Appendix G – Assessment of the CARM and Yanco modernisation projects to size environmental entitlement

Australian Government

MURRAY–DARLING BASIN AUTHORITY

Assessment of the CARM and Yanco modernisation projects to size environmental entitlement

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin
The Murray−Darling Basin Authority pays respect to the Traditional Owners and their Nations of the Murray−Darling Basin. We acknowledge their deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

The guidance and support received from the Murray Lower Darling Rivers Indigenous Nations and our many Traditional Owner friends and colleagues is very much valued and appreciated.

Aboriginal people should be aware that this publication may contain images, names or quotations of deceased persons.

Version control			
Version	**Revision date**	**Author/modifier**	**Distributed to**
v. 1	13/06/2023	JL/AK	NSW DPIE
v. 2	18/06/2023	JL	NSW DPIE
v. 3	25/06/2023	JL	NSW DPIE

Contents

Introduction

The Murray Darling Basin Authority (MDBA) and NSW government entered a Head Agreement in 2020 for providing modelling services to NSW for informing the implementation of various SDLAM projects. Under this bi-lateral agreement, NSW has requested a modelling assessment to determine potential entitlement volume to be created for environment when the Computer Aided River Management system for the Murrumbidgee River (CARM) project (NSW DPI water, 2015a) and the Modernising supply systems for effluent creeks (aka Yanco modernisation) project (NSW DPI water, 2015b) are assessed individually. In 2017, there was a similar assessment (MDBA, 2017b) conducted to inform the determination of SDL adjustment volume (MDBA 2017a). It reported the combined benefits from the CARM and Yanco modernisation projects. It was assessed that these two projects combined created a Long-Term Average Yield (LTAY) of 32 GL in total, out of which 16 GL needs to be allocated to the Murrumbidgee IVT account to counterbalance impacts to Murray users. This report is to determine how the total volume can be apportioned to the two projects.

CARM project

The CARM is an expert Decision Support System (DSS) created for river operations. Its primary role is to integrate both real time and modelled flow scenario information using a computer based hydrodynamic modelling system, to make better informed decisions on daily releases from dams and weirs. This will allow capture of operational surplus, through better tributary inflow forecasting, rainfall rejection forecasting and management of Yanco Creek offtake inflows, which can then be converted into environmental entitlement. More detailed information is available from NSW DPI water (2015).

The CARM project is inter-related with the water for rivers (WfR) initiative which achieved its water recovery target in 2012. As the SDL adjustment mechanism is based on the benchmark model which represent river conditions as of June 2009, the water for rivers project has divided into two phases of before and after 2009. The water recovery projects prior to 2009 are included into the SDL benchmark, and the post 2009 components are added into the CARM project model (DHI, 2016a and DHI 2016b).

There are further changes identified by MDBA to improve consistency of representing outcomes delivered by the water for rivers and tributary utilisation in the model. This is documented at Appendix B of the notification amendment of combined Murrumbidgee SDL projects.

Yanco modernisation project

This project is to improve operation efficiency in the Yanco creek system and generate water savings. It includes:

- Monitoring: provision of additional monitoring capability to provide enhanced information in real-time to the system operator and water users on flows and levels throughout the creek system;
- Controls (new works): a new weir and upgrades to existing weirs to allow re-regulation and tighter flow control and management along the length of the creek system;

- Alternative supplies: provision of alternative supply points into the creek system from the neighbouring irrigation corporations, at locations far closer to the end user, to better align demand and supply; and
- Operating rules: codification and documentation of the revised operational protocols to optimise use of the new controls and improve diversion efficiency as well as social and environmental outcomes.

Approach adopted

For maintaining consistency, the same approach to what has been used in the previous assessment (MDBA, 2017b) has been also used in this assessment which entails a two-step process.

At the first step, the Murrumbidgee model is reviewed to understand how much total general security unit shares can be created without affecting other users in the Murrumbidgee system. For this task, a fictitious extraction node at the end of system is created and general security entitlement at the node is sized differently to test any third-party impacts.

The second step involves determining how to divide the total entitlement volume assessed in the first step between Murrumbidgee in-valley contribution and the Murrumbidgee IVT account. The Murrumbidgee IVT account is used to counterbalance potential impacts to Murray users due to the reduced inflows from Murrumbidgee.

For this assessment, the modelling framework has been modified from the version used to development the Basin Plan Benchmark Run No 1132 (Commit No: 76e7775). The necessary changes required to model the two projects individually are included in the subsequent revision (Commit No: d310adc50).

Application of the adopted approach

Assessment of the CARM project

First step: Calculation of total General Security units available

5 different model runs were developed with different general security entitlement volumes in 10 GL intervals starting from 0 GL. The 10 GL intervals in entitlement volume is found to be equivalent to roughly 8 GL as LTAY in the model. Key water balance statistics from the model runs are summarised in Table 1.

When the CARM project is implemented on to the Benchmark without any additional water demand (i.e. 0 GL scenario), it shows that irrigation diversions are increased while flows are reduced. This is a result of better utilising forecasting capacity through the CARM operating tool leading to less unmanage surplus in the system and hence improved water availability. Table 1 also shows that the WfR extraction changed most from the Benchmark results. As described earlier, the Benchmark includes the WfR water recovery prior to 2009 and all other scenarios have the post 2009 water

saving projects whose benefits are modelled with additional water extraction from downstream of Bowering Dam.

Figure 1 indicates that the reduced flows in general coincided with the wet conditions generally experienced during winter-spring. Also, some efficiency is observed during the irrigation season (i.e. January – March).

The benefits of the CARM project start to reduce as the size of general security entitlement is increased. When the LTAY reaches to 32 GL, Table 1 shows that diversions go below the benchmark level indicating potential negative impacts.

Table 1: Key Murrumbidgee water balance statistics with different sizes of general security entitlement compared against Benchmark outcomes for assessing the CARM project

Water Balance (GL/yr)	Benchmark	Long-Term Average Yield (LTAY)				
		0 GL	16 GL	24 GL	32 GL	39 GL
MIA diversions	751.5	752.2	750.4	749.3	748.7	747.2
CIA diversions	230.8	232.0	231.0	230.5	229.8	229.2
NIA diversions	377.6	380.8	378.2	377.2	376.1	374.2
Township water supply	12.9	12.9	12.9	12.9	12.9	12.9
WfR extraction	97.0	123.4	121.9	122.8	122.0	121.0
Billabong creek at Darlot	258.9	254.7	254.5	254.6	254.4	254.5
Forest Creek flow	9.8	9.5	9.5	9.5	9.4	9.4
Balranald flows before GS extraction	1,575.8	1,559.8	1,566.7	1,568.8	1,572.3	1,578.5
GS entitlement modelled	-	-	20.0	30.0	40.0	50.0
Balranald flows after GS extraction	1,575.8	1559.8	1550.7	1545.1	1540.7	1539.1

Similarly, Table A- 1 and Table A- 2 in Appendix A: Comparison of environmental outcomes for Assessing the CARM project present environmental outcomes measured by Site Specific Flow Indicators (SFI) at the Mid-Murrumbidgee and Low-Murrumbidgee sections. They indicate that the SFI outcomes are relatively stable across the different scenarios of entitlement tested. Even though the third indicator at Mid-Murrumbidgee is changed the most, all SFIs are remained within the Limits of Change (LoC).

