	Autumn-early winter
2.3	Consultation with landholders, councils, community groups, Indigenous groups etc.	NSW OEH with DPI Water, Water NSW, Fisheries, LLS, MDBA, CEWO etc	Autumn-early winter
2.4	Operational assessment	NSW OEH with State Water, DPI Water and River Murray Ops	Autumn-early winter
2.5	Identify monitoring and reporting requirements	OEH, CEWO LTIM, TLM, Fisheries, DPI Water/Water NSW	Autumn-early winter
2.6	Risk Assessment	NSW OEH (Lead role)	Autumn-early winter
2.7	Approval Process	Environmental Water Holders.	Autumn-early winter
Phase 3 - Implementation of the Event			
3.1	Trigger conditions met (Gouburn, Murray and Murrumbidgee systems considered)	MDBA - River Murray Operational Advisory Group	Real time
3.2	Place an order with Water NSW.	NSW OEH	Real time
3.3	Implement notification system (SMS, email, media)	River Murray Ops, Water NSW, OEH	Real time

3.4	Water released	River Murray Ops, Water NSW	Real time
Phase 4 - Operational Considerations (consistent with current operational practice)			
4.1	Receive order - check that it is consistent with parameters discussed in the planning phase	Water NSW	Real time
4.2	Accept or reject order	WaterNSW	Real time
4.3	Communicate order/e-water event requirements - confirm start with MDBA	WaterNSW/MDBA	Real time
4.4	Implement delivery of e-water order in accordance with daily operating procedures	MDBA/WaterNSW	Real time
4.5	Continual Review - Assess event progress is achieving objectives and not creating unexpected outcomes. Consult e-water managers if issues arise, or corrective action if risks escalate or impacts identified.	MDBA/WaterNSW	Real time
Phase - Monitoring and Evaluation			
5.1	Collect specific hydrometric and inundation data	NSW OEH, Water NSW/DPI Water	Real time
5.2	Implement landholder based monitoring program	NSW OEH, DPI Water	Real time
5.3	Evaluate ecological outcomes	OEH, CEWO LTIM, TLM Icon Site Managers, Fisheries	Ongoing
5.4	Communicate ecological outcomes.	OEH, CEWO LTIM, TLM Icon Site Managers, Fisheries	Ongoing
5.5	Adaptive management - feedback into next event	OEH, CEWO LTIM, TLM Icon Site Managers, Fisheries	Ongoing

Appendix 13 Indicative project timeline

Indicative Timeline for Constraints Management Project - Yarrawonga to Wakool Reach

Project Component	August to Nov 2016	Dec 2016 - March 2017	2017	2018	2019	2020	2021	2022	2023	2024
Basin Plan Process	Submit final Concept Proposal for CMS Yarrawonga to Wakool	MDBA Modelling of project package to determine SDL Adjustment			SDL Adjustments incorporated into Natural Resource Plans					SDL Adjustment Projects Implementation Completed
	Continuation of Project Develop and Implementation									
Finalisation of Concept Proposal										
Define CMS Measure (NSW Government Agencies)	Clarify magnitude, frequency, duration and seasonality of managed environmental flows at key points within the reach.									
Refine Mitigation Strategies and Costs (LRG, DPI Water)	Restart costing study for farm based mitigation, including roadtest of mitigation strategies and costs with 12 - 15 landholder-led case studies. Process to be lead by Landholder Reference Group with support from DPI Water.									
Development of Supporing Policy, Protocols and Process - DPI Water and other NSW Agencies	Finalise policies and protocols Legacy Structures									
Design Mitigation and Compensation Program (LRG, DPI Water)	* Work with LRG and sub-reach groups to design mitigation and compensation framework. * Road test mitigation and compensation framework with individual farm case studies, Councils and a sample of affected businesses.									
Stakeholder Consultation and Engagement										
	* Revise TOR and additional membership for LRG. * Set up sub-reach groups. * Conduct sub-reach consultation. * Consult with Councils and affected businesses. * Provide communciation materials to reach community - mailouts and website.		* Conduct indivdual farm assessment and negotiations. * Conduct assessment and negotiation with Councils and affected businesses. * Provide communciation materials to reach community - mailouts and website.							
Monitor and Record Natural Flow Events										
	*Prepare to track and monitor natural flow events with on ground survey and aerial photography run. * Use results to groundtruth and inform impact and mitigation strategies.	Continue to monitor natural flow events to inform extent of impact and mitigation strategies.								
			Detailed Planning and Design							
			* Develop detailed project delivery plan, including final design and cost of mitigation strategies, Landholder Agreements, Council Agreements and Commercial Business Agreements, stage individal negotiation of Agreements. * Provision of funding to stakeholders for expert advice.							
					Implementation of Agreements and Works					
									Trial Relaxation of Contraints	

Appendix 14 Alignment with the Phase 2 Guidelines

The key evaluation criteria specified in the Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases have been addressed in this Concept Proposal as referenced in the table below.

Guidelines Section	Heading	Requirement	Concept Proposal Section
4.1	Project Details	Key Project Details and Overview	2.2, 2.3, 3.1, 3.2
4.2	Ecological values of the site	Description of the ecological values of the site	3.3, Appendix 2
4.3	Ecological values and targets	Confirm objectives and targets	Appendix 2.3
4.4.1	Anticipated ecological benefits	Proposed outcomes from the investment	3.3, Appendix A.1, A.2
4.4.2	Potential adverse ecological impacts	Assessment of potential adverse impacts	3.4, 6, Appendix 10
4.5.1	Current Hydrology and proposed changes	Clear articulation of current and proposed hydrology	3.2, Appendix 1
4.5.2	Environmental water requirements	Water requirements of new inundated areas	3.2, Appendix 1, Appendix 2
4.6	Operating regime	Explanation of the role of each operating scenario	Appendix 12
4.7	Assessment of the risks and impacts	Assessment of risks and mitigation options	6, Appendix 10
4.8	Technical feasibility and fitness for purpose	Evidence that the project infrastructure is technically feasible	4.1, 4.2, 4.3
4.9	Complementary actions and interdependencies	Confirm interaction with other initiatives	7.2, Appendix 2.3
4.10	Costs, Benefits and Funding Arrangements	Detailed costing and list of benefits	4.4, Appendix 3, 4 5, 6 and 7
4.11.1	Stakeholder management strategy	Confirm stakeholder list and stakeholder management strategy	5, Appendix 9
4.11.2	Legal and regulatory requirements	Legal and regulatory requirements	Will align with multiple jurisdictional requirements and satisfy govt. investment principles.
4.11.3	Governance and project management	Governance and project management	7, Appendix 11

Guidelines Section	Heading	Requirement	Concept Proposal Section
4.11.4	Risk assessment of Project Development and Delivery	Risks from project development and delivery	6, Appendix 10