Bradley Tucker

Review of progress on water recovery in the Murray-Darling Basin

Review for the Wentworth Group of Concerned Scientists

Bradley J Tucker
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Progress of water recovery:

Surface water

The overall targets for the reduction in consumptive use of water is from 13,623 gigalitres (GL) to a 'Sustainable Diversion Limit' (SDL) of 10,873GL per year, measured as a long term average. This translates to a 2,750 GL increase in the long term average volume of environmental water by 2019. An additional 450GL is to be acquired under the Basin Plan for enhanced environmental outcomes, bringing the total water recovery to 3,200GL.

There has been 2004.5GL recovered to date (30 Nov 2016), which is 72% of the 2,750GL (Table 1). None of the 450GL has been recovered to date. Nearly three quarters of the water recovery has occurred in four valleys of the southern Murray-Darling Basin: the Victorian Murray (397GL), Goulburn (362.3GL), NSW Murrumbidgee (389.5GL) and NSW Murray (318GL) (Table 2).

Most of the water (57%; 1,577GL) was recovered, or under contract to be recovered, prior to the Basin Plan between 2009 and 2012 (Table 1). A further volume of water (15%; 427.5GL) was acquired between 2012 and 2016. Progress on water recovery has slowed significantly since 2014 when the Government shifted the focus of water recovery from buybacks to on-farm efficiency investment to minimise socio-economic impacts of water recovery. Basin states have until 2024 to complete efficiency projects and recover the 450GL long term average annual water volume under the SDL adjustment mechanism.

Table 1. Progress of water recovery in Murray-Darling Basin

Date	LTAAY (GL) [1]	Percent Recovered	Source
30-Sep-12	1577	57%	DSEWPaC 2012 Environmental Water Recovery Strategy for the Murray-Darling Basin Draft for Consultation Department of Sustainability, Environment, Water, Populations and Communities
30-Jun-13	1658	60%	MDBA 2013 Annual Report 2012-13, Murray-Darling Basin Authority, Canberra.
30-Jun-14	1904	69%	MDBA 2014 Annual Report 2013-14, Murray-Darling Basin Authority, Canberra.
30-Jun-15	1950.5	71%	MDBA 2015 Annual Report 2014-15, Murray-Darling Basin Authority, Canberra.
29-Feb-16	1953.6	71%	MDBA 2016 Progress on water recovery http://www.mdba.gov.au/managing-water/environmental-water/progress-water-recovery
31-Mar-16	1955.3	71%	MDBA 2016 Progress on water recovery http://www.mdba.gov.au/managing-water/environmental-water/progress-water-recovery
30-Nov-16	2004.5	72%	DAWR 2016 Progress towards meeting environmental needs under the Basin Plan http://www.agriculture.gov.au/water/mdb/progress-recovery/progress-of-water-recovery

[1]Consists of water entitlements recovered or under contract to be recovered.

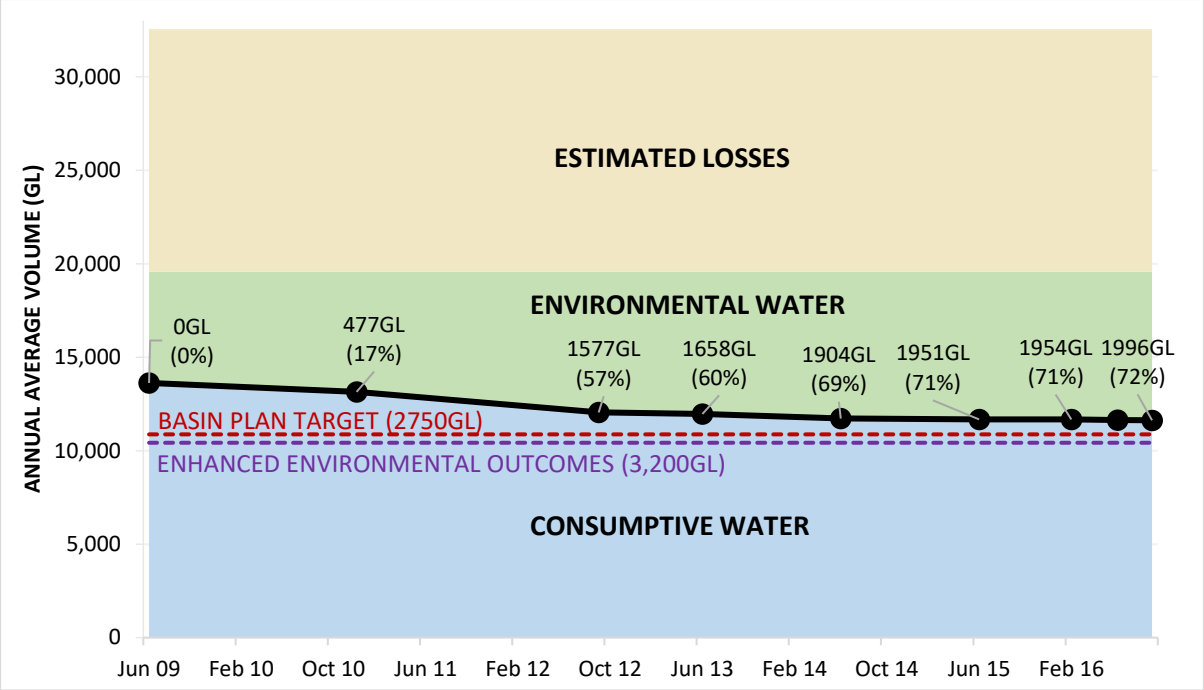

Figure 1. Long term average annual volumes of consumptive water, environmental water and estimated losses (e.g. evaporation, groundwater) in the Murray-Darling Basin from June 2009 to September 2016. Progress towards the 2,750GL and 3,200GL of water recovery under the Basin Plan is shown in black dots.

The summary in Table 2 below sets out water recovery targets across the Basin, current progress toward meeting the targets, and the balance of recovery required.

There are 2 key aspects of water recovery targets in the Basin Plan. These are:

- local targets, known in the Basin Plan as a 'local reduction amount', which apply at the SDL resource unit level.
- shared targets, known in the Basin Plan as a 'shared reduction amount', which apply at the shared zone level.

The terminology used in the Basin Plan, 'reduction amount', refers to the amount of reduction in water diversions for consumptive purposes (ie. BDL reduction). This 'reduction' is a condition of the water recovery contributing to the 2,750 GL water recovery target.

Most valleys have reached their local reduction targets as of November 2016 (Figure 2). Exceptions were the Condamine-Balonne (38.3GL remaining), Lachlan (0.1GL remaining), Wimmera-Mallee (0.4GL remaining), NSW Border Rivers (3.7GL remaining) and the Lower Darling (5.7GL remaining). These valleys were mainly in the northern Basin. SDLs in the northern Basin could change if the proposed amendments to the Basin Plan are successful.

Only the ACT zone has reached its shared reduction targets (Figure 3). In the southern Basin, the VIC zone has 251.7GL remaining, the NSW zone has 332.4GL remaining and the SA zone has 39.9GL remaining. The northern Basin zone has 73.2GL remaining.

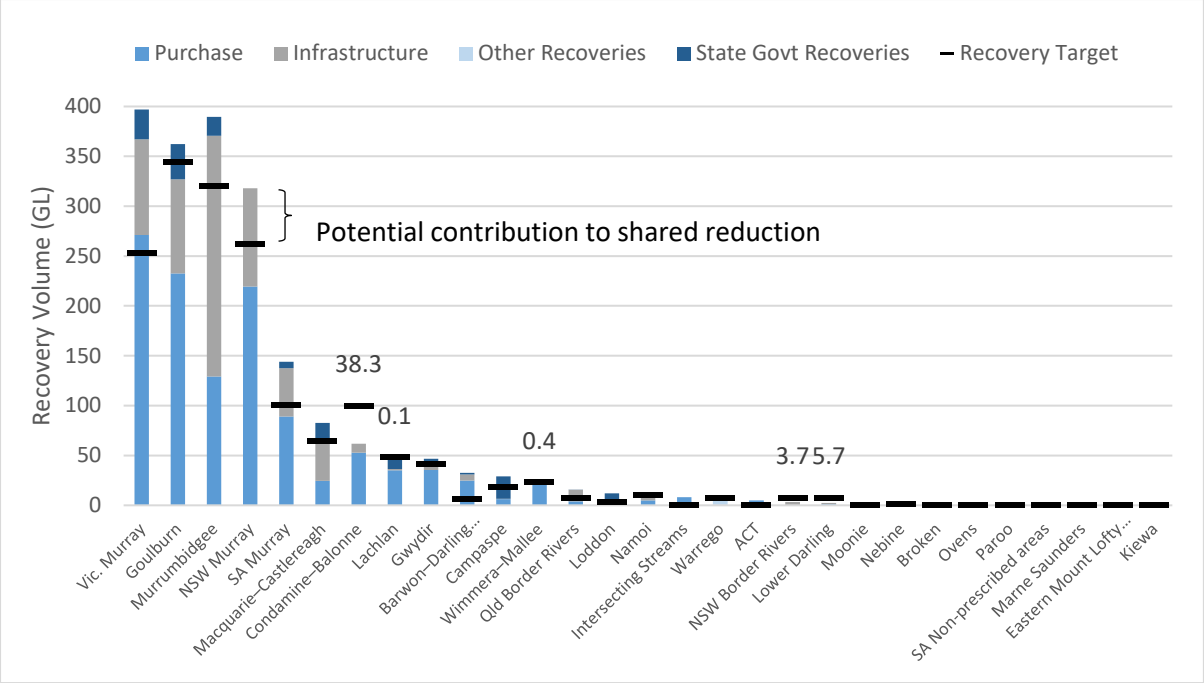

Figure 2. Water recovery relative to local targets (black lines) within valleys of the Murray-Darling Basin.

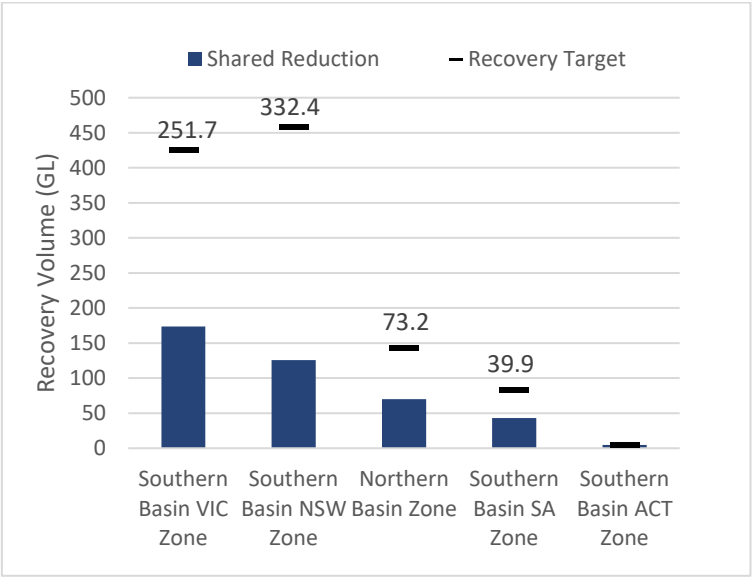

Figure 3. Water recovery relative to shared targets (black lines) within zones of the Murray-Darling Basin.

Table 2. Basin scale water recovery by SDL resource unit. (adapted from MDBA http://www.mdba.gov.au/managing-water/environmental-water/progress-water-recovery)

SDL Resource Unit (within zones)	**Total BDL (GL)**	**BDL (GL) excluding interception[1]**	**Total reduction target in GL (local plus shared)**	**Commonwealth recovery under the SRWUIP program**		**Other Commonwealth purchases[6] (GL)**	**State recovery[3] (GL)**	**Total recovery (GL)**	**Total recovery (local plus shared) still required (GL)**
				Purchased by Tender[5] (GL)	**Infrastructure Projects (GL)**				
Barwon-Darling Watercourse	197.5	198		24.6	6.2		1.5	32.3	
Condamine-Balonne	978.3	713.3		52.7	5.6		0	58.2	
Gwydir	450.2	325.2		35.5	5.1		6.2	46.9	
Intersecting Streams8	114	3		8.1	0		0	8.1	
Macquarie-Castlereagh	734.3	424.3		24.6	37.3		20.6	82.5	
Moonie	84.2	33.2		0	0.7	1.1		1.8	
Namoi	508.3	343.3		4.8	6.8		0	11.5	
Nebine	31.2	6.2		0	0	1		1	
NSW Border Rivers	302.6	207.6		0	3.3		0	3.3	
Paroo	9.9	0.2		0	0	0		0	
Queensland Border Rivers	320.1	242.1		3.6	11.3	0.5		15.3	
Warrego	127.7	44.7		0	0	8		8	
Total Northern Basin Zone	**3858**	**2541**	**390**	**153.8**	**76.2**	**10.6**	**28.4**	**269**	**121**
Lower Darling	60.5	55.0		1.0	1.3		0.0	2.2	
Murrumbidgee - NSW	2501.1	2000.1		129.2	208.9	2.4	19.0	359.6	
NSW Murray	1811.7	1707.7		219.5	86.7		0.0	306.2	
Total Southern Basin NSW Zone	**4373**	**3763**	**1048**	**349.6**	**296.9**	**2.4**	**19.0**	**668.0**	**380.0**
ACT (surface water)	52.5	40.5		4.9	0.0			4.9	
Total Southern Basin ACT Zone	**52.5**	**40.5**	**4.9**	**4.9**				**4.9**	**0.0**
Broken	56.2	13.2		0.0	0.2		0.0	0.2	
Campaspe	152.6	112.6		6.3	0.1		22.6	29.0	

Goulburn	1689.4	1580.4		232.6	94.3		35.4	362.3	
Kiewa	24.6	11.0		0.0	0.0		0.0	0.0	
Loddon	178.6	88.6		2.8	0.6		8.6	11.9	
Ovens	83.4	25.4		0.1	0.0		0.0	0.1	
Victorian Murray	1707.1	1662.1		271.0	96.6		30.1	397.7	
Total Southern Basin Victoria Zone	**3892**	**3493**	**1052**	**512.7**	**191.8**		**96.7**	**801.2**	**251.1**

Eastern Mount Lofty Ranges	28.3	15.3		0.0	0.0				
South Australian Murray	665.0	665.0		86.3	13.0	36.0	6.4	141.7	
Marne Saunders	2.9	2.9		0.0	0.0				
SA Non-Prescribed	3.5	0.0		0.0	0.0				
Total Southern Basin South Australia Zone	**700**	**683**	**184**	**86.3**	**13.0**	**36.0**	**6.4**	**141.7**	**42.1**

Lachlan[7]	618.4	302.4		35.0	1.5		11.4	48.0	
Wimmera-Mallee (surface water)	128.5	66.5		22.6	0.0			22.6	

TOTAL	**13623**	**10890**	**2750**	**1164.9**	**579.4**	**49.0**	**161.9**	**1955.3**	**794.7**

Notes:

1. Watercourse diversions under the Baseline Diversion Limit - arrangements as at 30 June 2009 under conditions from 1895 to 2009.
3. Includes NVIRP Stage 1.
5. Includes water purchased from the Wimmera and Murray Irrigation Irrigator Led Group Proposals, water acquired from the New South Wales Government relating to its purchase of Toorale Station, the Commonwealth water purchase from the Victorian Government relating to the Goulburn-Murray Water Connections Program and water purchased from ACTEW Corporation (Australian Capital Territory).
6. Includes Commonwealth water recoveries from the South Australian River Murray Sustainability Program (SARMSP, which is funded separately from SRWUIP), water gifted by the Queensland Government to the Commonwealth, and Commonwealth water recoveries secured through the Water Smart Australia Program.