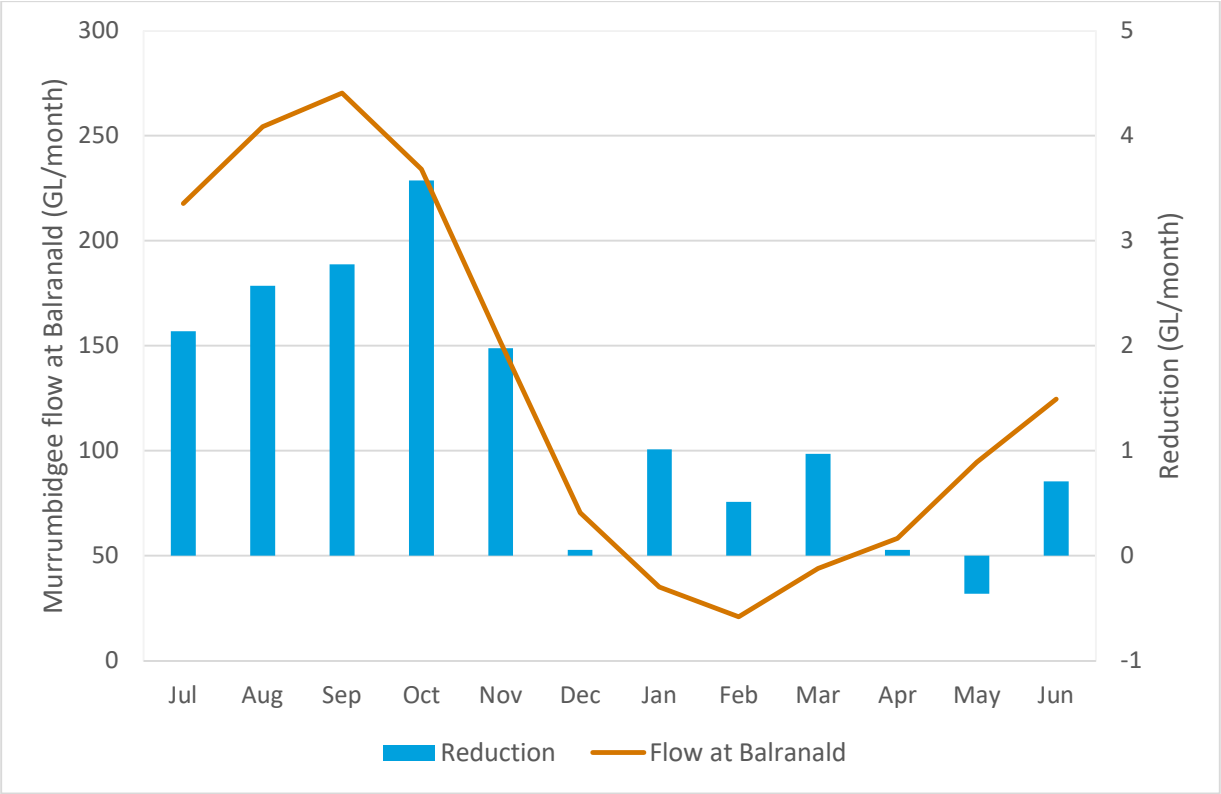

Figure 1: Monthly Murrumbidgee flows at Balranald and its reduction introduced by implementing the CARM project

The impacts of different sizes of general security entitlement are further examined in Figure 2 ~ Figure 4 where announced allocations are presented at some months. Figure 2 shows some improvements in allocation indicating the LTAY can be increased more than 8 GL without affecting other users. Figure 4, however, shows that some impacts during the peak irrigation season and they are remained affected by the end of a year when the size of LTAY is 39 GL and bigger. When it is sized between 16 GL and 32 GL (Figure 3), the small impacts in February exist but are disappeared by June and the allocation profile is returned to a similar level of benchmark results. It suggests that the LTAY cannot be sized bigger than 32 GL, otherwise there will be some third-party impacts to other users.

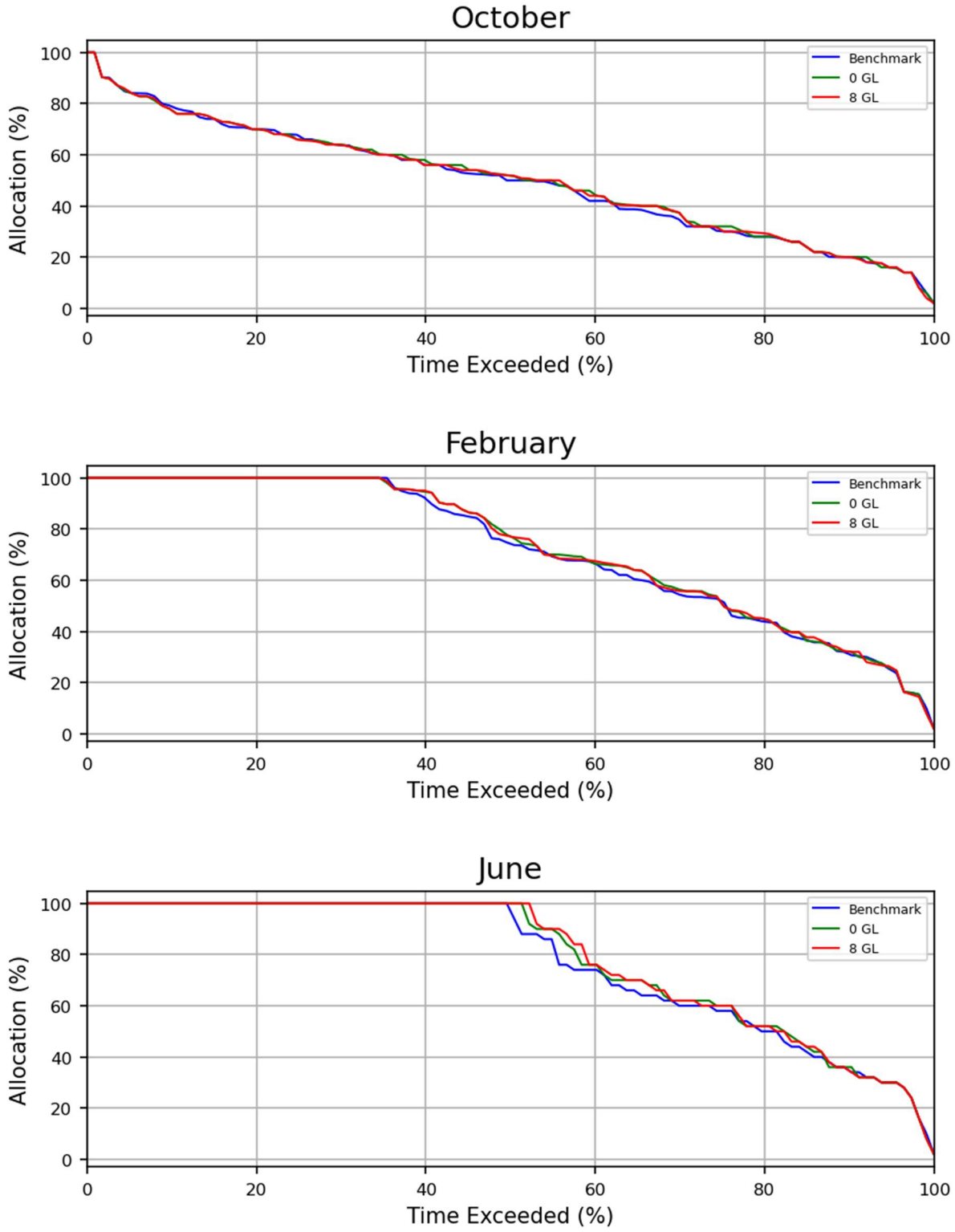

Figure 2: Murrumbidgee announced allocation (%) in October, February and June with LTAY at 0 GL and 8 GL for assessing the CARM project

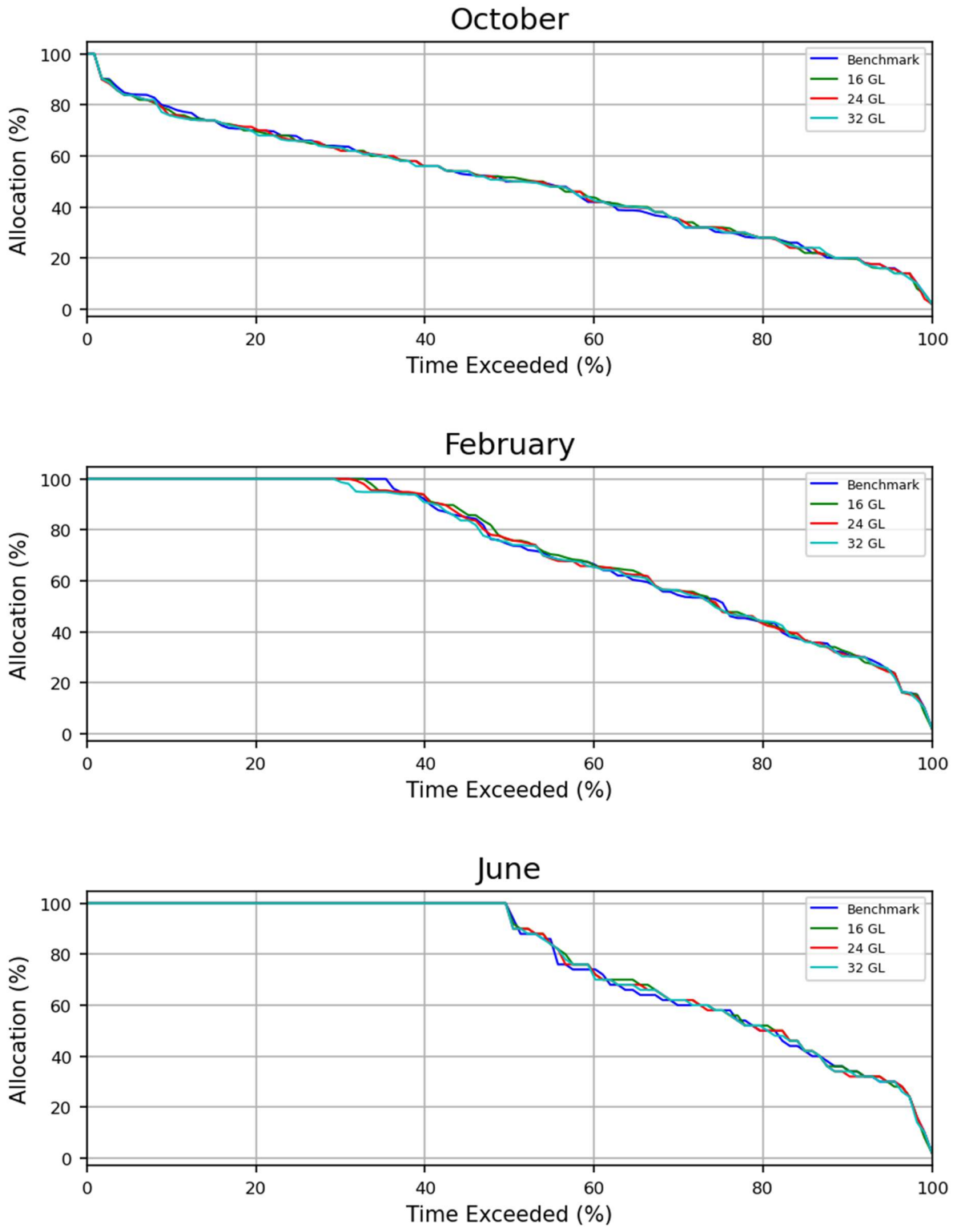

Figure 3: Murrumbidgee announced allocation (%) in October, February and June with LTAY at 16 GL, 24 GL, and 32 GL for assessing the CARM project

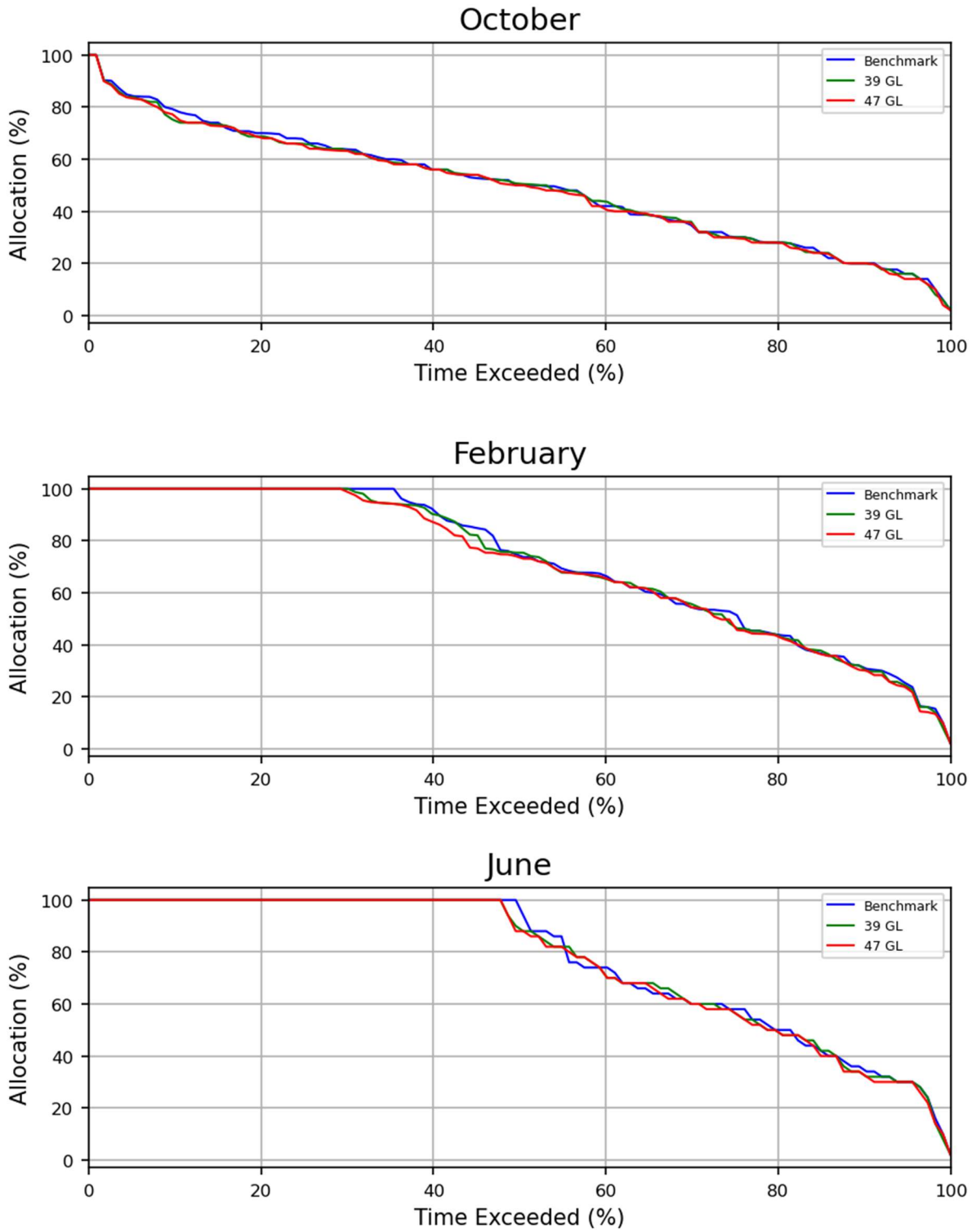

Figure 4: Murrumbidgee announced allocation (%) in October, February and June with an environmental account created at 39 GL and 47 GL for assessing the CARM project

Second step: Assessment of IVT account

In the second step, impacts to the Murray system is examined. Based on the findings from the first step, different entitlement volumes between 20 GL and 40 GL are used to understand different behaviours in the Murray system. Also, there are some additional modellings undertaken on IVT account volumes to counter-balance impacts to Murray users. It is assumed that the IVT account behaviours similar to the normal general security entitlement holders. That is, the account is increased when general security allocation in Murrumbidgee is improved and is debited when water is used to meet Murray downstream demands instead of orders being propagated to further upstream.

As entitlement volumes are increased, Murrumbidgee inflows to the Murray system are reduced. Table 2 indicates that the reduced inflows from Murrumbidgee are mostly translated to less flows at the end of the system with very small changes in the system losses. However, when the entitlement is sized bigger than 30 GL, NSW Murray diversions are started to be reduced. Therefore, different sizes of IVT account are further modelled for managing this impact. It shows NSW diversions are restored back to the Benchmark level when IVT general security entitlement is 10 GL.

Table 2: Water balance of the Murray system comparing different volumes of general security entitlement created in the Murrumbidgee system and different sizes of IVT account for assessing the CARM project

Murray Water Balance (GL/yr)	Benchmark	Total LTAY / IVT account					
		0 GS/0 GL	16 GL/0 GL	24 GL/0 GL	24 GL/8 GL	24 GL/12 GL	32 GL/0 GL
Inflows	13,369	13,350	13,340	13,334	13,342	13,346	13,329
Diversions	**2,944**	**2,944**	**2,944**	**2,941**	**2,944**	**2,945**	**2,941**
NSW Murray	1,226	1,227	1,226	1,224	1,226	1,227	1,223
Lower Darling	41	41	41	41	41	41	41
Vic Murray	1,196	1,196	1,196	1,196	1,196	1,196	1,196
SA Murray	481	481	481	481	481	481	481
Losses	3,413	3,412	3,410	3,411	3,411	3,412	3,410
Barrage outflow	7,081	7,062	7,054	7,050	7,055	7,057	7,047

Reliability plots in NSW Murray and Vic Murray (Figure 5 and Figure 6) indicate that water available in the Murray system is only marginally affected by entitlement volumes created and used in the Murrumbidgee system if it is sized below 40 GL. Environmental outcomes in the Murray system are presented at

Table A- 3 in Appendix A: Comparison of environmental outcomes for Assessing the CARM project which indicates a similar story where SFI outcomes are not significantly altered.