Notes on surface water recovery not included in the estimates -

7. Lachlan - the amount of water estimated to have been recovered exceeds the local reduction amount by 1.707GL. As the Lachlan is a disconnected SDL resource unit the over-recovery cannot be used to meet to meet the 2750 GL reduction. To address this over-recovered volumes are excluded from the recovery estimates above (i.e. volumes of 0.863GL in SRWUIP and 0.844GL in State recoveries are excluded).

Intersecting Streams - this data includes unregulated water entitlements acquired from the NSW Government relating to its purchase of Toorale Station. As part of the Intersecting Streams Unregulated and Alluvial water sharing plan, an additional entitlement has been issued to the Commonwealth – unregulated river special additional high flow entitlement. This is a new class of entitlement and at this time there is no long-term diversion limit equivalent factor available to estimate the long-term diversion limit for this entitlement. At this stage, the unregulated river special additional high flow entitlement has not been counted towards 'bridging the gap'.

Groundwater

The target for groundwater recovery under the Basin Plan is 40.4GL and is to be recovered from two SDL resource units. There was 2.7GL (6.7%) recovered as of 30 November 2016. There is 37.7GL (93.3%) left to be recovered.

	Sustainable Diversion Limit Reduction Amount			*Recovery Progress*		*Remaining*
SDL Resource Unit (or Shared Zone)	Local Target (GL)	Shared Target (GL)	Total Target (GL)	Purchase (GL)	Total Recovery (GL)	Total recovery remaining (GL)
Upper Condamine Alluvium (Central Condamine Alluvium)	35.4	N/A	35.4	2.7	2.7	32.7
Upper Condamine Alluvium (Tributaries)	5.0	N/A	5.0	0.0	0.0	5.0
Total Basin	40.4	N/A	40.4	2.7	2.7	37.7

Remaining water recovery

There is 754GL of surface water recovery remaining (27% of the 2,750GL), plus 450GL to recover for enhanced environmental outcomes. There is also 37.7GL of ground water recovery remaining (93.3% of the 40.4GL). There are considerable challenges in recovering this water because:

1. 1500GL cap will limit opportunities for buybacks;
2. Remaining water recovery could be more expensive because (a) infrastructure is more expensive than buybacks (b) the low hanging fruit (i.e. best sites) are already taken. Thus there is a risk of running out of money before we can recover all the water;
3. Not certain there will be suitable locations for upgrading irrigation infrastructure (a) relies on voluntary uptake, and people may be concerned of the risks of economic impacts to individuals despite gains on the larger scale (i.e. some farms cut off completely from water supply), and (b) locations where water recovery is required may not be suitable for upgrading infrastructure;
4. Regarding the 450GL, basin states have provided little clarity around exactly what projects will be put forward, how much water will be delivered under these projects and how much these will cost.

Also potential changes to the SDLs may mean less water recovery altogether (see figure below):

1. SDL adjustment – a net change in the SDL of up to ±544GL (5% of SDL), depending on the final package of supply and efficiency measures;
2. Proposed changes to SDLs in the Northern Basin– 70GL increase in SDLs.
3. Proposed changes to groundwater SDLs – a total increase of 160GL in three groundwater resource areas.

With these changes, there is a possibility that the water recovery amount could be as low as 2,136GL. This is less than the 2,400GL minimum requirements, which according to ESLT modelling

"was insufficient to achieve a number of key environmental objectives for the River Murray downstream of the Murrumbidgee junction (including the Coorong, Lower Lakes and Murray Mouth)."

These figures are modelled on average historical rainfall and runoff. Long term average water availability under climate change may be less than historical averages, particularly in the southern Basin where average inflows could change by -10 to +5% in the south and -11 to +8% in the north by 2030. Volumes available for the environment under a changing climate will need to be revisited in future reviews of the Basin Plan.

It is critical that the MDBA's estimate of water recovery is accurate and up to date. The volume of water recovered (Table 1) is estimated by converting entitlements to long term average annual water yield based on the reliability of entitlements (also known as a 'cap factor'). Changing the cap factor will not change the amount of water that needs to be recovered, only the estimate of what has been recovered so far. The MDBA will need to ensure that cap factors are frequently reviewed in light of changing resource availability, management rules and other factors influencing reliability, so that the Commonwealth can acquire the appropriate entitlements and meet recovery targets.

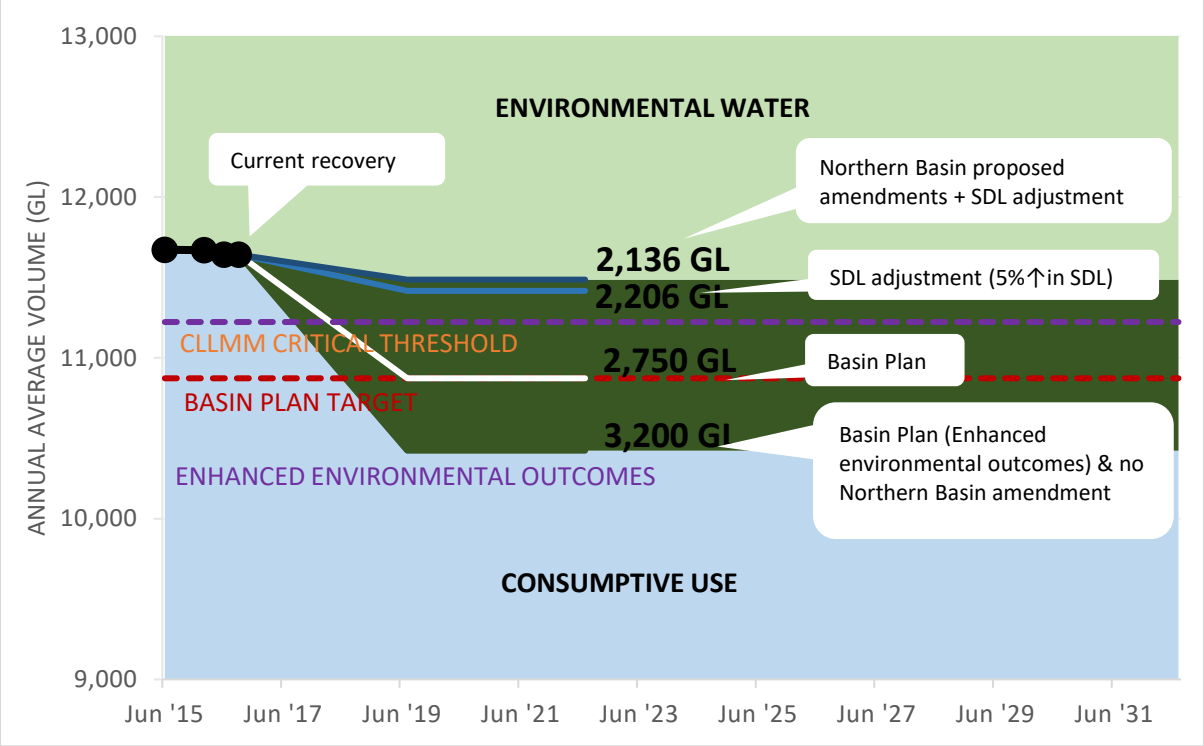

Figure 4. Alternative scenarios for surface water recovery depending on how the SDL adjustment and proposed amendments in the Northern Basin are progressed.

Recovery strategies:

The Australian Government's Water Recovery Strategy for the Murray-Darling Basin (June 2014) prioritises water recovery for environmental purposes through infrastructure investment over water buybacks. Prior to the release of this strategy, in November 2013 the Australian Government introduced a 1500 gigalitre cap on surface water buybacks to address community and industry stakeholder pressure over the potential adverse social and economic impacts on irrigation dependent communities that may arise from water purchases. The cap means that currently the only option to recover the remaining water is via infrastructure projects that reduce water use and loss by industry. These projects have been summarised by SDL resource unit in Table 2.

Overall, $13 billion has been committed by the Commonwealth Government for a suite of programs (Table 3). Of this, $7.1 billion (55%) has been spent and $5.9 billion remains. Some of these programs are explained in more detail below.

Table 3. Expenditure under the Water for the Future program.

Program	**Commitment ($bn)**
Enhanced environmental outcomes for Water for the Environment Special Account	1.775
On- and off-farm irrigation efficiency and infrastructure projects and related activities	5.6
Water purchase	3.1
Supply or offset measures	1.3
South Australian River Murray Sustainability Program	0.265
South Australian Riverland Floodplains Integrated infrastructure Program	0.155
Murray-Darling Basin Regional Economic Diversification Program	0.1
The Living Murray Initiative	0.184
Water Smart Australia projects	0.332
Water for Rivers	0.038
Lower Lakes Remediation	0.009
Hume Dam remedial works	0.01

Program	**Expenditure**
Total expenditure	13
Expenditure to date	7.1
Remainder	5.9
% spent	55%

Water for the Environment Special Account

In addition to the 2,750GL recovery, the Commonwealth government established a Water for the Environment Special Account to recover an additional 450GL and ease or remove constraints to delivery of environmental water. This $1.76billion fund is established via Part 2AA of the *Water Act 2007.* Water access rights acquired by the Commonwealth using funds from the Water for the Environment Special Account form part of the Commonwealth environmental water holdings. According to the Australian Government Special Accounts Balances and Cash Flows Report for year ended 30 June 2015, the Department credited $15 million but nothing was spent in this year. Accounts for year ended 30 June 2016 are not available at the time of writing.

See http://www.finance.gov.au/resource-management/appropriations/special-accounts/

Yearly payments		
Item	**Financial year**	**Amount for financial year**
1	2014-2015	$15,000,000.00
2	2015-2016	$40,000,000.00
3	2016-2017	$110,000,000.00
4	2017-2018	$430,000,000.00
5	2018-2019	$320,000,000.00
6	2019-2020	$350,000,000.00
7	2020-2021	$315,000,000.00
8	2021-2022	$105,000,000.00
9	2022-2023	$60,000,000.00
10	2023-2024	$30,000,000.00

Figure 5 Amounts credited to the Water for the Environment Special Account (s86AG Water Amendment (Water for the Environment Special Account) Act 2013

The Sustainable Rural Water Use and Infrastructure Program (SRWUIP)

The Sustainable Rural Water Use and Infrastructure Program (SRWUIP) has been the key platform for water recovery and consists of 3 components – irrigation infrastructure projects, water purchase measures and supply measures.

Water infrastructure projects funded under the SRWUIP that are expected to contribute to the reduction to SDLs are detailed in Table 4. Market multiple and contracted values for each project are provided, however it is not clear at what price the market multiple was determined. A static market multiple at project commencement does not account for the significant opportunity cost lost during time for infrastructure completion when the water is physically recovered. This is demonstrated by the low completion rate of projects shown in Annexure A of the water recovery strategy.

Table 4 Australian Government investment in Murray-Darling Basin gap bridging water infrastructure projects (Water Recovery Strategy for the Murray-Darling Basin, Commonwealth of Australia 2014)

State	Programme/Project	Contracted ($m)	Water recovery towards Bridging the Gap (GL LTAAY)	Market Multiple
NSW	SPP[1]—NSW—Private Irrigation Infrastructure Operators Program (PIIOP)	642	**113**	2.4
	SPP—NSW Water Metering Scheme (Pilot Project)	22	**4**	3.5
	SPP—NSW Water Metering Scheme (excluding pilot)	199	**28**	2.3
	SPP—NSW Basin Pipes (Stock and Domestic)	137	**30**	2.5

	SPP—Irrigated Farm Modernisation (Border Rivers-Gwydir Pilot Project)	7	**0.5**	2.3
	SPP—Irrigated Farm Modernisation Project	85	**12**	2.5
	Nimmie Caira Enhanced Environmental Water Delivery Project	180	**133**	2.4
Qld	SPP—On Farm Water Use Efficiency Project (Healthy Headwaters)—rounds under contract to date	51	**7**	2.0
Vic	SPP—NVIRP Stage 2 Project (now known as Goulburn-Murray Water Connections Project Stage 2)	956	**102**	4.9
	SPP—NVIRP on-farm component	44	**10**	2.3
	Victorian Farm Modernisation Project (assuming all three tranches proceed)	100	**30**	1.9
	Sunraysia Modernisation Project	103	**7**	7.1
SA	SPP—SA Private Irrigation Infrastructure Program (PIIP-SA)	14	**3**	2.6
	South Australian River Murray Sustainability Program (SARMSP)—irrigation efficiency component[2]	80	**16.8**	2.5
Southern Basin	On-Farm Irrigation Efficiency Program—including pilot projects and first three rounds under contract.	296	**83**	2.3
Total 'bridging the gap' infrastructure water recovery[3]			**560[4]**	

Notes

1 SPP = State Priority Project—funds for which were committed under the 2008 Intergovernmental Agreement on Murray-Darling Basin Reform.