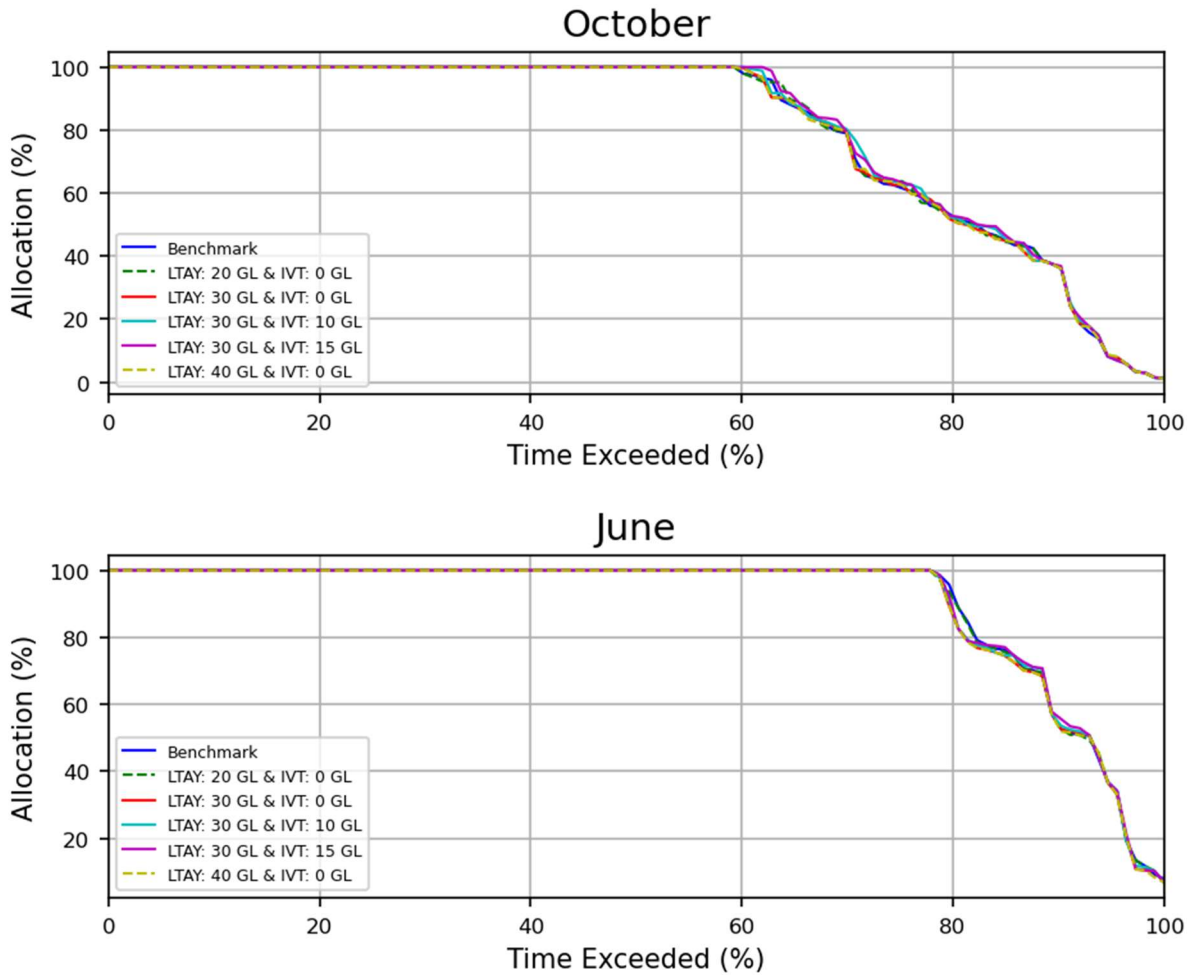

Figure 5: NSW Murray announced allocation (%) in October and June with different Long-Term Average Yield (LTAY) and IVT account created in Murrumbidgee for assessing the CARM project

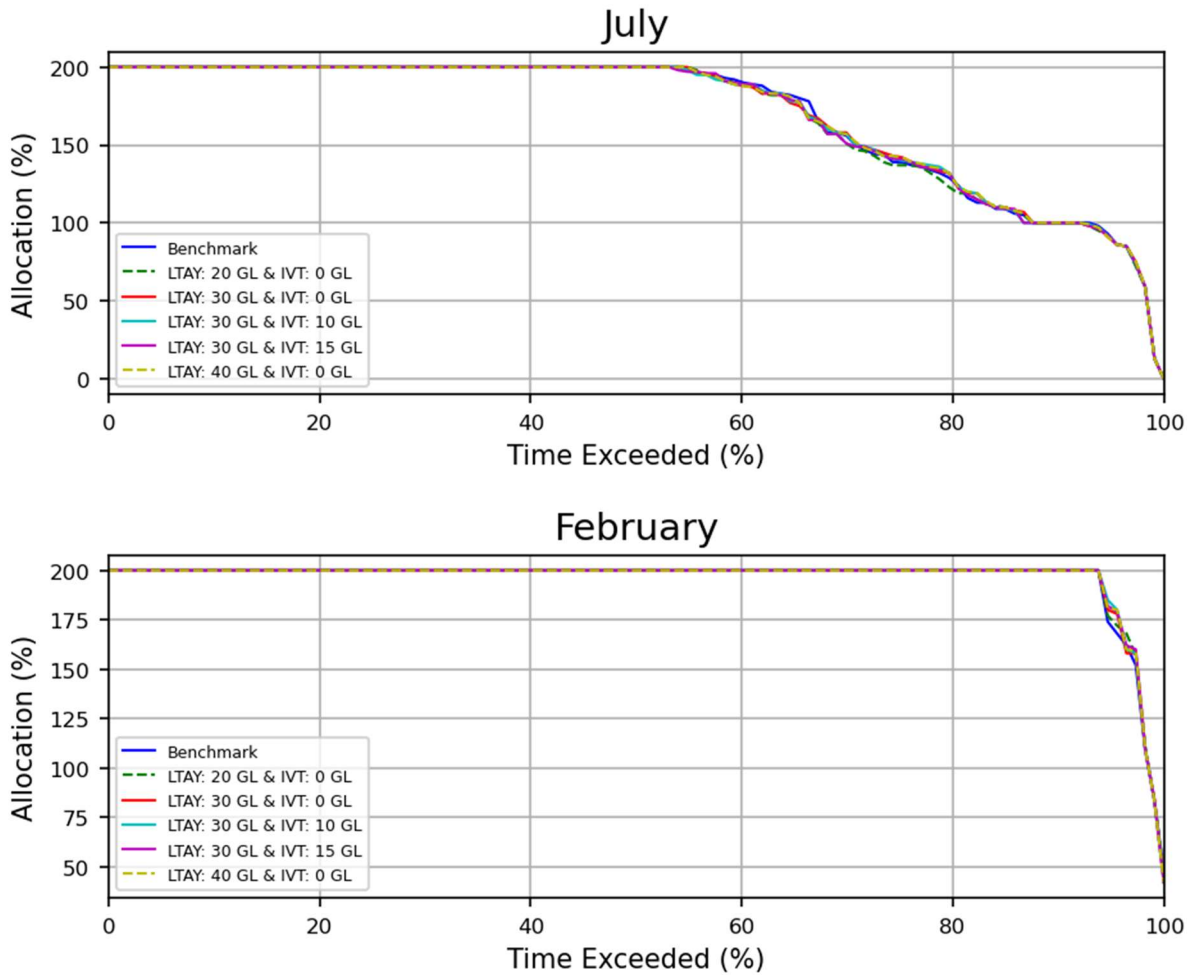

Figure 6: Vic Murray announced allocation (%) in July and February with different Long-Term Average Yield (LTAY) and IVT account created in Murrumbidgee for assessing the CARM project

Assessment of the Yanco modernisation project

First step: Calculation of total General Security units available

Similar to the CARM project assessment, different model runs were developed with different general security entitlement volumes in 10 GL intervals starting from 0 GL. It is found that the interval of 10 GL leads to 8 GL difference in LTAY. Key water balance statistics from the model runs are summarised in Table 3.

When the modernisation project is implemented without with 0 GL entitlement, it shows third party benefits of increased irrigation diversions. The benefits are reduced as LTAY is increased, and almost returned back to the Benchmark level when it is sized to 16 GL.

Figure 7 also shows that there is minor reduction in February allocation when LTAY volume is equal to and bigger than 16 GL. By June the impact is disappeared with 16 GL LTAY but cannot be fully recovered with 24 GL in LTAY. Based on Table 3 and Figure 7, it would be appropriate to assign LTAY of 16 GL to the project.

Table 3: Key Murrumbidgee water balance statistics with different sizes of general security entitlement compared against Benchmark outcomes for assessing the Yanco moderisation project

Water Balance (GL/yr)	Benchmark	Long-Term Average Yield (LTAY)			
		0 GL	8 GL	16 GL	24 GL
MIA diversions	751.5	752.2	751.6	750.6	749.6
CIA diversions	230.8	232.2	231.6	230.7	230.4
NIA diversions	377.6	379.7	379.1	377.1	375.1
Township water supply	12.9	12.9	12.9	12.9	12.9
WfR extraction	97.0	95.6	95.5	95.4	93.9
Billabong creek at Darlot	258.9	252.6	252.5	252.5	252.5
Forest Creek flow	9.8	7.8	7.8	7.8	7.8
Balranald flows before GS extraction	1,575.8	1,575.9	1,570.7	1,567.2	1,564.1
GS entitlement modelled	-	-	10.0	20.0	30.0
Balranald flows after GS extraction	1,575.8	1,575.9	1,562.8	1,551.3	1,540.4

Second step: Assessment of IVT account

Based on the entitlement volume determined in the first step, impacts to Murray users are tested in this step. With different Murrumbidgee IVT account volumes in 5 GL intervals, key water balance terms are presented at Table 4 to guide an appropriate size of the IVT account. Table 4 indicates that there are some impacts to NSW diversions as the total entitlement volume in Murrumbidgee is increased but the impacts are started to disappear as the size of IVT account is increased. When the IVT account is with 15 GL, NSW diversions exceeds the Benchmark level. This indicates that The IVT account with 10 GL general security entitlement would be sufficient to neutralise the impacts to Murray users.

Table 4: Water balance of the Murray system comparing different volumes of general security entitlement created in the Murrumbidgee system and different sizes of IVT account for assess the Yanco modernisation project

Murray Water Balance (GL/yr)	Benchmark	Total LTAY / IVT account					
		0 GS/0 GL	16 GL/0 GL	16 GL/4 GL	16 GL/8 GL	16 GL/12 GL	24 GL/0 GL
Inflows	13,369	13,365	13,329	13,333	13,337	13,341	13,329
Diversions	**2,944**	**2,942**	**2,941**	**2,943**	**2,944**	**2,945**	**2,941**
NSW Murray	1,226	1,226	1,223	1,225	1,226	1,227	1,223
Lower Darling	41	41	41	41	41	40	41
Vic Murray	1,196	1,195	1,196	1,196	1,196	1,196	1,196
SA Murray	481	481	481	481	481	481	481
Losses	3,413	3,413	3,410	3,410	3,411	3,411	3,410
Barrage outflow	7,081	7,078	7,047	7,049	7,051	7,053	7,047

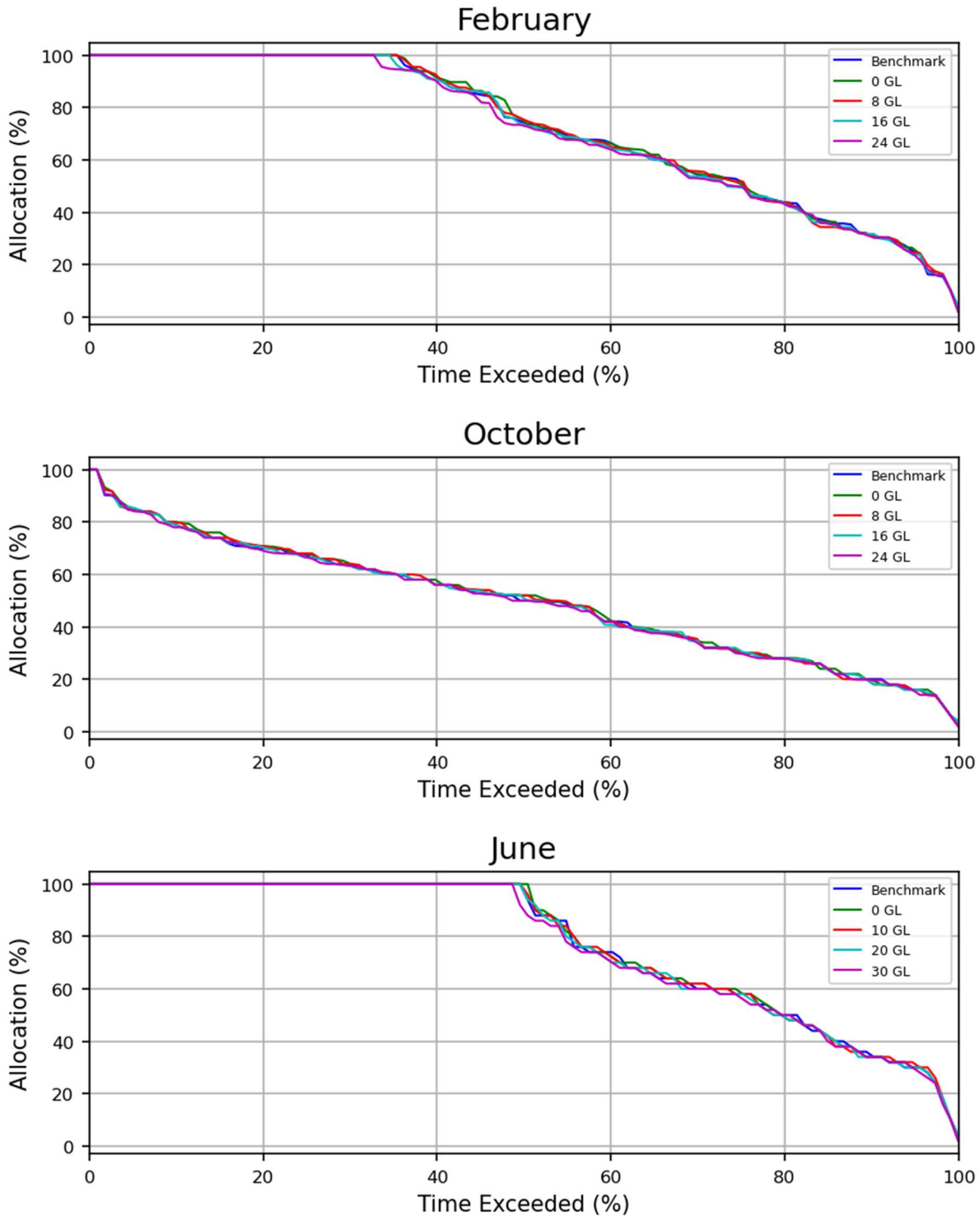

Figure 7: Murrumbidgee announced allocation (%) in October, February and June with different Long-Term Average Yield (LTAY) volumes of 0 GL, 8 GL, 16 GL and 24 GL for assessing the Yanco modernisation project

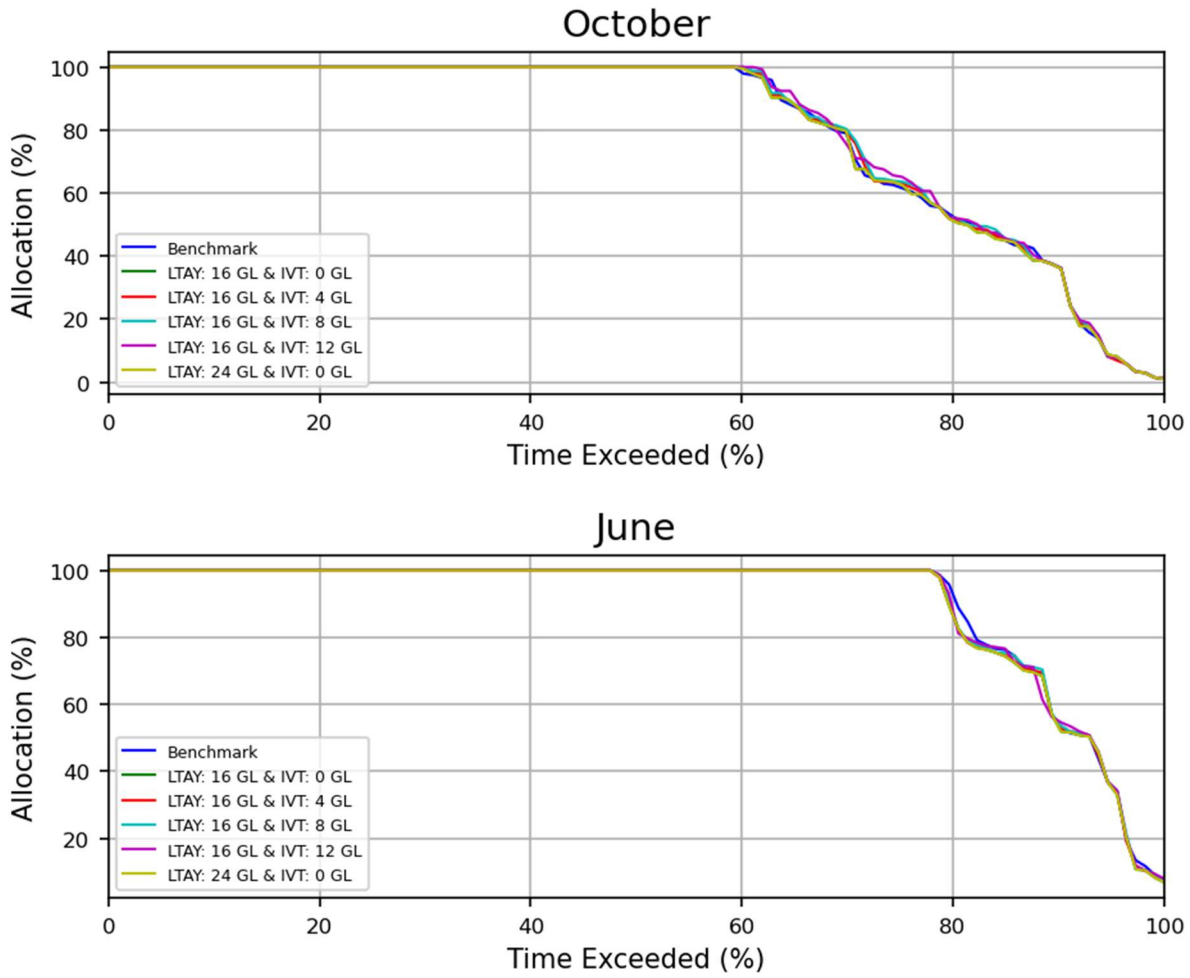

Figure 8: NSW Murray announced allocation (%) in October and June with different Long-Term Average Yield (LTAY) volumes created in Murrumbidgee for assessing the Yanco modernisation project