2 SARMSP is funded separately from SRWUIP.

3 'Bridging the gap' water recovery from infrastructure investments is reported at the point at which water savings have been received, estimated or agreed in signed project works contracts. Until water transfer contracts have been exchanged however, these figures may be subject to change. The recovery volume is shown in gigalitres (GL) and expressed as long term average annual yield (LTAAY)), and is subject to rounding.

4 A further 17 gigalitres of Disconnected Basin (Lachlan River) water has been recovered through infrastructure initiatives but is not 'gap bridging'.

The strategy of water recovery by floodplain manipulation via infrastructure has been pursued contrary to evidence that suggests direct market intervention is a more cost effective and faster way

to recover water. In 2010 the Productivity Commission detailed the following recommendations on water recovery in the MDB:

Purchasing water products from willing sellers is generally the most effective and efficient means of acquiring water, where governments are liable for the cost of recovering water for the environment – Finding 6.3

Funding irrigation infrastructure upgrades is generally not a cost-effective way for governments to recover water for the environment – Finding 6.4

Rather than having a $5.8 billion program focused predominately on infrastructure upgrades, it would have been more effective and efficient to:

- *use the sustainable diversion limits from the Basin Plan to determine the targets for reallocation in each catchment*
- *use the buyback program as the sole means of easing the transition to those targets*
- *consider establishing a much smaller program to assist irrigators and related communities adjust to a future with less water, through the most effective means available (not just subsidies for irrigation infrastructure)* – Finding 6.5

Subsidising these projects is an attractive approach for decision makers and politicians because modernising irrigation infrastructure and rationalising water use can result in water savings which are then allocated to the Commonwealth Environmental Water Holder for environmental purposes. Furthermore, recovery in this way has been promoted as a way to assist communities adjusting to socio-economic impacts resulting from exiting irrigation and reductions in consumptive water entitlements. For the remaining taxpayers, recovering water through subsidising efficiency improvements is significantly more expensive than direct water buybacks. Others suggest that this difference is likely to widen as cost per ML of water recovered increases, further diminishing marginal returns (see Figure 6).

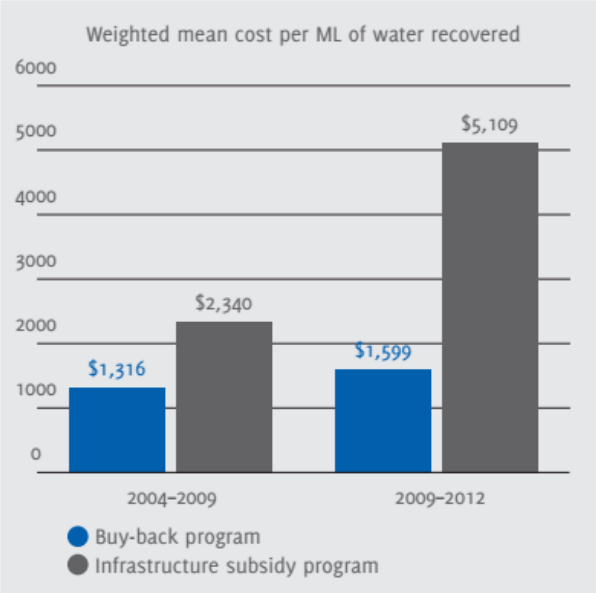

Figure 6 Comparison of market buy-back vs infrastructure subsidies. (Taken from Loch et al. 2014).

Restoring the Balance in the Murray Darling Basin (water entitlement buyback)

The Restoring the Balance in the Murray-Darling Basin Program is the market buy back of water entitlements component of SRWUIP. The latest water purchase information by SDL resource unit is available from http://agriculture.gov.au/water/markets/commonwealth-water-mdb/progress-water-purchases

Table 5. Total water recovery from buy backs in the Murray-Darling Basin (as of 31 August 2016). Taken from http://agriculture.gov.au/water/markets/commonwealth-water-mdb/progress-water-purchases

SDL resource unit (catchment)	Water purchase tenders—entitlement (ML)	Water purchase tenders—LTAAY (ML)	Other purchases—LTAAY (ML)[1]	Purchases exempt from 1500 GL Limit - LTAAY (ML)	Total LTAAY (ML)[2,3]
All catchments	1 359 149	1 016 883	148 641	2 880	1 168 403

1. Other purchases include water purchased from the Wimmera and Murray Irrigation Irrigator Led Group Proposals, water acquired from the NSW Government relating to its purchase of Toorale Station, water purchased from the Victorian Government relating to the Goulburn–Murray Water Connections Program and water purchased from ACTEW Corporation (Australian Capital Territory).

2. Data includes unregulated water entitlements acquired from the NSW Government relating to its purchase of Toorale Station. An additional new entitlement (unregulated river special additional high flow entitlement for 9.720 GL is part of the *Water sharing plan for the intersecting streams unregulated and alluvial water sources*) has been issued to the Commonwealth. This recovery is not shown in the table because there is currently no long-term diversion limit equivalent factor available to estimate the long-term average annual yield (LTAAY) recovery volume for this entitlement.

3. Consistent with the Water Act 2007 (s85B, C and D), the 2.9 GL LTAAY of water secured from the SA Government in May 2016 is exempt from the 1500 GL limit on water purchases.

The average prices of offers pursued from recent water purchasing initiatives under the Restoring the Balance in the Murray-Darling Basin Program are reported in the website below.

http://agriculture.gov.au/water/markets/commonwealth-water-mdb/average-prices

For example, the average price of offers pursued from the November 2015 – February 2016 Queensland Upper Condamine Alluvium groundwater tender was $1,736.13 per ML.

The Commonwealth Environment Water Office is responsible for management of Commonwealth environmental water holdings under the Basin Plan. Commonwealth water holdings are the direct result of government purchases of entitlements and a substantial investment in more efficient water infrastructure in the Murray Darling Basin. The portfolio of water entitlements by catchment is updated periodically and available through the website below.

https://www.environment.gov.au/water/cewo/portfolio-mgt/holdings-catchment

The CEWO has accumulated a large and diverse range of entitlements, including significant quantities of low yielding entitlements (e.g. General, low, supplementary). In some catchments the Long Term Average Annual Yield (LYAAY) represents less than half the total registered entitlement

volume (e.g. Gwydir, Lachlan, Macquarie). Accumulation of water entitlements and LTAAY are shown in Figure 7.

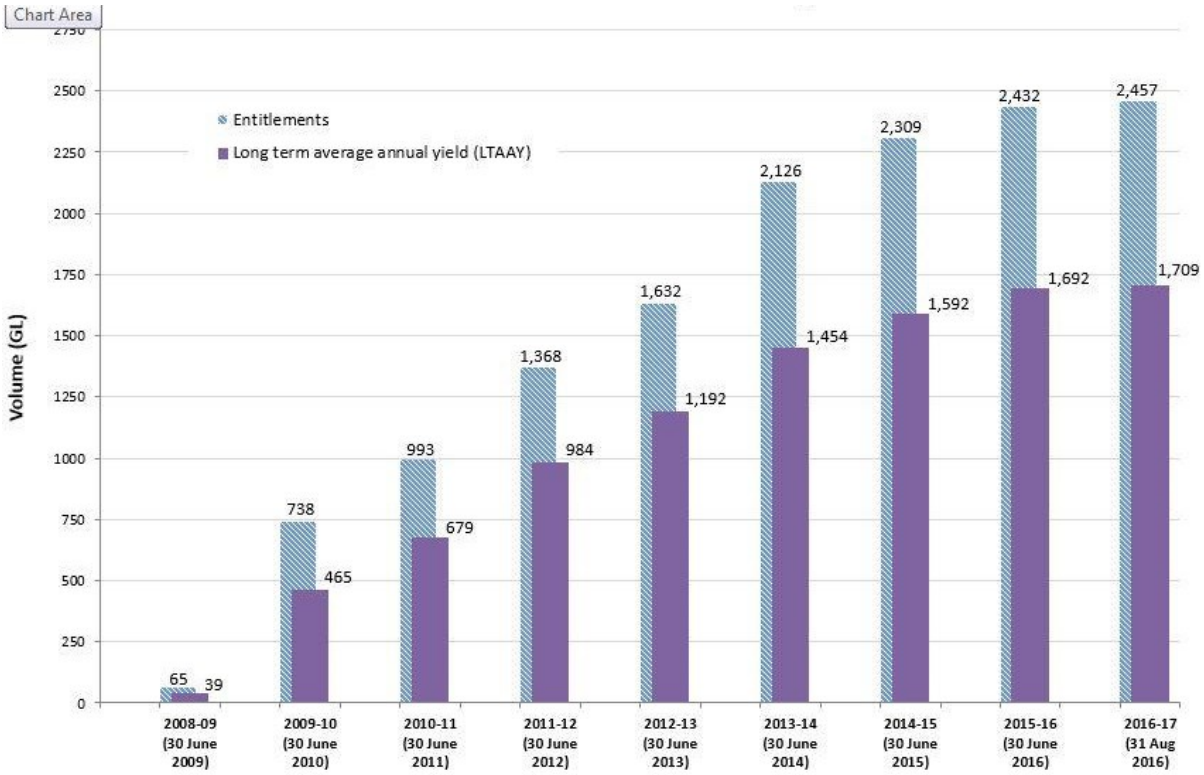

Figure 7. Total entitlements and Long term average annual yield of Commonwealth Environmental Water Holdings (from CEWO)

Water allocation and use

The MDBA is required to keep a register of consumptive water diversions based on data provided by the states. This register is to be used as the basis for ensuring compliance with SDLs. The Cap register has been prepared up to 30 June 2014. However at the time of writing the *Transition Period Water Take Reports* have not yet been published so we were not able to determine compliance with the SDLs under the Basin Plan.

Total water allocations and diversions for the Murray-Darling Basin between 1997-98 and 2014-15 are shown in Figure 8. Average annual allocations during this period were 9,450GL and average annual diversions were 8,507GL. There was a declining trend in allocations and diversions between 1997-98 and 2008-09 during the drought period. This was followed by an increasing trend between 2008-09 and 2012-13 during a relatively wet period. There was a subsequent decline in total allocations and diversions from 2012-13 to 2014-15 in the drier period and under the Basin Plan. Variability was due to a number of factors including water availability, management rules and behaviour of irrigators. Diversions may exceed allocations in a given year because of carryover and trade.

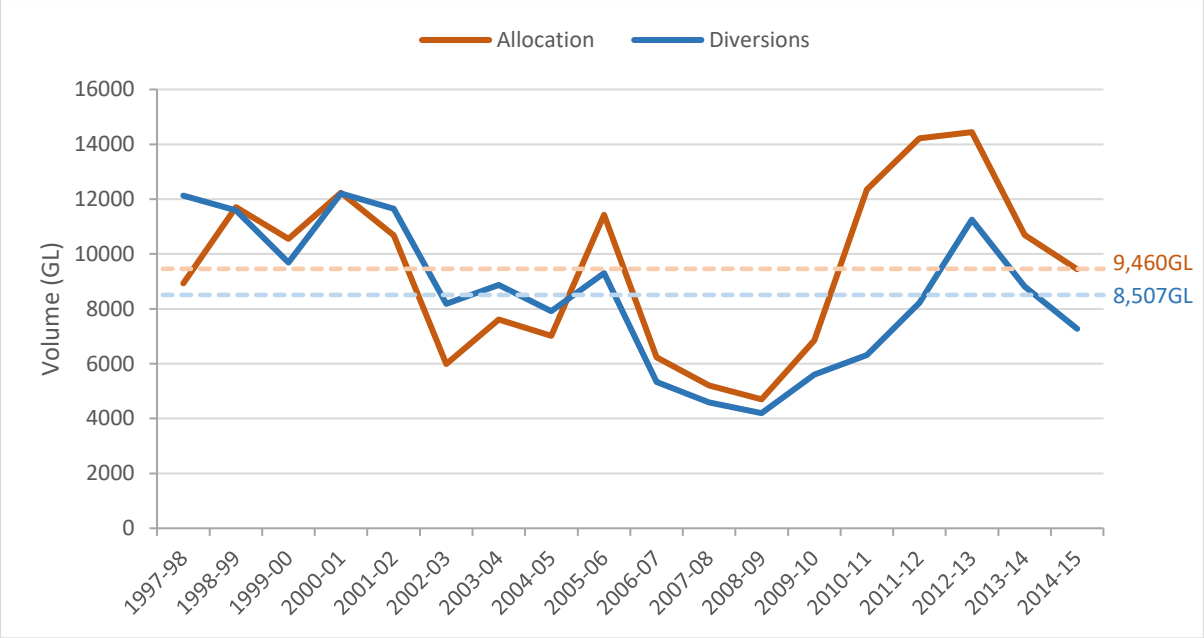

Figure 8. Overall water allocations and diversions for the Murray-Darling Basin based on the Cap register (MDBA, 2016).

At the valley scale, trends in diversions varied (Figure 9). There were clear long term declines in diversions in some valleys including the ACT, Broken and Campaspe. In other valleys, diversions were variable and showed no strong trends e.g. the Barwon-Darling, Namoi, NSW Border Rivers and Victorian Murray.

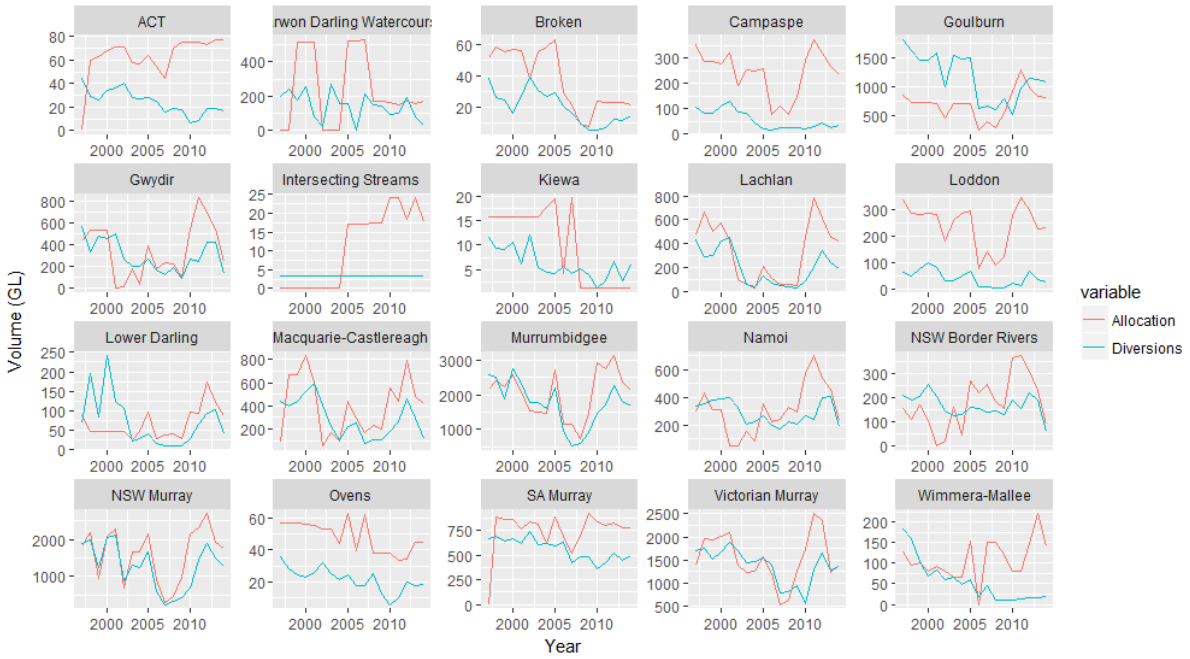

Figure 9. Allocations and diversions each year in valleys of the Murray-Darling Basin between 1997-98 and 2013-14.

Adjusting the SDLs

Environmental works and measures projects involve the manipulation of water via infrastructure to achieve similar or better environmental outcomes using less water than previously estimated in the Murray-Darling-Basin Plan. The types of projects proposed by the States include the installation of regulators and ancillary infrastructure such as pumps and pipes to enable broader seasonal

floodplain or wetland inundation , and the removal of physical constraints to facilitate the delivery of environmental flow.

Some environmental works and measures are also considered suitable as a supply measure, as defined in the Murray-Darling Basin Plan. Supply measures are works, river operations or rule changes that enable the use of less water but still achieve the Plan's environmental outcomes.

On 22 April 2016 the Murray-Darling Ministerial Council Ministers agreed to a package of supply, efficiency and constraints measures that will result in changes to the sustainable diversion limits (SDL) of the Murray–Darling Basin Plan. As of April, the MDBA had modelled 15 of the 37 nominated projects and estimated these projects will offset 370GL of water (long term annual average yield).

The Ministerial Council also requested that the Commonwealth amend the Basin Plan to provide for a second SDL adjustment step by 30 June 2017. This amendment was passed by parliament in 2016. This has allowed for a second tranche of projects to be developed to further offset water under the Basin Plan.

Ministers also reiterated their request for Basin officials, after 30 June 2016, to consider opportunities for a wider range of complementary projects, such as carp control, to provide triple bottom line benefits under the Basin Plan. This is a concerning direction to provide to the states developing SDL adjustment projects because it legitimises effort and resources to be spent on unintended impacts resulting from the delivery of these projects rather than focusing on tangible water recovery. This has the potential for an evolving acceptance of complementary measures as substitutes for physical water recovery.

There are several issues with regard to the offsetting of water with infrastructure projects and other non-flow activities:

1) Use of constructed infrastructure cannot replicate all the functions that occur when a river naturally floods. Hence, sole reliance on site-specific management using works and measures could lead to a failure to achieve many of the management objectives for the floodplain and wider region. This is because:
    a. Objectives proposed for infrastructure usually deal with comparatively simple cause/effect relations which are relatively well understood at the relevant scale, while relationships between flow and elements of the ecosystem are part of a highly complex cause/effect system.
    b. Most infrastructure projects are aimed at a limited range of outcomes such as the provision of water regimes mimicking the irrigation requirements of eucalypts, with limited attention to other biota.
    c. Infrastructure projects are designed to produce a limited suite of hydrological outcomes in a prescribed landscape. Purchased water, on the other hand, is more versatile. In theory it can be used to produce a wide range of hydrological regimes (and therefore ecological outcomes) and its use is not limited to the valley or year in which it was harvested. Not only does it provide the flexibility to create multi -site (and/or multi-outcome) events, as evidenced by the recent series of trials managed by MDBA, but it allows new knowledge to be easily translated into river operations programs.
2) Construction and use of infrastructure could increase the risk of unintended consequences for ecosystems and land and water users, such as disconnecting parts of the floodplain from inundation or enhancing the risk of blackwater events;

3) Requires ongoing cost and maintenance;
4) Any offset of water from the river system will result in reduced in-channel flows and flows at the end of system which is counteractive to objectives for the Coorong, Lower Lakes and Murray Mouth;
5) The idea that you can engineer a floodplain ecosystem that will support existing and new species is not yet scientifically proven (known as the 'field of dreams' hypothesis). There is little scientific evidence of the long-term benefits of interventions. Ecological benefits expected from these interventions are based on hypothetical relationships between hydrology and the aquatic ecosystem. Leaving aside the possible risks from non-hydrological factors, operation of infrastructural interventions will require a period of experimentation and monitoring as part of an adaptive management program.

This report focuses on the benefits and risks associated with works and measures. Delivery of any infrastructure project requires mitigation of environmental risk, in particular where complex and sensitive ecological systems are impacted. Cumulative impacts from the array of potential projects - including an understanding of benefits or increased risks of delivering combinations of projects - is missing. At the basin scale, science-based strategic assessment of the suite of preferred projects is critical for understanding of water recovery benefits and ecological consequences. Analysis has shown that environmental works based projects in effect compete for available environmental water. It is also possible that some non-works proposals could compete (Martin and Turner 2015). Until such time all proposed state projects have developed detailed business cases including modelling and sensitivity analysis on configurations of preferred projects, it is impossible to understand whether the SDL adjustment mechanisms ill deliver end-of-system flow requirements, and other targets set out in the Basin Plan.

At the time of writing this report, only 10 project business cases from Victoria and 5 project business cases from South Australia were available to the Wentworth Group. Analysis and summaries of key issues relating to the delivery and operation of these proposals is provided in the Appendix. The review also considered the previous 2015 stocktake assessment commissioned by the Murray-Darling Basin Ministerial Council, which included nine Victorian environmental works and measures projects (Martin and Turner 2015).

Some consistent key risk issues across projects include:

- Poorly defined project governance arrangements considering the complex planning, operational and management procedures that will involve the collaboration and cooperation of Federal and State government agencies.
- Private land impacts from flooding are known for 5 … of the Victorian projects, with no comprehensive assessment of third party impacts for another 2 projects
- Increases in carp and other pest fish species are expected to affect all of the projects.
- Stranding of native fish during/after watering or lack of flow cues for exit. General adverse impacts on ecological function and connectivity for aquatic species.
- Demands on water infrastructure design to operate effectively through a wide range of hydrological regimes. Associated episodic reduction in hydrodynamic diversity (eg lentic habitat creation, prolonged inundation of vegetation)
- Finalisation of infrastructure design (see above point), construction and ongoing operation and maintenance cost and ownership have not been addressed in business cases. Smaller projects are likely to yield a low supply volume benefit at very high cost. Plausible supply

contribution for nine Victorian environmental works and measures projects was estimated at 40-50GL with a moderate certainty (Martin and Turner 2015).

- Sensitivity analysis on the operation of infrastructure and linkages to other projects is missing and will affect estimates of supply contribution.
- Adverse water quality impacts when water ponded on floodplains eventually returns to the channel (salt migration; anoxic blackwater; eutrophication).

Chowilla TLM Ecological Principles

The Basin Plan requires at least equivalent environmental outcomes to be achieved by supply measure projects. Projects are assessed under an ecological elements method developed by CSIRO and commissioned by the MDBA as per its responsibilities under Schedule 6 of the Basin Plan.

The Chowilla TLM business plan utilised conceptual models of the expected responses to managed inundation of the Chowilla Floodplain operating the Chowilla Regulator and the ancillary structures (see Monitoring Strategy for Chowilla Creek Regulator and ancillary structures, DEWNR 2014). While using conceptual models provides a useful simplification of key processes, it should be noted that management for one objective will directly or indirectly affect the ability to achieve other objectives. Hence, achieving successful managed inundations will not be as simple as just add water (DEWNR 2014).

Therefore, a set of ten Ecological Principles have been established to guide management actions. These are:

1. Managed inundations are not a substitute for natural floods

2. The scale of management actions will be adaptively managed so as to maintain conditions within the Basin Plan and other statutory water quality targets

3. Management will strive for a balance between maximising benefit and minimising the likelihood of identified hazards causing harm

4. Flow regime, history and components of pulses will be used in planning management actions

5. Management actions will be synchronised to river hydrology

6. Maintaining water exchange is a key priority

7. The source of water used in management actions will be taken into account

8. Outcomes from multi-site watering will be taken into account

9. Operating regimes will be flexible and responsive to emerging conditions

10. Management shall strive for a resilient, sustainable ecosystem

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APPENDIX 1– Victorian business case summaries and ecological risks

Project	**Type**	**Total cost & ownership/operation responsibilities**	**Stage**	**Complexity of works**	**Ecological Objectives**	**Changes in river hydrology**
Belsar Yungera	Supply measure	Approx. $55.6 million Ongoing maintenance costs estimated to be maximum $2.324 million annually Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach' (ie. Would be managed by a Victorian agency such as DEPI, Mallee CMA, North Central CMA, Parks Victoria or G-MW)	New project→ Measures proposed will work in conjunction with proposed altered river operations and existing environmental infrastructure Seeking 100% of funding Mallee Catchment Management Authority (MCMA)	-Construction of 3 large regulators, 12 smaller supporting regulators, 2 culverts, 3.6km of track raising, a 4km low pressure pipeline and a fish passage which connect parts of the floodplain through tiered watering events -Operational by 2024	Inundation will promote the germination of aquatic plants which provide understory habitat for aquatic fauna, maintain the health and promote growth of tree communities and the important habitats they provide Key environmental outcome is to maintain the productivity and structure of Black Box Woodland which requires inundation on average 5-6 years in 10 for 4-8 weeks → this is not met under the current hydrologic regime Restore and enhance habitat linkages between the river and Narooyia Creek for Murray cod and other native fish : **meets associated Basin Plan objective 1,2,4,5,6,7,8,9,10,1,14** Restore and enhance native fish habitat by improving the productivity of riparian zones and wetlands: **meets associated Basin Plan objective 1,2,4,5,6,7,8,9,10,11,13, 14** Restore and enhance semi-permanent wetlands capable of supporting growling grass frog : **meets associated Basin Plan objective 1,2,4,5,6,7,8,9,10,11,13,14** Maintain lignum shrubland as a frequently flooded and productive habitat for fish and	-The Basin Plan will primarily affect flows less than that required for floodplain watering -E.g. flows of 30,000ML/day will occur 6 times in 10 years under baseline, 8 times under basin plan and 9.5 naturally -By comparison flows of 80,000ML/day will occur 1.7 times in 10 years under baseline, 2 times under Basin Plan and 5 naturally -The measure can provide equivalent inundation to that of a 50,000ML/d flow event and the frequency of this event will increase from 3.8 to 7.2 events in 10 years - -

					waterbirds: **meets associated Basin Plan objective 1,2,4,5,6,7,8,9,10,11,13, 14** Restore and enhance floodplain productivity to maintain resident populations of vertebrate fauna including carpet python and bats: **meets associated Basin Plan objective 1,2,4,5,6,7,8,9,10,11,13, 14** Intermittently provide productive lake habitat for hundreds of waterbirds: **meets associated Basin Plan objective 1,2,4,5,6,7,8,9,10,11,13, 14** Contribute to the carbon requirements of the River Murray channel ecosystem: **meets associated Basin Plan objective 1,2,4,5,6,7,8,9,10,11,13, 14**	
Burra Creek	Supply measure	Approx. $12.1 million Ongoing maintenance and operation costs are estimated at a maximum of $500,000 annually Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government	New project Seeking 100% of funding MCMA	-Construction involves multiple regulators, raised track and levees and a drop structure (this will provide a plunge pool for a downstream fish passage) -Water controlled by B1. B2 and B4 regulators and a levee -Construction occurs on public	The project will address deficiencies in the water regime in the northern section of Burra Creek and adjacent lignum and black box floodplain vegetation Flooding the adjacent floodplain will improve vegetation health, productivity and connection with the River Murray and enable biota and nutrient exchange Restore seasonal aquatic habitat to Burra Creek: **meets associated Basin Plan objective 1,2,4,6,7,8,9,10,11,14** Restore floodplain productivity to maintain resident populations of vertebrate fauna including bats, sugar glider and lace monitor: **meets associated Basin Plan objective 1,2,4,6,7,8,9,10,11,14**	-Contribute towards bridging the gap between natural and baseline conditions -Environmental watering will occur for 3 main water regime classes: seasonal anabranch and billabongs, lignum shrubland and woodland and black box and red gum woodland -Inundation area of 407ha