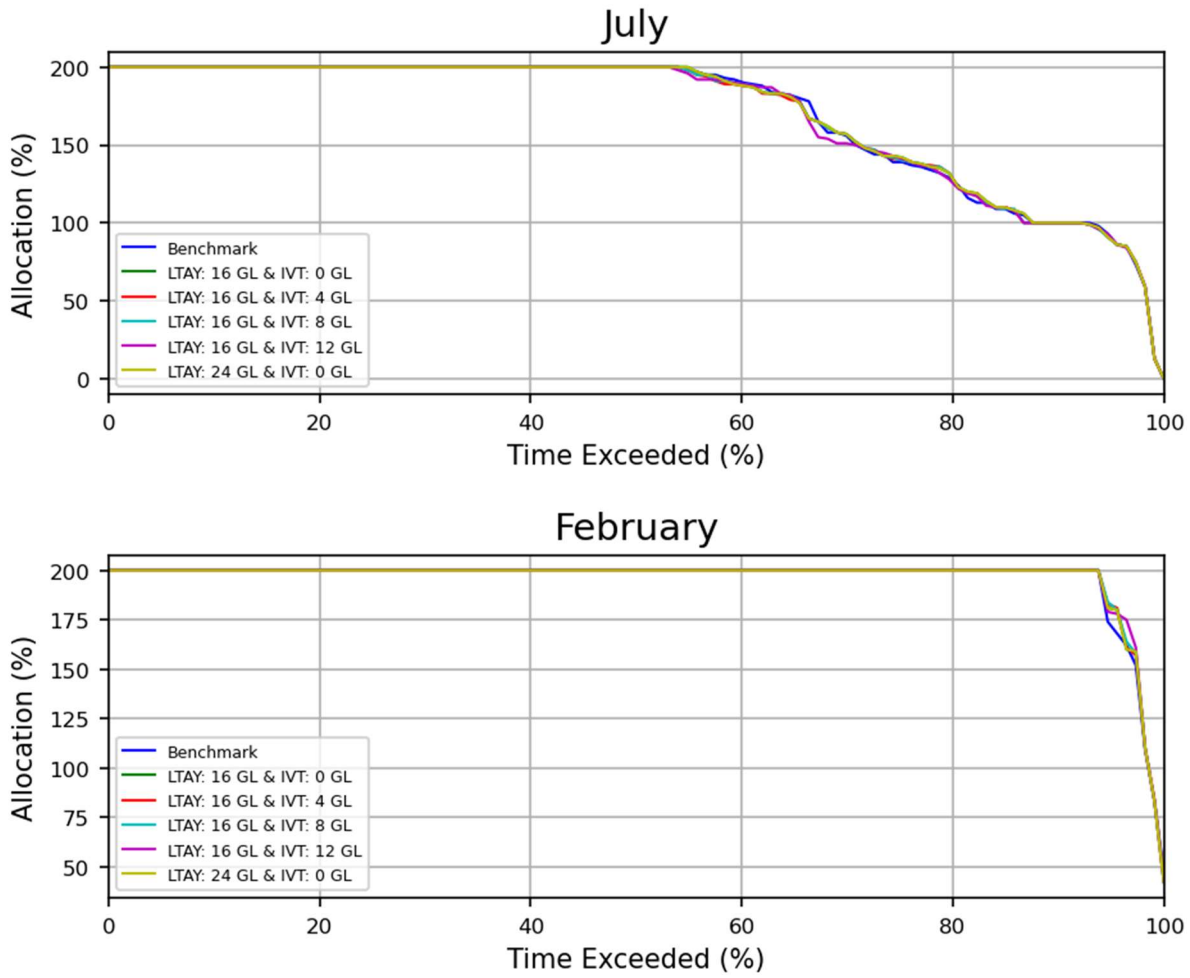

Figure 9: Vic Murray announced allocation (%) in July and February with different Long-Term Average Yield (LTAY) volumes created in Murrumbidgee for assessing the Yanco modernisation project

Conclusion

A modelling study has been conducted to inform a Long-Term Average Yield (LTAY) that can be created from the CARM and Yanco modernisation projects separately. This study is an extension of a previous study of MDBA (2017b) where a similar assessment was done for the combined outcomes from the two projects.

Similar to the previous assessment, a two staged approach is adopted. At the first step, the total volume that can be created in the Murrumbidgee system is assessed. Out of the total, Murrumbidgee IVT account is sized at the second step to neutralise impacts to the Murray users.

The modelling study found that the CARM project yields up to 24 GL (modelled with general security entitlement of 30 GL) in total if the project is assessed by itself. Out of the total yield, one third would likely need to be assigned to the IVT account. A similar assessment on the Yanco modernisation project suggests that a long-term average yield of 16 GL (modelled with general security entitlement of 20 GL) can be assigned for the project and a half of the total yield needs to be assigned to the IVT account. These results are summarised at Table 5. It indicates that outcomes of the two projects when they are assessed individually add up to more than what could be achievable if they are

modelled together and assessed as combined benefits as per MDBA (2017a). This is an expected outcome and a reflection of the inter-linked nature of the two projects. To deal with the discrepancy, the projects contributions are apportioned proportionally to the entitlement volumes assessed individually out of the combined assessment volume. The results are presented at the end of Table 5.

Table 5: Summary of environmental water entitlment avaialble from the CARM and Yanco modernisation projects when they are assessed indivisually and combined together.

Long-Term Average Yield (GL)	Total	Internal	IVT
CARM individual assessment	24.0	16.0	8.0
Modernisation individual assessment	16.0	8.0	8.0
Assessment of the two projects combined (MDBA, 2017a)	**32.0**	**16.0**	**16.0**
CARM contribution	**18.7**	**10.7**	**8.0**
Modernisation contribution	**13.3**	**5.3**	**8.0**

References

NSW DPI Water, 2015a. Business Case: Computer Aided River Management System for the Murrumbidgee River.

NSW DPI Water, 2015b. Business Case: Modernising supply systems for effluent creeks – Murrumbidgee River.

MDBA, 2017a. Assessment of the CARM and Modernisation projects for entitlement creation, Technical Report No. 2017/18.

MDBA, 2017b. Modelling assessment to determine SDL Adjustment Volume, MDBA publication no: 35/17.

Appendix A: Comparison of environmental outcomes for Assessing the CARM project

Table A- 1: Environmental outcomes achieved at Mid-Murrumbidgee with different sizes of Long-Term Average Yield (LTAY) volume compared against key reference scenarios and Limits of Change

Mid-Murrumbidgee flow indicators	Without development	Baseline	Bench mark	Limits of change	Water Recovery Modelled (LTAY, GL)				
					0 GL	16 GL	24 GL	32 GL	39 GL
26,850 ML/d for a total duration of 45 days (with min duration of 1 day) between Jul & Nov	28%	11%	11%	11%	11%	11%	11%	11%	11%
26,850 ML/d for 5 consecutive days between Jun & Nov	67%	46%	60%	54%	60%	60%	60%	60%	60%
34,650 ML/d for 5 consecutive days between Jun & Nov	57%	29%	41%	37%	39%	38%	37%	38%	37%
44,000 ML/d for 3 consecutive days between Jun & Nov	44%	22%	23%	22%	22%	22%	22%	22%	22%
63,250 ML/d for 3 consecutive days between Jun & Nov	21%	11%	10%	10%	10%	10%	10%	10%	10%

Table A- 2: Environmental outcomes achieved at Low-Murrumbidgee with different sizes of Long-Term Average Yield (LTAY) volume compared against key reference scenarios and Limits of Change