		approach' (ie. Would be managed by a Victorian agency such as DEPI, Mallee CMA, North Central CMA, Parks Victoria or G-MW)		land with 76ha of private land inundated at the maximum level -Contingency forms 48% of the total costings	Contribute to the carbon requirements of the River Murray channel ecosystem: **meets associated Basin Plan objective 1,2,4,6,7,8,9,10,11,14**	-The works would allow for frequency of inundation equivalent to 20,000ML/d with a maximum of 30,000ML/d flow events which would inundate 407ha of the Burra North floodplain
Goulburn	Constraints measure	Approx $140.12 million Ongoing cost of $1.1 million annually for operation and maintenance Delegation of asset ownership and operation cannot be confirmed at this time. Victoria currently has agreed arrangements in place through the BSOG to resolve asset ownership for its nine	New project→ complemented by a range of ongoing in stream and riparian works and the establishment of national parks Seeking 100% of funding Goulburn Broken Catchment Management	-Works enabling delivery of flow are relatively straightforward, including improved modelling and forecasting tools and the development of revised operational procedures -Cost of these actions are approx. $5 million	Increase the abundance, spatial distribution and size class diversity of key native fish species Increase the abundance and richness of aquatic and flood dependent native vegetation species Increase macroinvertebrate biomass and diversity Protect and promote natural channel form and dynamics (.e.g sediment diversity, rates of sediment transport and bank erosion rates) Increase instream physical habitat diversity (.e.g shallow and deep water habitats)	-Project would deliver target flows of up to 25,000ML-30,000ML/d at Shepparton during a controlled flood event -This would flood up to 12,000ha of the Goulburn floodplain which includes a maximum of 8,700ha of private land and 562 properties -Project aims to restore the frequency

		works-based supply measures and this would inform any arrangements that are finalised for the project	Authority (GBCMA)	-Cost of program management = $8.4 million -Cost of community and landholder engagement = $12.0 million -Majority of costs are associated with the mitigation of third party impacts (see risks table) **<u>Other:</u>** Key uncertainties are: -Actual frequency, timing and duration of environmental flows -Potential errors in inundation modelling -Economic assumptions -Appropriate balance between easement and infrastructure-based mitigation measures -Costs of engineering works	Provide sufficient rates of in-stream primary production and respiration to support native fish and macroinvertebrate communities Increased discharge from the Goulburn River through bank-full and overbank flows could also contribute to flow targets set for the central Murray system and further downstream as far as the Lower Lakes and Murray mouth In combination with other measures proposed for the River Murray channel, the project could offset operational constraints caused by the Barmah Choke	of minor flow peaks in the lower Goulburn River by delivering an additional 1 to 3 overbank flows (25,000ML/d) per decade for short durations -Target flows could be achieved by additional releases from Lake Eildon (limited to a maximum of 10,000ML/d to reduce impacts on the mid-Goulburn reach) and additional releases by ceasing diversions to Waranga Basin and passing these flows downstream over Goulburn Weir

Gunbower	Supply measure	$12.8 million Ongoing annual operation and maintenance costs estimated at $902,726 during operating years and $386,120 during non-operating years Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach'	New project Seeking 100% of funding North Central Catchment Management Authority (NCCMA)	-Infrastructure package involves the construction of a regulator, diversion weir, pump pads, short pipeline, remedial works, access tracks, irrigation channel, upgrade to three road culvert crossings and a forest regulator -Package designed to be operationally flexible, minimise adverse ecological and third party impacts and be cost-effective **<u>Other:</u>** -The project aims to connect the forests to an alternative water supply: the Torrumbarry Irrigation Area so the success of the	Enhance water-dependent ecosystems that support numerous listed threatened species and ecological communities Provide opportunities for connectivity between the River Murray and permanent wetlands within the forest (Black Charlie Lagoon) Provide wetting and drying phases that enhance ecological community structure and stimulate species interactions and food webs- this will also be tailored to meet the hydrological requirements of water-dependent values within the range of tolerance to maintain overall ecosystem resilience Provide Gunbower National Park with a watering regime that sustains the ecological character of the forest as without the project the area cannot be watered outside natural flood events (which are of an inadequate frequency and duration even under the proposed Basin plan) Protect and enhance a diversity of habitat types across the forest which will be critical to biota under a drying climate Healthy River Red Gum flood dependent understory and temporary wetlands Drought refuge habitat provided for fauna (particularly small-bodied native fish) in Black Charlie Lagoon	-Project will mimic a natural flood event of up to 50,000ML/d within the upper zone and up to 45,000ML/d in the central section across 500ha of the Gunbower National Park -This will be achieved by delivering water to the forest through 2 new supply inlets: Camersons Creek supply inlet (upgrade of natural connection) and Old Cahuna Main Channel supply inlet (construction of new connection to the existing irrigation system) -Prior to river regulation, flow events of 50,000ML/d occurred 52 in every 100 years and now occur 25 in every 100 years

				project depends on the physical capacity of the system to deliver the required flows, time of year and demand from other customers	Healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment	

Guttrum and Benwell	Supply measure	$28,449,309 (approx. $28.4 million) Estimated annual cost of $1.2 million of ongoing operation and maintenance Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach'	New project Seeking 100% of funding North Central Catchment Management Authority (NCCMA)	-Infrastructure package includes; construction of 2 inlet channels, connecting channels and regulator and levee works -17 landholders adjacent to project site -Main costs are associated with construction and ancillary works and risk management -Costs include estimated changes for delays due to weather, approvals and contingency	Maintain and restore healthy floodplain communities across Guttrum and Benwell Forests, to ensure that indigenous plant and animal species and communities survive and flourish Reinstate a more natural flooding regime that protects and enhances the ecological values within the Guttrum and Benwell Forests Restore the health of semi-permanent wetlands Restore the health of River Red Gum FDU Restore healthy wetland bird community, through improved access to food and habitat that promotes breeding and recruitment Enhance River Murray native fish populations by increasing access to productive floodplain outflows	-Works would inundate approx. 719ha in Guttrum Forest and 481ha in Benwell Forest through mimicking a 26,000ML/d flood event in the River Murray for Guttrum forest and a 24,000ML/d flood event for Benwell forest -Environmental water will be delivered via the irrigation channel system
Hattah Lakes North	Supply measure	$8,811,408 (approx. $8.8 million) -Maximum ongoing annual cost of	Project would complement existing works undertaken as	-Infrastructure package involves the construction of 2 regulators, a	Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, lace monitor and bats: **meets associated**	-Up to 1,130ha will be inundated, including red gum and black box

		$695,000 for operation and maintenance Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach' (ie. Would be managed by a Victorian agency such as DEPI, Mallee CMA, North Central CMA, Parks Victoria or G-MW)	part of the Living Murray Scheme Seeking 100% of funding MCMA	causeway and 1.7km of levees on track alignment -The project will build on infrastructure built under TLM scheme -Project site is part of 2 national parks, both of which are managed by Parks Victoria and 112ha of private land	**Basin Plan objective 1,2,4,6,7,8,9,10,11, 12, 13,14** Provide occasional breeding habitat for waterbirds: **meets associated Basin Plan objective 1,2,4,6,7,8,9,10,11,12** Maintain the health and age structure of red gum and black box trees: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Maintain a plant community of drought-tolerant wetland species in infrequently inundated areas: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Contribute to the carbon requirements of the River Murray channel ecosystem: **meets associated Basin Plan objective 2,7** Table 5-2. Comparison of water regimes provided by natural, baseline, Basin Plan and the Hattah Lakes Natural, baseline, Basin Plan (Gippel, 2014)	woodland vegetation communities -Inundation of black box woodlands requires flow events of 140,000ML/d -Operation of the measure and inundation will be via releases of water from the central lakes area behind the existing Oateys Regulator, constructed as part of TLM initiative -Other regulators will control flooding across floodplains and privately owned land

Threshold (ML/d)	WRC	Scenario	Frequency Mean (/100 yrs)	Duration Median (days)	Event start date Median (day of year, 1 Jan = 1)
80,000	Red Gum Forest and Woodland	With Measure[1]	60	50	244
		Natural	50.9	55	252
		Baseline	17.5	40	258
		Basin Plan 2750 without measure	21.9	37	259
120,000	Black Box Woodland	With Measure[1]	25	30	244
		Natural	27.2	27	256
		Baseline	8.8	40	242
		Basin Plan 2750 without measure	9.6	41	237
140,000	Episodic Wetlands	With Measure[1]	15	30	244
		Natural	17.5	29	257
		Baseline	6.1	62	237
		Basin Plan 2750 without measure	7	37	236

[1] based upon interpretation of the preliminary operations plan adapted from Ecological Associates 2014c

Lindsay Island	Supply measure	$72, 831, 526 (approx. $72.8 million) -Annual operating and maintenance cost approx. $2.7 million Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach' (ie. Would be managed by a Victorian agency such as DEPI, Mallee CMA, North Central CMA, Parks Victoria or G-MW)	New project → will work in conjuction with Mulcra Island and Chowilla infrastructure and other existing environmental infrastructure (e.g. TLM infrastructure such as Upper Lindsay inlet regulators, Lake Wallawalla regulators and Websters Lagoon) Seeking 100% of funding MCMA	-Construction of one main regulator with supporting works - The work involves construction of a regulator at Berribee, one vertical slot fish-way, 5 containment regulators and 2.6km of raised tracks in the 'primary component', the 'secondary component' involves 13 additional regulators, 4.9km of raised track and ancillary works at 5 locations	'To protect and restore the key species, habitat communities and functions of the Lindsay Island ecosystem by providing the hydrological environments required by indigenous plant and animal species and communities' (Ecological Associates 2014) Enhance Murray cod habitat by improving the productivity of connected riparian zones and wetlands while maintaining fast-flowing habitat: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Maintain resident populations of frogs and small fish in wetlands: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Provide reliable breeding habitat for waterbirds, including colonial nesting species: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Frequently provide habitat for thousands of waterbirds: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, insectivorous bats and Giles' plaingale: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Contribute to the carbon requirements of the River Murray channel ecosystem: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14**	-The primary component will inundate 3546ha of the Lindsay Island floodplain -Watering will occur mimicking flows of 40,000ML/d to greater than 120,000ML/d

Nyah Floodplain	Supply measure	$10,942,589 (approx. $10.9 million) -Ongoing annual cost of $525,046 for operation and maintenance Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach' (ie. Would be managed by a Victorian agency such as DEPI, Mallee CMA, North Central CMA, Parks Victoria or G-MW)	New project Seeking 100% of funding MCMA	-Construction involves 4 new regulators and 1.648km of low level track raising to form a levee -Located entirely on Crown Land, managed by Parks Victoria	Restore the vegetation structure of wetland plant communities: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Re-establish resident populations of frogs and small fish: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Provide seasonal feeding and reproductive opportunities for riverine fish species: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Provide reliable breeding habitat for waterbirds, including colonial nesting species: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Restoring floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, sugar glider and grey crowned babbler: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Contribute to the carbon requirements of the River Murray channel ecosystem: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14**	-The works will allow a natural water regime (up to 25,000ML/d) to be replicated across 488 hectares of inundation dependent habitat -Proposed works allow for this inundation to be achieved at much lower River Murray flows -Project aims to affect the following water regimes: seasonal anabranch, seasonal wetland, red gum swamp forest and red gum forest and woodland

Vinifera Floodplain	Supply measure	$9,122,148 (approx. $9.1 million) Ongoing maintenance and operation costs at a maximum of $472,692 annually Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach' (ie. Would be managed by a Victorian agency such as DEPI, Mallee CMA, North Central CMA, Parks Victoria or G-MW)	New project Seeking 100% of funding MCMA	-Primary infrastructure works include 2 box regulators and a levee with overflow sills and a drop structure (much like the Nyah Floodplain/Burra Creek cases) -Located entirely on Crown Land within Vinifera Park	Restore vegetation structure of wetland plant communities: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Re-establish resident populations of frogs and small fish: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Provide reliable breeding habitat for waterbirds, including colonial nesting species: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Restoring floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, sugar glider and grey-crowned babbler: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Contribute to the carbon requirements of the River Murray channel ecosystem: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14**	-Project will result in the inundation of 350ha of inundation-dependent habitat through the replication of flows of up to 20,000ML/d -This event would require 2,743ML of volume -Without the proposed works, inundation of the area would require more substantial River Murray flooding events -Watering regime will benefit seasonal wetlands, red gum swamp forest and red gum forest and woodlands

Wallpolla Island	Supply measure	$59,523,808 (appox $60 million) Ongoing maintenance and operation costs expected to be maximum $2,508,572 million annually Delegation of asset ownership and operation, including any financial responsibility cannot be formally ascertained at this time as it requires a 'whole-of-government approach' (ie. Would be managed by a Victorian agency such as DEPI, Mallee CMA, North Central CMA, Parks Victoria or G-MW)	New project Seeking 100% of funding MCMA	-Works include construction of 4 main regulators, a fishway, 22 containment and regulation support structures and 4.5km of raised track -Works comprise 3 main components, Mid Wallpolla, Upper Wallpolla and Wallpolla South with each area having a different target inundation level -Works are also designed to complement weir pool manipulation activities	Increase resident populations of frogs, waterbirds and small fish in wetlands: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Provide reliable breeding habitat for waterbirds, including colonial nesting species: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Enhance local populations of channel specialist fish by augmenting anabranch habitat and improving the productivity of connected riparian zones and wetlands: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Frequently provide habitat for thousands of waterbirds: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, insectivorous brats and Giles planigale: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14** Contributing to the carbon requirements of the River Murray channel ecosystem: **meets associated Basin Plan objective 1,2,3,4,6,7,8,9,10,11,12,13,14**	-The project would inundate 2,651ha of Wallpolla Island floodplain, wetlands and river benches -Flows of 30,000ML/d up to 120,000ML/d -Key watering objective is to maintain productivity and structure of black box woodlands which require inundation 3 years in every 10 for 2-6 weeks, requiring a flow of 100,000ML/d -This is not currently being achieved -There will be 4 different environmental watering infrastructure for Wallpolla Island to manage operational scenarios -Watering will mainly be managed through 2 main regulators and infrastructure

BUSINESS CASE ASSESSMENT OF ECOLOGICAL RISK FOR VIC PROJECTS
Belsar Yungera

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Adverse salinity impacts or water quality outcomes as a result of watering actions; particularly hypoxic blackwater events -Rise in river salinity from salt migration from floodplain soils as a result of works is considered a high risk without mitigation and a moderate risk with mitigation. Involves additional groundwater monitoring bores	Likely	High	-Involves planning, operations and managing consequences phases -Firstly, a consideration of seasonal conditions and monitoring of antecedent floodplain conditions are taken into account before watering events -Secondly, during a watering event through-flows will be maintained where possible, DO and water temperature will be monitored to identify hypoxic areas and watering will commence as early as possible to move organic matter from the floodplain -Finally, if blackwater events do occur this will be managed by delaying outflows if river flows are low or otherwise managing outflows and river flows to dilute low DO water, disposing of hypoxic water by pumping to higher wetlands and agitating water using infrastructure to increase aeration	Moderate
Increase in pest species	Certain	Very High	-Tailor watering regimes to provide competitive advantage for native fish over carp -Dry out wetlands that contain large numbers of carp -Use time water manipulations to drown non-native seedlings, minimise growth, germination and seed set and to promote native species -Control current populations of pest plants and animals via existing management strategies and	Moderate/Low (moderate risk of an increase of carp and pest animals and low risk of proliferation of pest plants)

			support partner agencies to seek further funding for targeted weed control programs if necessary	
The potential to favour certain species to the detriment of others or to adversely affect certain species -Through the destruction of habitat or habitat disturbance or invasion of river red gum in open wetlands/watercourses	Certain	Moderate to Very High	-Utilise existing access tracks, ensure clear on-site delineation of construction zones, ensure adequate supervision during works and design and locate infrastructure to minimise the extent of clearing wherever possible to minimise construction impacts on habitat -Remediate site on completion of construction activities	Low to moderate
Adverse impacts on ecological function and connectivity -Prolonged inundation of vegetation, increase in fire frequency/intensity, flow regimes do not match requirements for key species, stranding of fish on floodplains, barriers to fish and other aquatic fauna movement	Possible	Moderate	-No mitigation actions identified for fire management -Assess the response of certain species of concern to watering events and adjust operations if required -Target different taxa at different times -Ensure through-flows replicate a more natural hydraulic gradient -Design structures for maximum operational flexibility -Develop a 'fish exit strategy' to ensure a fish passage is maintained for as long as possible for fish to move off the floodplain during the drawdown stage	Low

Burra Creek (same as Belsar Yungera)

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Adverse salinity impacts or water quality outcomes as a result of watering actions; particularly hypoxic blackwater events	Likely	High	-Involves planning, operations and managing consequences phases -Firstly, a consideration of seasonal conditions and monitoring of antecedent floodplain conditions are taken into account before watering events -Secondly, during a watering event through-flows will be maintained where possible, DO and water temperature will be monitored to identify hypoxic areas and watering will commence as early as possible to move organic matter from the floodplain -Finally, if blackwater events do occur this will be managed by delaying outflows if river flows are low or otherwise managing outflows and river flows to dilute low DO water, disposing of hypoxic water by pumping to higher wetlands and agitating water using infrastructure to increase aeration	Moderate
Increase in pest species	Certain	Very High	-Tailor watering regimes to provide competitive advantage for native fish over carp -Dry out wetlands that contain large numbers of carp -Use time water manipulations to drown non-native seedlings, minimise growth, germination and seed set and to promote native species -Control current populations of pest plants and animals via existing management strategies and support partner agencies to seek further funding for targeted weed control programs if necessary	Moderate/Low (moderate risk of an increase of carp and pest animals and low risk of proliferation of pest plants)

The potential to favour certain species to the detriment of others or to adversely affect certain species -Through the destruction of habitat or habitat disturbance or invasion of river red gum in open wetlands/watercourses	Certain	Moderate to Very High	-Utilise existing access tracks, ensure clear on-site delineation of construction zones, ensure adequate supervision during works and design and locate infrastructure to minimise the extent of clearing wherever possible to minimise construction impacts on habitat -Remediate site on completion of construction activities	Low to moderate
Adverse impacts on ecological function and connectivity -Prolonged inundation of vegetation, increase in fire frequency/intensity, flow regimes do not match requirements for key species, stranding of fish on floodplains, barriers to fish and other aquatic fauna movement	Possible	Moderate	-No mitigation actions identified for fire management -Assess the response of certain species of concern to watering events and adjust operations if required -Target different taxa at different times -Ensure through-flows replicate a more natural hydraulic gradient -Design structures for maximum operational flexibility -Develop a 'fish exit strategy' to ensure a fish passage is maintained for as long as possible for fish to move off the floodplain during the drawdown stage	Low

Gunbower

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Abundance of pest fish species	Almost certain	Very high	-Watering regime will provide temporary inundation of areas which will be dried out and targeted flows rather	High

			than a single large flow means pest fish cannot disperse from the forest into Gunbower Creek or the River Murray downstream and will be retained in the temporary wetlands as food for wetland birds -Proposed screening of adult pest fish for forest inlets -Carp screen on the inlet regulator to Black Charlie Lagoon/Baggots Creek area -Young carp are still able to enter the system and grow to adult size -Residual risk after the addition of a carp screen on one inlet regulator is still high as other crossings have fish passages which would be blocked by a screen	
Adverse impacts on water quality and salinity downstream	High	Low	-Salinity impact at Morgan under the operating scenarios was estimated at <0.01 µS/cm EC) (negligible) -Potential of blackwater events due to floodplain watering scenario but the risk of causing ecological impacts is considered low -No formal understanding of any potential cumulative impacts -No mention of mitigation strategies to avoid or manage blackwater events	Not stated
Impaired river connectivity	None	-	-Project does not alter the existing connectivity between the River Murray and Gunbower National Park -All through-flows and return flows to the River Murray are retained at their current rates/levels -Important to note that delivery of environmental water to the central forest floodplain will be from Old Cohuna Main Channel rather than the River Murray (this option	N/A

			was investigated under TLM) which means it will not provide connectivity with the River Murray -This connectivity will occur through natural and hybrid events (where environmental water tops up natural inflows)	

Guttrum and Benwell

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Abundance of pest fish species	Almost certain	Very high	-Due to semi-permanence of wetlands the risks of carp are temporary and short-lived as the floodplains will dry -Screening of adult pest fish for forest inlets -Carp screens with rotating screens (self-cleaning) will be considered for installation to minimise operational maintenance requirements -Main mitigation measure will be control of water releases and consideration of drying/wetting patterns and pest fish species habitats	High
Fish stranding	Likely	High	-Coarse screens at the inlets to prevent entry of large-bodied fish into forests -Sequencing water to maximise cues and exit routes -Recent evidence from Gunbower Forest suggests the above style of fish exist strategy is very successful with flow changes cueing native fish to leave the floodplain -Routine monitoring	Low
Giant Rush colonisation	Possible	High		Moderate

			-Maintain strong seasonal profile to flooding regimes with peaks in spring and a recession over late spring and summer will reduce risk as giant rush invasion is influenced by seasonal conditions -Monitoring and consideration of other plans/modifications to operating scheme	
River Red Gum encroachment	Unlikely	High	-Can reduce diversity and is influenced by damp soils and warm temperatures -Flooding regimes that include prolonged inundation, high temperatures over summer and frost during the winter provide the best conditions for preventing encroachment -Extending the drawdown period to late summer/early autumn in lie with natural drawdown periods will counteract encroachment -Red Gum's could also be physically removed but this is labour intensive and a last resort	Low
Water quality/Blackwater/Salinity downstream -High risk of blackwater events, however, these are unlikely to affect water quality in the Murray River due to small outflows and a full assessment of impacts on downstream water quality would be undertaken should the project be approved	Likely	High	-Estimated salinity impact expected to be negligible at Morgan -Blackwater events would be localised and this would be managed through the operating and watering scheme -Managing inflows/outflows and dilution from the River Murray -Cumulative impacts and downstream impacts cannot be ascertained	Low

Hattah Lakes North (same as Belsar Yungera)

Mitigation measures to be undertaken are detailed and have been effective in previous environmental infrastructure projects undertaken in the region under TLM scheme

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Salinity -A preliminary salinity assessment has been completed which suggests groundwater levels are currently higher than historic levels and that successive watering events coupled with natural floods would not significantly increase salt loads	Likely	Moderate	-Avoid watering salinity hotspots identified through the use of AEM datasets, instream nanoTEM and other salinity investigations -Monitor the salinity of ground and surface water salinity before, during and after watering events to inform management and ensure sufficient volumes are available for mitigation such as dilution	Low
Adverse water quality outcomes as a result of watering actions; particularly hypoxic blackwater events	Likely	High	-Involves planning, operations and managing consequences phases -Firstly, a consideration of seasonal conditions and monitoring of antecedent floodplain conditions are taken into account before watering events -Secondly, during a watering event through-flows will be maintained where possible, DO and water temperature will be monitored to identify hypoxic areas and watering will commence as early as possible to move organic matter from the floodplain	Moderate

			-Finally, if blackwater events do occur this will be managed by delaying outflows if river flows are low or otherwise managing outflows and river flows to dilute low DO water, disposing of hypoxic water by pumping to higher wetlands and agitating water using infrastructure to increase aeration	
Increase in pest species	Certain	Very High	-Tailor watering regimes to provide competitive advantage for native fish over carp -Dry out wetlands that contain large numbers of carp -Use time water manipulations to drown seedlings, minimise growth, germination and seed set and to promote native species -Control current populations of pest plants and animals via existing management strategies and support partner agencies to seek further funding for targeted weed control programs if necessary	Moderate/Low (moderate risk of an increase of carp and pest animals and low risk of proliferation of pest plants)
The potential to favour certain species to the detriment of others or to adversely affect certain species -Through the destruction of habitat or habitat disturbance or invasion of river red gum in open wetlands/watercourses	Certain	Moderate to Very High	-Utilise existing access tracks, ensure clear on-site delineation of construction zones, ensure adequate supervision during works and design and locate infrastructure to minimise the extent of clearing wherever possible to minimise construction impacts on habitat -Remediate site on completion of construction activities	Low to moderate

Adverse impacts on ecological function and connectivity -Prolonged inundation of vegetation, increase in fire frequency/intensity, flow regimes do not match requirements for key species, stranding of fish on floodplains, barriers to fish and other aquatic fauna movement	Possible	Moderate	-No mitigation actions identified for fire management -Assess the response of certain species of concern to watering events and adjust operations if required -Target different taxa at different times -Ensure through-flows replicate a more natural hydraulic gradient -Design structures for maximum operational flexibility -Develop a 'fish exit strategy' to ensure a fish passage is maintained for as long as possible for fish to move off the floodplain during the drawdown stage	Low
Consideration of significant, threatened or listed species	N/A	N/A	-The project is expected to benefit these species by increasing the frequency, duration and extent of floods -Construction will result in temporary and permanent vegetation removal and habitat disturbance -Detailed ecological assessments will be carried out during the design process to inform construction activities	

Lindsay Island

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Salinity	Likely	Moderate	-Avoid watering salinity hotspots identified through the use of AEM datasets, instream nanoTEM and other salinity investigations -Monitor the salinity of ground and surface water salinity before, during and after watering events to	Low

			inform management and ensure sufficient volumes are available for mitigation such as dilution	
Adverse water quality outcomes as a result of watering actions; particularly hypoxic blackwater events	Likely	High	-Involves planning, operations and managing consequences phases -Firstly, a consideration of seasonal conditions and monitoring of antecedent floodplain conditions are taken into account before watering events -Secondly, during a watering event through-flows will be maintained where possible, DO and water temperature will be monitored to identify hypoxic areas and watering will commence as early as possible to move organic matter from the floodplain -Finally, if blackwater events do occur this will be managed by delaying outflows if river flows are low or otherwise managing outflows and river flows to dilute low DO water, disposing of hypoxic water by pumping to higher wetlands and agitating water using infrastructure to increase aeration	Moderate
Increase in pest species	Certain	Very High	-Tailor watering regimes to provide competitive advantage for native fish over carp -Dry out wetlands that contain large numbers of carp -Use time water manipulations to drown seedlings, minimise growth, germination and seed set and to promote native species -Control current populations of pest plants and animals via existing management strategies and support partner agencies to seek further funding for targeted weed control programs if necessary	Moderate/Low (moderate risk of an increase of carp and pest animals and low risk of proliferation of pest plants)

The potential to favour certain species to the detriment of others or to adversely affect certain species -Through the destruction of habitat or habitat disturbance or invasion of river red gum in open wetlands/watercourses	Certain	Moderate to Very High	-Utilise existing access tracks, ensure clear on-site delineation of construction zones, ensure adequate supervision during works and design and locate infrastructure to minimise the extent of clearing wherever possible to minimise construction impacts on habitat -Remediate site on completion of construction activities	Low to moderate
Adverse impacts on ecological function and connectivity -Prolonged inundation of vegetation, increase in fire frequency/intensity, flow regimes do not match requirements for key species, stranding of fish on floodplains, barriers to fish and other aquatic fauna movement	Possible	Moderate	-No mitigation actions identified for fire management -Assess the response of certain species of concern to watering events and adjust operations if required -Target different taxa at different times -Ensure through-flows replicate a more natural hydraulic gradient -Design structures for maximum operational flexibility -Incorporate fish passage requirements into regulator design which includes a vertical slot fishway at Berribee regulator and fish-friendly designs to allow passive passage at other regulators	Low
Episodic reduction in hydrodynamic diversity -Installation of regulators within waterways will affect flows and create lentic ones in regulator pools when in	Likely	High	-Design structures to minimise waterway obstruction -Develop operational protocols to maintain hydraulic diversity -Assess the response of species of concern during and after managed watering events and adjust operational arrangements if required	Moderate

operation which may reduce the extent and variety of aquatic habitat and change the structure and diversity of wetland floodplain communities -In particular, regulator operation is likely to reduce or eliminate fast-flowing habitat that is particularly important to some fish species e.g. Murray cod				
Prolonged inundation of vegetation within the Berribee Regulator pool -May damage vegetation health and result in death of less tolerant species	Possible	Moderate	-Ensure through-flow when operating structures to more closely replicate a more natural hydraulic gradient -Incorporate information on operations, potential impacts and tolerance of inundation regimes and the role of natural floods in ecosystem function into operational plans to minimise impact	Low
Consideration of significant, threatened or listed species	N/A	N/A	-The project is expected to benefit these species by increasing the frequency, duration and extent of floods -Construction will result in temporary and permanent vegetation removal and habitat disturbance -Detailed ecological assessments will be carried out during the design process to inform construction activities -The Mullaroo Creek and Lindsay River are widely acknowledged for their significant native fish populations (particularly Murray Cod) which may be affected by operation	