Low-Murrumbidgee flow indicators	Without development	Baseline	Bench mark	Limits of change	Water Recovery Modelled (LTAY, GL)				
					0 GL	10 GL	24 GL	32 GL	39 GL
Total volume of 175 GL (flow > 5,000 ML/d) between Jul & Sep	94%	94%	94%	85%	93%	93%	93%	93%	93%
Total volume of 270 GL (flow > 5,000 ML/d) between Jul & Sep	92%	86%	86%	77%	86%	86%	86%	85%	87%
Total volume of 400 GL (flow > 5,000 ML/d) between Jul & Oct	92%	83%	83%	75%	79%	78%	80%	79%	80%
Total volume of 800 GL (flow > 5,000 ML/d) between Jul & Oct	78%	60%	60%	54%	58%	58%	58%	58%	58%
Total volume of 1,700 GL (flow > 5,000 ML/d) between Jul & Nov	56%	30%	30%	27%	29%	29%	29%	29%	29%
Total volume of 2,700 GL (flow > 5,000 ML/d) between May & Feb	44%	18%	18%	16%	17%	18%	17%	17%	17%

Table A- 3: Environmental outcomes in the Murray system with varying volumes of Long-Term Average Yield (LTAY) and IVT account in Murrumbidgee

Indicator Description	**Frequency Target**	**Bench mark**	**Limits of Change**	**0 GL/ 0 GL**	**16 GL/ 0 GL**	**24 GL/ 0 GL**	**24 GL/ 8 GL**	**24 GL/ 12 GL**	**32 GL / 0 GL**
Upper Murray Measured at Yarrawonga DS									
12,500 ML/d for a total duration of 70 days (with min duration of 7 consecutive days) between Jun & Nov	70 - 80 %	76%	74%	76%	77%	77%	78%	78%	77%
16,000 ML/d for a total duration of 98 days (with min duration of 7 consecutive days) between Jun & Nov	40 - 50 %	53%	42%	53%	53%	53%	53%	53%	53%

Indicator Description	Frequency Target	Benchmark	Limits of Change	0 GL/ 0 GL	16 GL/ 0 GL	24 GL/ 0 GL	24 GL/ 8 GL	24 GL/ 12 GL	32 GL / 0 GL
25,000 ML/d for a total duration of 42 days (with min duration of 7 consecutive days) between Jun & Nov	40 - 50 %	50%	45%	50%	50%	51%	50%	50%	51%
35,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May	33 - 40 %	36%	32%	36%	36%	37%	37%	38%	38%
50,000 ML/d for a total duration of 21 days (with min duration of 7 consecutive days) between Jun & May	25 - 30 %	17%	15%	17%	17%	17%	17%	17%	17%
60,000 ML/d for a total duration of 14 days (with min duration of 7 consecutive days) between Jun & May	20 - 25 %	14%	10%	14%	14%	13%	14%	14%	14%
15,000 ML/d for a total duration of 150 days (with min duration of 7 consecutive days) between Jun & Dec	30%	35%	22%	34%	35%	35%	35%	35%	35%
Mid Upper Murray Measured at Torrumbarry DS									
16,000 ML/d for a total duration of 90 days (with min duration of 7 consecutive days) between Jun & Nov	70 - 80 %	68%	65%	68%	68%	68%	68%	68%	68%
20,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Nov	60 - 70 %	64%	57%	64%	64%	64%	64%	64%	64%
30,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & May	33 - 50 %	40%	34%	40%	40%	40%	40%	40%	40%
40,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & May	25 - 33 %	24%	18%	24%	24%	24%	24%	24%	24%
20,000 ML/d for a total duration of 150 days (with min duration of 7 consecutive days) between Jun & Dec	30%	26%	20%	26%	26%	26%	26%	26%	26%
Lower Upper Murray Measured at Euston DS									
40,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	40 - 50 %	46%	38%	45%	46%	46%	46%	46%	45%
50,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	30 - 40 %	30%	22%	30%	30%	30%	30%	30%	30%
70,000 ML/d for a total duration of 42 days (with min duration of 7 consecutive days) between Jun & Dec	20 - 33 %	18%	10%	18%	18%	18%	18%	18%	18%
85,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May	20 - 30 %	11%	6%	11%	11%	11%	11%	11%	11%
120,000 ML/d for a total duration of 14 days (with min duration of 7 consecutive days) between Jun & May	14 - 20 %	8%	4%	8%	8%	8%	8%	8%	8%
150,000 ML/d for a total duration of 7 days (with min duration of 7 consecutive days) between Jun & May	10 - 13 %	6%	5%	6%	6%	6%	6%	6%	6%
Lower Murray Measured at SA border									
20,000 ML/d for 60 consecutive days between Aug & Dec	71 - 80 %	69%	68%	69%	69%	69%	69%	69%	69%
40,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & Dec	50 - 70 %	55%	46%	54%	54%	54%	54%	54%	54%
40,000 ML/d for a total duration of 90 days (with min duration of 7 consecutive days) between Jun & Dec	33 - 50 %	38%	34%	38%	38%	39%	39%	39%	39%
60,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	25 - 33 %	27%	24%	26%	26%	26%	26%	26%	26%

Indicator Description	Frequency Target	Benchmark	Limits of Change	0 GL/ 0 GL	16 GL/ 0 GL	24 GL/ 0 GL	24 GL/ 8 GL	24 GL/ 12 GL	32 GL / 0 GL
80,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May	17 - 25 %	15%	11%	15%	15%	15%	15%	15%	15%
100,000 ML/d for a total duration of 21 days (with min duration of 1 day) between Jun & May	13 - 17 %	7%	4%	7%	7%	7%	7%	7%	7%
125,000 ML/d for a total duration of 7 days (with min duration of 1 day) between Jun & May	10 - 13 %	5%	4%	5%	5%	5%	5%	5%	5%
Edward-Wakool Measured at Deniliquin									
1,500 ML/d for a total duration of 180 days (with min duration of 1 day) between Jun & Mar	99 - 100 %	94%	89%	94%	94%	94%	94%	94%	94%
5,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	60 - 70 %	66%	59%	66%	66%	66%	66%	66%	66%
5,000 ML/d for a total duration of 120 days (with min duration of 7 consecutive days) between Jun & Dec	35 - 40 %	36%	25%	36%	36%	36%	35%	35%	36%
18,000 ML/d for a total duration of 28 days (with min duration of 5 consecutive days) between Jun & Dec	25 - 30 %	16%	11%	16%	16%	16%	16%	16%	16%
30,000 ML/d for a total duration of 21 days (with min duration of 6 consecutive days) between Jun & Dec	17 - 20 %	13%	11%	13%	13%	13%	13%	13%	13%
Lower Darling Measured at Weir32									
7,000 ML/d for 10 consecutive days between Jun & May	70 - 90 %	54%	50%	54%	53%	54%	54%	53%	54%
17,000 ML/d for 18 consecutive days between Jun & May	20 - 40 %	21%	20%	21%	21%	21%	21%	21%	21%
20,000 ML/d for 30 consecutive days between Jun & May	14 - 20 %	11%	4%	11%	11%	11%	11%	11%	11%
25,000 ML/d for 45 consecutive days between Jun & May	8 - 10 %	8%	8%	8%	8%	8%	8%	8%	8%
45,000 ML/d for 2 consecutive days between Jun & May	7 - 10 %	7%	6%	7%	7%	7%	7%	7%	7%
Coorong, Lower Lakes and Murray Mouth									
Lake Alexandrina salinity: Percentage of days that Lake Alexandrina salinity is less than 1,500 EC	-	100%	100%	100%	100%	100%	100%	100%	100%
Lake Alexandrina salinity: Percentage of days that Lake Alexandrina salinity is less than 1,000 EC	-	99%	95%	99%	99%	99%	99%	99%	99%
Barrage flows: Percentage of years that barrage flows are greater than 2,000 GL/yr (measured on a three year rolling average) with a minimum of 650 GL/yr	-	97%	95%	97%	97%	97%	97%	97%	97%
Barrage flows: Percentage of years that barrage flows are greater than 600 GL for any two year period	-	100%	100%	100%	100%	100%	100%	100%	100%
Coorong Salinity: Percentage of days South Lagoon average daily salinity is less than 100 grams per litre.	-	100%	96%	100%	100%	100%	100%	100%	100%
Mouth Openness: Percentage of years mouth open to an average annual depth of 1.0 meters (-1.0 m AHD) or more	-	93%	90%	93%	93%	93%	93%	93%	93%
Mouth Openness: Percentage of years mouth open to an average annual depth of 0.7 metres (-0.7 m AHD) or more	-	96%	95%	96%	96%	96%	96%	96%	96%

Appendix B: Comparison of environmental outcomes for Assessing the Yanco modernisation project

Table B- 1: Environmental outcomes achieved at Mid-Murrumbidgee with different sizes of Long-Term Average Yield (LTAY) compared against key reference scenarios and Limits of Change

Mid-Murrumbidgee flow indicators	Without development	Baseline	Benchmark	Limits of change	Water Recovery Modelled (LTAY, GL)			
					0 GL	8 GL	16 GL	24 GL
26,850 ML/d for a total duration of 45 days (with min duration of 1 day) between Jul & Nov	28%	11%	11%	11%	11%	11%	11%	11%
26,850 ML/d for 5 consecutive days between Jun & Nov	67%	46%	60%	54%	61%	61%	61%	61%
34,650 ML/d for 5 consecutive days between Jun & Nov	57%	29%	41%	37%	41%	41%	41%	41%
44,000 ML/d for 3 consecutive days between Jun & Nov	44%	22%	23%	22%	23%	23%	23%	23%
63,250 ML/d for 3 consecutive days between Jun & Nov	21%	11%	10%	10%	10%	10%	10%	10%

Table B- 2: Environmental outcomes achieved at Low-Murrumbidgee with different sizes of Long-Term Average Yield (LTAY) compared against key reference scenarios and Limits of Change

Low-Murrumbidgee flow indicators	Without development	Baseline	Benchmark	Limits of change	Water Recovery Modelled (LTAY, GL)			
					0 GL	8 GL	16 GL	24 GL
Total volume of 175 GL (flow > 5,000 ML/d) between Jul & Sep	94%	94%	94%	85%	94%	94%	94%	94%
Total volume of 270 GL (flow > 5,000 ML/d) between Jul & Sep	92%	86%	86%	77%	85%	85%	86%	87%
Total volume of 400 GL (flow > 5,000 ML/d) between Jul & Oct	92%	83%	83%	75%	82%	83%	82%	83%
Total volume of 800 GL (flow > 5,000 ML/d) between Jul & Oct	78%	60%	60%	54%	60%	60%	60%	60%
Total volume of 1,700 GL (flow > 5,000 ML/d) between Jul & Nov	56%	30%	30%	27%	30%	30%	30%	30%
Total volume of 2,700 GL (flow > 5,000 ML/d) between May & Feb	44%	18%	18%	16%	18%	18%	18%	18%

Table B- 3: Environmental outcomes in the Murray system with varying volumes of Long-Term Average Yield (LTAY) and IVT account in Murrumbidgee

Indicator Description	**Frequency Target**	**Benchmark**	**Limits of Change**	**0 GL/ 0 GL**	**16 GL/ 0 GL**	**16 GL/ 4 GL**	**16 GL/ 8 GL**	**16 GL/12 GL**	**24 GL / 0 GL**

Upper Murray Measured at Yarrawonga DS									
12,500 ML/d for a total duration of 70 days (with min duration of 7 consecutive days) between Jun & Nov	70 - 80 %	76%	74%	76%	77%	77%	78%	78%	77%
16,000 ML/d for a total duration of 98 days (with min duration of 7 consecutive days) between Jun & Nov	40 - 50 %	53%	42%	53%	53%	53%	53%	52%	53%
25,000 ML/d for a total duration of 42 days (with min duration of 7 consecutive days) between Jun & Nov	40 - 50 %	50%	45%	50%	51%	51%	51%	50%	51%
35,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May	33 - 40 %	36%	32%	36%	38%	38%	38%	37%	38%
50,000 ML/d for a total duration of 21 days (with min duration of 7 consecutive days) between Jun & May	25 - 30 %	17%	15%	17%	17%	17%	17%	17%	17%
60,000 ML/d for a total duration of 14 days (with min duration of 7 consecutive days) between Jun & May	20 - 25 %	14%	10%	13%	14%	14%	14%	14%	14%
15,000 ML/d for a total duration of 150 days (with min duration of 7 consecutive days) between Jun & Dec	30%	35%	22%	33%	34%	34%	34%	34%	34%
Mid Upper Murray Measured at Torrumbarry DS									
16,000 ML/d for a total duration of 90 days (with min duration of 7 consecutive days) between Jun & Nov	70 - 80 %	68%	65%	68%	68%	68%	68%	68%	68%
20,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Nov	60 - 70 %	64%	57%	64%	64%	64%	64%	64%	64%
30,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & May	33 - 50 %	40%	34%	40%	40%	40%	40%	40%	40%
40,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & May	25 - 33 %	24%	18%	24%	24%	24%	24%	24%	24%
20,000 ML/d for a total duration of 150 days (with min duration of 7 consecutive days) between Jun & Dec	30%	26%	20%	27%	26%	26%	26%	27%	26%
Lower Upper Murray Measured at Euston DS									
40,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	40 - 50 %	46%	38%	46%	45%	46%	46%	46%	45%
50,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	30 - 40 %	30%	22%	30%	30%	30%	30%	30%	30%
70,000 ML/d for a total duration of 42 days (with min duration of 7 consecutive days) between Jun & Dec	20 - 33 %	18%	10%	18%	18%	18%	18%	18%	18%
85,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May	20 - 30 %	11%	6%	11%	11%	11%	11%	11%	11%
120,000 ML/d for a total duration of 14 days (with min duration of 7 consecutive days) between Jun & May	14 - 20 %	8%	4%	8%	8%	8%	8%	8%	8%
150,000 ML/d for a total duration of 7 days (with min duration of 7 consecutive days) between Jun & May	10 - 13 %	6%	5%	6%	6%	6%	6%	6%	6%
Lower Murray Measured at SA border									
20,000 ML/d for 60 consecutive days between Aug & Dec	71 - 80 %	69%	68%	69%	69%	69%	69%	69%	69%
40,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & Dec	50 - 70 %	55%	46%	55%	54%	54%	54%	54%	54%
40,000 ML/d for a total duration of 90 days (with min duration of 7 consecutive days) between Jun & Dec	33 - 50 %	38%	34%	38%	39%	39%	39%	39%	39%

60,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	25 - 33 %	27%	24%	26%	25%	25%	25%	25%	25%
80,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May	17 - 25 %	15%	11%	15%	15%	15%	15%	15%	15%
100,000 ML/d for a total duration of 21 days (with min duration of 1 day) between Jun & May	13 - 17 %	7%	4%	7%	7%	7%	7%	7%	7%
125,000 ML/d for a total duration of 7 days (with min duration of 1 day) between Jun & May	10 - 13 %	5%	4%	5%	5%	5%	5%	5%	5%
Edward-Wakool Measured at Deniliquin									
1,500 ML/d for a total duration of 180 days (with min duration of 1 day) between Jun & Mar	99 - 100 %	94%	89%	94%	94%	94%	94%	94%	94%
5,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec	60 - 70 %	66%	59%	66%	66%	66%	66%	66%	66%
5,000 ML/d for a total duration of 120 days (with min duration of 7 consecutive days) between Jun & Dec	35 - 40 %	36%	25%	36%	36%	36%	36%	35%	36%
18,000 ML/d for a total duration of 28 days (with min duration of 5 consecutive days) between Jun & Dec	25 - 30 %	16%	11%	16%	16%	16%	16%	16%	16%
30,000 ML/d for a total duration of 21 days (with min duration of 6 consecutive days) between Jun & Dec	17 - 20 %	13%	11%	13%	13%	13%	13%	13%	13%
Lower Darling Measured at Weir32									
7,000 ML/d for 10 consecutive days between Jun & May	70 - 90 %	54%	50%	53%	54%	54%	54%	53%	54%
17,000 ML/d for 18 consecutive days between Jun & May	20 - 40 %	21%	20%	21%	21%	21%	21%	21%	21%
20,000 ML/d for 30 consecutive days between Jun & May	14 - 20 %	11%	4%	11%	11%	11%	11%	11%	11%
25,000 ML/d for 45 consecutive days between Jun & May	8 - 10 %	8%	8%	8%	8%	8%	8%	8%	8%
45,000 ML/d for 2 consecutive days between Jun & May	7 - 10 %	7%	6%	7%	7%	7%	7%	7%	7%
Coorong, Lower Lakes and Murray Mouth									
Lake Alexandrina salinity: Percentage of days that Lake Alexandrina salinity is less than 1,500 EC	-	100%	100%	100 %	100%	100 %	100%	100%	100%
Lake Alexandrina salinity: Percentage of days that Lake Alexandrina salinity is less than 1,000 EC	-	99%	95%	99%	99%	99%	99%	99%	99%
Barrage flows: Percentage of years that barrage flows are greater than 2,000 GL/yr (measured on a three year rolling average) with a minimum of 650 GL/yr	-	97%	95%	97%	97%	97%	97%	97%	97%
Barrage flows: Percentage of years that barrage flows are greater than 600 GL for any two year period	-	100%	100%	100 %	100%	100 %	100%	100%	100%
Coorong Salinity: Percentage of days South Lagoon average daily salinity is less than 100 grams per litre.	-	100%	96%	100 %	100%	100 %	100%	100%	100%
Mouth Openness: Percentage of years mouth open to an average annual depth of 1.0 meters (-1.0 m AHD) or more	-	93%	90%	93%	93%	93%	93%	93%	93%
Mouth Openness: Percentage of years mouth open to an average annual depth of 0.7 metres (-0.7 m AHD) or more	-	96%	95%	96%	96%	96%	96%	95%	96%

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