			-The design of minor regulators allow for passive fish passage and a vertical slot fishway that matches the specification of the fishway on the Mullaroo Creek Regulator (under construction through TLM) is proposed at the Berribee Regulator -The hydraulic model mirrors the approach taken for the recently commissioned Chowilla Floodplain Living Murray works where fish ecologists have worked in conjunction with hydraulic modellers to develop appropriate operational scenarios	

Nyah Floodplain

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Salinity	Likely	Moderate	-Avoid watering salinity hotspots identified through the use of AEM datasets, instream nanoTEM and other salinity investigations -Monitor the salinity of ground and surface water salinity before, during and after watering events to inform management and ensure sufficient volumes are available for mitigation such as dilution	Low
Adverse water quality outcomes as a result of watering actions; particularly hypoxic blackwater events	Likely	High	-Involves planning, operations and managing consequences phases -Firstly, a consideration of seasonal conditions and monitoring of antecedent floodplain conditions are taken into account before watering events -Secondly, during a watering event through-flows will be maintained where possible, DO and water temperature will be monitored to identify hypoxic	Moderate

			areas and watering will commence as early as possible to move organic matter from the floodplain -Finally, if blackwater events do occur this will be managed by delaying outflows if river flows are low or otherwise managing outflows and river flows to dilute low DO water, disposing of hypoxic water by pumping to higher wetlands and agitating water using infrastructure to increase aeration -Should water quality be affected, water can be disposed within the site (pump to higher wetlands)	
Increase in pest species	Certain	Very High	-Tailor watering regimes to provide competitive advantage for native fish over carp -Dry out wetlands that contain large numbers of carp -Use time water manipulations to drown seedlings, minimise growth, germination and seed set and to promote native species -Control current populations of pest plants and animals via existing management strategies and support partner agencies to seek further funding for targeted weed control programs if necessary	Moderate/Low (moderate risk of an increase of carp and pest animals and low risk of proliferation of pest plants)
The potential to favour certain species to the detriment of others or to adversely affect certain species -Through the destruction of habitat or habitat disturbance or invasion of	Certain	Moderate to Very High	-Utilise existing access tracks, ensure clear on-site delineation of construction zones, ensure adequate supervision during works and design and locate infrastructure to minimise the extent of clearing wherever possible to minimise construction impacts on habitat -Remediate site on completion of construction activities	Low to moderate

river red gum in open wetlands/watercourses				
Adverse impacts on ecological function and connectivity -Prolonged inundation of vegetation, increase in fire frequency/intensity, flow regimes do not match requirements for key species, stranding of fish on floodplains, barriers to fish and other aquatic fauna movement	Possible	Moderate	-No mitigation actions identified for fire management -Assess the response of certain species of concern to watering events and adjust operations if required -Target different taxa at different times -Ensure through-flows replicate a more natural hydraulic gradient -Design structures for maximum operational flexibility -Develop a 'fish exit strategy' to ensure a fish passage is maintained for as long as possible for fish to move off the floodplain during the drawdown stage	Low
Consideration of significant, threatened or listed species	N/A	N/A	-The project is expected to benefit these species by increasing the frequency, duration and extent of floods -Construction will result in temporary and permanent vegetation removal and habitat disturbance -Detailed ecological assessments will be carried out during the design process to inform construction activities	

Vinifera Floodplain (same as Lindsay Island)

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Salinity	Likely	Moderate	-Avoid watering salinity hotspots identified through the use of AEM datasets, instream nanoTEM and other salinity investigations	Low

			-Monitor the salinity of ground and surface water salinity before, during and after watering events to inform management and ensure sufficient volumes are available for mitigation such as dilution	
Adverse water quality outcomes as a result of watering actions; particularly hypoxic blackwater events	Likely	High	-Involves planning, operations and managing consequences phases -Firstly, a consideration of seasonal conditions and monitoring of antecedent floodplain conditions are taken into account before watering events -Secondly, during a watering event through-flows will be maintained where possible, DO and water temperature will be monitored to identify hypoxic areas and watering will commence as early as possible to move organic matter from the floodplain -Finally, if blackwater events do occur this will be managed by delaying outflows if river flows are low or otherwise managing outflows and river flows to dilute low DO water, disposing of hypoxic water by pumping to higher wetlands and agitating water using infrastructure to increase aeration	Moderate
Increase in pest species	Certain	Very High	-Tailor watering regimes to provide competitive advantage for native fish over carp -Dry out wetlands that contain large numbers of carp -Use time water manipulations to drown seedlings, minimise growth, germination and seed set and to promote native species -Control current populations of pest plants and animals via existing management strategies and	Moderate/Low (moderate risk of an increase of carp and pest animals and low risk of proliferation of pest plants)

			support partner agencies to seek further funding for targeted weed control programs if necessary	
The potential to favour certain species to the detriment of others or to adversely affect certain species -Through the destruction of habitat or habitat disturbance or invasion of river red gum in open wetlands/watercourses	Certain	Moderate to Very High	-Utilise existing access tracks, ensure clear on-site delineation of construction zones, ensure adequate supervision during works and design and locate infrastructure to minimise the extent of clearing wherever possible to minimise construction impacts on habitat -Remediate site on completion of construction activities	Low to moderate
Adverse impacts on ecological function and connectivity -Prolonged inundation of vegetation, increase in fire frequency/intensity, flow regimes do not match requirements for key species, stranding of fish on floodplains, barriers to fish and other aquatic fauna movement	Possible	Moderate	-No mitigation actions identified for fire management -Assess the response of certain species of concern to watering events and adjust operations if required -Target different taxa at different times -Ensure through-flows replicate a more natural hydraulic gradient -Design structures for maximum operational flexibility -Incorporate fish passage requirements into regulator design which includes a vertical slot fishway at Berribee regulator and fish-friendly designs to allow passive passage at other regulators	Low
Episodic reduction in hydrodynamic diversity	Likely	High	-Design structures to minimise waterway obstruction -Develop operational protocols to maintain hydraulic diversity	Moderate

-Installation of regulators within waterways will affect flows and create lentic ones in regulator pools when in operation which may reduce the extent and variety of aquatic habitat and change the structure and diversity of wetland floodplain communities -In particular, regulator operation is likely to reduce or eliminate fast-flowing habitat that is particularly important to some fish species e.g. Murray cod			-Assess the response of species of concern during and after managed watering events and adjust operational arrangements if required	
Consideration of significant, threatened or listed species	N/A	N/A	-The project is expected to benefit these species by increasing the frequency, duration and extent of floods -Construction will result in temporary and permanent vegetation removal and habitat disturbance -Detailed ecological assessments will be carried out during the design process to inform construction activities	

Wallpolla Island

Risk	*Likelihood*	*Risk without mitigation*	*Mitigation*	*Risk after mitigation*
Adverse salinity impacts including saline mounds	Likely	Moderate		Low

-High risk that increases in salinity may breach Basin Salinity Management Strategy requirements			-Avoid watering salinity hotspots identified through the use of AEM datasets, instream nanoTEM and other salinity investigations -Monitor the salinity of ground and surface water salinity before, during and after watering events to inform management and ensure sufficient volumes are available for mitigation such as dilution -5 new bore sites and upgrades and maintenance of existing water monitoring systems	
Adverse water quality outcomes as a result of watering actions; particularly hypoxic blackwater events	Likely	High	-Involves planning, operations and managing consequences phases -Firstly, a consideration of seasonal conditions and monitoring of antecedent floodplain conditions are taken into account before watering events -Secondly, during a watering event through-flows will be maintained where possible, DO and water temperature will be monitored to identify hypoxic areas and watering will commence as early as possible to move organic matter from the floodplain -Finally, if blackwater events do occur this will be managed by delaying outflows if river flows are low or otherwise managing outflows and river flows to dilute low DO water, disposing of hypoxic water by pumping to higher wetlands and agitating water using infrastructure to increase aeration	Moderate
Increase in pest species	Certain	Very High	-Tailor watering regimes to provide competitive advantage for native fish over carp -Dry out wetlands that contain large numbers of carp	Moderate/Low (moderate risk of an increase of carp and pest animals and low

			-Use time water manipulations to drown seedlings, minimise growth, germination and seed set and to promote native species -Control current populations of pest plants and animals via existing management strategies and support partner agencies to seek further funding for targeted weed control programs if necessary	risk of proliferation of pest plants)
The potential to favour certain species to the detriment of others or to adversely affect certain species -Through the destruction of habitat or habitat disturbance or invasion of river red gum in open wetlands/watercourses	Certain	Moderate to Very High	-Utilise existing access tracks, ensure clear on-site delineation of construction zones, ensure adequate supervision during works and design and locate infrastructure to minimise the extent of clearing wherever possible to minimise construction impacts on habitat -Remediate site on completion of construction activities	Low to moderate
Adverse impacts on ecological function and connectivity -Prolonged inundation of vegetation, increase in fire frequency/intensity, flow regimes do not match requirements for key species, stranding of fish on floodplains, barriers to fish	Possible	Moderate	-No mitigation actions identified for fire management -Assess the response of certain species of concern to watering events and adjust operations if required -Target different taxa at different times -Ensure through-flows replicate a more natural hydraulic gradient -Design structures for maximum operational flexibility -Incorporate fish passage requirements into regulator design which includes a vertical slot fishway at Berribee regulator and fish-friendly designs to allow passive passage at other regulators	Low

and other aquatic fauna movement				
Episodic reduction in hydrodynamic diversity -Installation of regulators within waterways will affect flows and create lentic ones in regulator pools when in operation which may reduce the extent and variety of aquatic habitat and change the structure and diversity of wetland floodplain communities -In particular, regulator operation is likely to reduce or eliminate fast-flowing habitat that is particularly important to some fish species e.g. Murray cod	Likely	High	-Design structures to minimise waterway obstruction -Develop operational protocols to maintain hydraulic diversity -Assess the response of species of concern during and after managed watering events and adjust operational arrangements if required	Moderate
Mismatch between vegetation requirements and internal regulator pool operation -Vegetation in the deepest part of the Mid-Wallpolla Weir pool may receive excessive inundation (duration and depth) if the	Possible	Moderate	-Ensure through-flow when operating structures (including consideration of raising the upstream head via Lock 9) to more closely replicate a more natural hydraulic gradient -Incorporate information on operations, potential impacts and tolerance of inundation regimes and the role of natural floods in ecosystem function into operational plans to minimise impact	Low

inundation requirements of vegetation at the perimeter of the pool are met→ this would cause localised impacts on vegetation health and possible death of less tolerant species				
Consideration of significant, threatened or listed species	N/A	N/A	-The project is expected to benefit these species by increasing the frequency, duration and extent of floods -Construction will result in temporary and permanent vegetation removal and habitat disturbance -Detailed ecological assessments will be carried out during the design process to inform construction activities -Operation of the project could have adverse impacts on threatened species as the waterways and wetlands of Wallpolla island support significant native fish populations -Design allows for passive fish passages through minor structures and a vertical slot fishway at the structure 1 regulator and these measures will allow the movement of small and large bodied fish during a range of operational scenarios -All structures designed to allow fish movement even when not in operation -The approach to hydraulic modelling is taken from the Chowilla Floodplain Living Murray works	

Third Party Risks: including reliability in a range of scenarios, risk to items of national significance and also public/private land impacts

Project	*Third Party Impacts*	*Reliability of structure in a range of scenarios*

Belsar Yungera	-770ha of private land inundated during the maximum inundation event, some of which is protected under conservation covenants or as an offset → no agreements have been made, however, preliminary discussions have been generally supportive of the project	-The works have been designed to provide maximum operational flexibility and 6 scenarios have been developed; Default: default configuration when there are no watering events Seasonal fresh: aimed at allowing water to flow through Narcooyia creek during Basin Plan flows (>10,000ML/d) Belsar intermediate: enable watering of Red Gum forest and woodland on lower floodplains (30,000-50,000ML/d) Belsar Island maximum: broadscale of inundation of areas mentioned above and also Black Box Woodland (50,000-90,000ML/d) Lakes Powell and Carpul : As above (170,000ML/d with Belsar Maximum) Natural inundation: all structures are open during natural floods to allow full connectivity -High operational flexibility and assurance the irrigation supply and access to irrigation infrastructure is maintained at all times
Burra Creek	As the area of private land inundated in the maximum flow event is relatively low (76ha) and operation would mostly occur under the maximum, this factor is not considered critical to the feasibility of the project	-5 watering scenarios; default, seasonal fresh (20,000ML/d), Burra intermediate (20,000-30,000ML/d), Burra maximum (30,000ML/d) and natural inundation (>30,000ML/d) -Watering decisions and operating scenarios will be based on water availability, floodplain water requirements, ecological targets, operational risks and regional context
Goulburn	-High cost of private and public land and infrastructure mitigation actions totaling approx. $113 million -Mitigation of third party impacts involves acquisition of easements over private land and other works which would cost an estimated $32 million (included in above figure)	Not stated

	-Total project cost also included inundation modelling, groundwater and hydrologic modelling and risk studies which have not yet been conducted and current costing are based on assumptions -The Shepparton Irrigation region has a long history of land and water management so there is considerable knowledge of groundwater and salinity in the area -The risk assessment panel deemed salinity risks associated with the project to be low as; the floodplain contains relatively fresh groundwater, groundwater levels are deep and there is only moderate potential for vertical infiltration or lateral movement → mitigation includes upgrades in water table monitoring and assessments	
Gunbower	-High risk of third party impacts; including loss of recreation, heritage and flooding but these are localised -Feasability assessment states the project has minimal adverse ecological and third party impacts, is non-intrusive and is low in cost to construct and operate	-The project will be operationally flexible -There are 2 separate, parallel scenarios -These are permanent wetland watering and forest floodplain watering -These scenarios can be delivered either as standalone watering events or as 'hybrid events' to enhance unregulated flows -The project must consider the demand of irrigation and all scenarios have acknowledged the issue of capacity availability and believe the impact would be negligible but it has not been modelled
Guttrum Benwell	-Third party flooding expected only if existing levees fail and would be	-Watering events will occur in 3 phases: filing phase, maintenance phase and drawdown phase

	mitigated by ongoing maintenance and potential upgrades→ low risk -Levees provide protection from floods of a greater level than the 26,000ML/d maximum of the project	-There are 3 operating scenarios: river red gum watering, semi-permanent wetland watering and hybrid events **<u>Other:</u>** -Return flows to the River Murray will occur under the forest floodplain watering scenarios in each forest and environmental water will be retained within the wetland systems before gradually infiltrating and evaporation
Hattah Lakes North	-Does inundate private land but agreements with landowners would not be made until project approval	-Four operating scenarios; default, river red gum, black box, natural flood Default: all regulators open allowing natural flows River red gum: involves synchronisation between existing TLM works and proposed works to deliver flows of 80,000ML/d Black box: managed by regulators, TLM operations and temporary pumps >120,000ML/d Natural flood: all regulators open to allow full connectivity and minimise impact of infrastructure on natural flooding patterns -Decisions to initiate watering events will be based on water availability, water requirements, operational risks and regional context
Lindsay Island	-No comprehensive evaluation of the extent and impacts of inundation on third parties ie. Private landowners	-Variety of operational scenarios Default: default configuration during normal regulated flows Seasonal fresh: utilises Upper Lindsay and Mullaroo creek regulators and the raising of Lock 7 and aims to stimulate spawning of golden perch, silver perch and Australian smelt and maintains fast-flowing habitat for Murray cod (>10,000ML/d) Berribee intermediate: targets lower floodplains with all regulators open except for Berribee and Lock 7 raised above normal operating level; aims are to provide wetland habitat for aquatic fauna and good conditions for red gum and lignum (30,000-50,000ML/d) Berribee maximum: maximum inundation; targets upper floodplain; all regulators open but waterflow monitored and released gradually; suitable for watering red gum and black box communities (50,000-90,000ML/d)

		Berribee maximum and pumping: variation of above scenario; utilises temporary pumps to increase flooded area by 1000ha; enables large areas of black box woodland to be watered (170,000ML/d) Natural inundation: all regulating structures open to allow connectivity; outcomes depend on the magnitude and duration of river flows Watering is seasonably based and subject to water availability, water requirements, operational risks and regional context
Nyah Floodplain	-No comprehensive evaluation of the extent and impacts of inundation on third parties ie. Private landowners	-5 operating scenarios Default: default configuration of water management structures (all structures open) Seasonal fresh: all environmental regulators open; ideal for seasonal anabranch (>13,000ML/d) Nyah intermediate: intermediate operation of the Nyah regulators and their associated support structures to enable watering of Parnee Malloo Creek, low level floodplain wetlands and lower floodplains without inundating upper flood plain areas; ideal for seasonal wetland (up to 17,500ML/d) Nyah maximum: maximum operation of regulators and support structures to enable flooding to upper floodplains; ideal for red gum swamp forest (up to 20,000ML/d) Natural flooding: full connectivity; ideal for red gum forest and woodland (>20,000ML/d) -High degree of operational flexibility in situations relevant to water availability, water requirements, operational risks, regional context -Mimicking natural variability allows for a diverse range of inundation events which restores patterns of vegetation present pre-regulation conditions
Vinifera Floodplain	-No impacts on private land -Impacts on public land are related to recreational uses and easily mitigated	-Watering will be monitored and facilitated by the V1, V2 and V4 regulators -5 operating scenarios Default: normal regulated flows and all environmental structures open Seasonal fresh: provide flow along Vinifera Creek and is achieved through suitable Murray River flows; all environmental regulators in default position; ideal for Vinifera Creek (>13,000ML/d) Vinifera intermediate: intermediate operation of Vinifera regulators to enable watering of creek and lower floodplain; ideal for creek and seasonal wetland (up to 17,500ML/d)

		Vinifera maximum: maximum operation of Vinifera regulators to enable watering of creek and upper floodplain areas; ideal for red gum swamp forest (up to 20,000ML/d) Natural inundation: all regulating structures open to allow connectivity; ideal for red gum forest and woodland (>20,000ML/d) -High degree of operational flexibility -Environmental watering scenarios and timing based on water availability, water requirements, operational risks and regional context
Wallpolla Island	-At maximum inundation, the project would flood 817ha of private land with a single landholder who's land has previously been watered by the MCMA and a letter of support was provided in the appendix -Flooding of private land can also be avoided by not operating at the maximum level	-6 operating scenarios Default: normal regulated flows; all structures open Seasonal fresh: targets in-channel flows and is achieved by opening all structures to allow water to flow through Finnigans and Wallpolla Creek; ideal for watercourses (up to 40,000ML/d) Mid Wallpolla maximum: structure 1 and associated structures operating to maximum height to enable inundation of Mid-Wallpolla; this scenario also takes advantage of high river flows; ideal for watercourses, semi-permanent wetlands and temporary wetlands (60,000ML/d) Mid and Upper Wallpolla maximum: structure 1 and 4 regulators and associated structures operated to maximum height to inundate mid and upper Wallpolla; ideal for watercourses, semi-permanent wetlands and temporary wetlands (80,000ML/d) Mid and Upper Wallpolla and pumping: variation of above scenario; additional water delivered to Wallpolla South through temporary pumps; ideal for black box woodland and occasionally, alluvial plain (100,000ML/d) Natural inundation: all environmental operating mechanisms open to allow connectivity -Transitions between scenarios influence by mitigation management; inflows; natural flooding events and ecological opportunities -Environmental watering scenarios and timing based on water availability, water requirements, operational risks and regional context

APPENDIX 2 - SA business case summaries and ecological risks
Project: Chowilla floodplain Supply measure

Summary	**Total cost & ownership/operation responsibilities**	**Stage**	**Complexity of works**	**Ecological Objectives**	**Changes in river hydrology**	**Third Party Impacts**
Chowilla Floodplain contains the largest remaining area of natural river red gum. The area is compromised of 100km of anabranch creeks, which spread into a series of temporary wetlands during high river flows creating an area of outstanding environmental significance. Flows through the anabranch system result in a mosaic of flowing water habitats now rare in the lower Murray. Flow regulation and diversions have reduced flooding frequency and elevated saline groundwater levels. A number of works have already been undertaken on the Chowilla Floodplain as part of the TLM scheme, this proposal aims to use these in conjunction with the River Murray locks and weirs to provide a mechanism to enable areas of the floodplain to be inundated.	The Environmental Water Operations group within River Murray Operations and Major Projects branch of the SA DEWNR is responsible for delivering TLM program at Chowilla. SA Water is the 'operational agent' of the Minister for Water, thereby operating and maintaining works on the Chowilla Floodplain. No costings for the particular project provided in the documents. Construction as part of TLM scheme is funded through the MDBA Environmental Works and Measures Program. Cost and budget for ongoing works can be seen in the MDBA Corporate Plan.	Phase 2 Assessment for consideration as part of existing TLM Environmental Works and Measures at Chowilla Floodplain. SA Water, Murray Darling Basin Authority (MDBA) & Government of South Australia (Department of Environment, Water and Natural Resources) (DEWNR)	Complex planning, operations and management procedures which involves the collaboration of a variety of government agencies. Environmental watering proposals will be presented to land managers from SA and NSW (DEWNR & NSW Office of Water) and SA Water (involves collaboration between SA and NSW). Involves using existing, new and upgraded structures to manage the delivery of water to the Chowilla Floodplain. No additional construction.	3 broad ecological objectives: High value wetlands maintained Current area of river red gum maintained At lest 20% of the original area of black box vegetation maintained. Improve the health, abundance and distribution of fauna and flora species. Maintain or increase the diversity and extent of distribution of native fish species and restrict the abundance and biomass of introduced fish species. Ensure water quality is maintained through avoiding unacceptable salinity levels and monitoring biogeochemical processes, turbidity and dissolved oxygen levels. Restore and enhance floodplain connectivity through improving and maintaining carbon processes, flow regimes and sedimentation and erosion. Establish groundwater conditions conducive to improving vegetation condition & avoid fringe degradation due to soil salinization in areas where ground water levels fluctuate in the absence of inundation.	The real-time management of water required by SA for all purposes (including environmental water) is coordinated by DEWNR in liaison with SA Water and the MDBA. Operation of the Chowilla Floodplain infrastructure may occur in conjunction with other icon sites and environmental water activities-> floodplain restoration projects are underway downstream at Pike and Katarapko floodplains and future Chowilla watering would need to be planned in conjunction with these sites. Up to 15 structures can be used to manage environmental watering on the Chowilla Floodplain. Water management actions include; No action Delivery of water to individual wetlands (pumping and/or gravity) Weir pool manipulation- raising of the Lock 6 weir pool in conjunction with operation of the Chowilla regulator to inundate the floodplain	Range of land tenure applies for the Chowilla Floodplain; SA Government are the landowner for the SA portion (excluding 17.3ha of freehold land), which consists of several land tenures including; Chowilla Game Reserve (gazetted under the National Parks and Wildlife Act 1972 (SA), Chowilla Station, Freehold, Kulcurna (NSW portion)

					Pulse flows via Pipeclay and Slaney weirs In-channel rise (using the regulator) Managed inundations (using the regulator) and; Manage hydrograph recession (using the regulator). Low floodplain inundation= approx 50,000ML/day Mid-floodplain inundation= approx 75,000ML/day Maximum-floodplain inundation=approx 90,000ML/day At flows >50,000ML/day river operations are in 'flood' mode, meaning structures may need to be deactivated to avoid damage to the structures. The limit at which flows will have inundated access tracks and precluded ability to access structures in order to manager the recession of the hydrograph is approx 60,000ML/day	

Project: South East Flows Restoration Project (SERFP) Supply measure

Summary	Total cost & ownership/operation responsibilities	Stage	Complexity of works	Ecological Objectives	Changes in river hydrology	Water Saving
Broad scale land clearance, drainage networks and drought have severely impacted on the ecological health of the Coorong and Lakes Alexandrina and Albert Wetland (which have international importance). These have caused dramatically reduced water levels and years without flows over the barrages resulted in low water levels, habitat destruction and hypersaline conditions in the Coorong South Lagoon. Due to the extreme salinity, the Coorong South Ecosystem collapsed and key aquatic plant species were loss and small-bodied fish species withdrew to the North Lagoon and Murray Mouth. Since 2010, significant flows over the barrages have restored salinity	The $60 million SEFRP is fully costed and funded through the Coorong, Lower Lakes and Murray Mouth Recovery Project Schedule SA-07 to the South Australian and Commonwealth Water Management Partnership Agreement No additional Commonwealth funding is required through the SDL adjustment mechanism for project delivery (this document) The State of SA is responsible for managing the existing South East Drainage system which includes existing drains (e.g. Tilley Swamp, Taratap and Blackford), wetlands and environmental assets through the South Eastern Water Conservation and Drainage (SEWCD) Board. While DEWNR is delivering the project in agreement with the SEWCD Board, the SEWCD will ultimately be the managing authority once construction is completed.	Submission of the SEFRP for Phase 2 Assessment by the SDL Adjustment Assessment Committee Project delivery already underway The SEFRP is a sub-project of the SA Government's priority project Murray Futures: CLLMM Recovery Project	The SEFRP project will construct the SEFRP channel which will use a combination of widening existing drains (totalling 81km) and newly constructed drains (totally 12km) to divert additional water from the Upper South East into the Coorong South Lagoon. This includes the upgrade to the existing Tilley Swamp and Taratap drains, and the construction of a section of new drain connecting the Blackford Drain to the Taratap drain to allow the Taratap and Tilley Swamp Conservation Park wetlands to be more frequently inundated The fresh water delivered to Coorong Lagoon will be in addition to the estimated median	Overriding ecological objectives are to; -Help maintain salinity between the target-management ranges of 60g/L and 100g/L in order to ensure that the lethal effects of high salinity on the ecosystem are mitigated during periods of low barrage flows -The Tilley Swap and Taratap ('en route') wetlands benefit from the provision of additional flows Increase the resilience of the Coorong South Lagoon ecosytem Restablish lost species, such as the aquatic plant Ruppia tuberosa to pre-drought extent It is important to note that post-drought when high barrage flows were reintroduced to the region, this had a significant impact on the improvement of ecosystem health- specifically the regrowth of Ruppia tuberosa and reintroduction of macroinvertebrate species as well as reduced salinity.	Depending on the water requirements of the Coorong South Lagoon; delivery of water will be managed by- -Ancillary structures to deliver flow from the proposed channel to local en route wetlands (Taratap & Tlley Swamp) -The weir on Blackford Drain to divert flow into the proposed drain -Releases made from Morella Basin to the Coorong South Lagoon at the end of the system With the construction of new and upgrade of existing drainage channels, channel capacity will range between 1,300ML/day and 800ML/day and has the potential to deliver and additional 5-45.3GL of environmental water per year directly into the Coorong South Lagoon, with a median volume of up to 26.5GL/year.	The project will deliver increased fresh flows directly into the lagoon, potentially reducing the frequency of periods where the salinity exceeds 100g/L. This has the potential to reduce requirements for barrage flows. Two scenarios for barrage flow inflows: -SDL Adjustment Benchmark run, representing a water recovery volume of 2750 GL -BP2400 model run, representing a water recovery of 2400 GL and a possible reduced water recovery volume resulting from the SDL Adjustment Mechanism

within the ranges required to support the key biota that represent a healthy ecosystem, however, it has been slow to respond and the long-term impacts of hypersalinity are visible The SEFRP aims to enhance flows to wetlands in the Upper South East and to provide flows to the South Lagoon of the Ramsar listed Coorong to help manage salinity and enhance ecosystem resilience. The SEFRP is part of the Coorong Lower Lakes and Murray Mouth (CLLMM) Recovery Project and the area is listed as a Ramsar wetland of International Importance and the many threatened and migratory species that inhabit the site are protected under the Commonwealth EPBC Act 1999.	This means the SEWCD is responsible for managing the infrastructure to meet set objectives (which will be developed by the South East Natural Resource Management board)		flow of 29.7 GL/yr from existing projects 75-week construction period	This suggests that high barrage flows in this area is essential for ecosystem health and resilience.		