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MURRAY–DARLING BASIN AUTHORITY

Hydrologic Modelling for the Northern Basin Review – Macquarie-Castlereagh Modelling Addendum

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1. Introduction

From 2013 to 2016, the MDBA conducted a review of Basin Plan settings in the Northern Basin. This review acknowledged that the 2012 decision was based on information that, although the best available at the time, could be improved through further research and consultation with the community.

The three-year work program included a large body of hydrologic modelling to represent a wide range of water recovery options (MDBA 2016a). MDBA also completed parallel research programs investigating the environmental, social and economic impacts associated with each recovery option (MDBA 2016b,c).

The results of this work were presented to the Authority to assist in their triple-bottom line decision (MDBA 2016d) regarding Basin Plan settings in the Northern Basin. Based on the modelling work, the environmental, social and economic research, and community feedback, the Authority recommended that the Northern-wide 390 GL recovery volume chosen in 2012 be reduced to 320 GL.

The review encompassed the Northern Basin as a whole, but with a focus on the Condamine–Balonne and Barwon–Darling catchments. The hydrologic modelling work conducted for these two catchments was the subject of the NBR hydrologic modelling report (MDBA 2016a). However, a further subset of model scenarios was completed to investigate the recovery volume for the Macquarie–Castlereagh catchment — the 320 GL recommendation also included a reduction in the Macquarie–Castlereagh recovery from 84 to 71 GL.

This document describes the modelling work underlying the Macquarie–Castlereagh recommendation. It is an addendum to the main NBR modelling report (MDBA 2016a), which describes in detail the underlying models and Basin Plan modelling methodology.

2. A History of the Macquarie–Castlereagh Recovery Volume

The Basin Plan recovery volume recommended by the Authority for the Macquarie–Castlereagh has been refined over recent years in response to ongoing improvement in the underlying evidence base. There has been three phases in setting the recovery volume, described below.

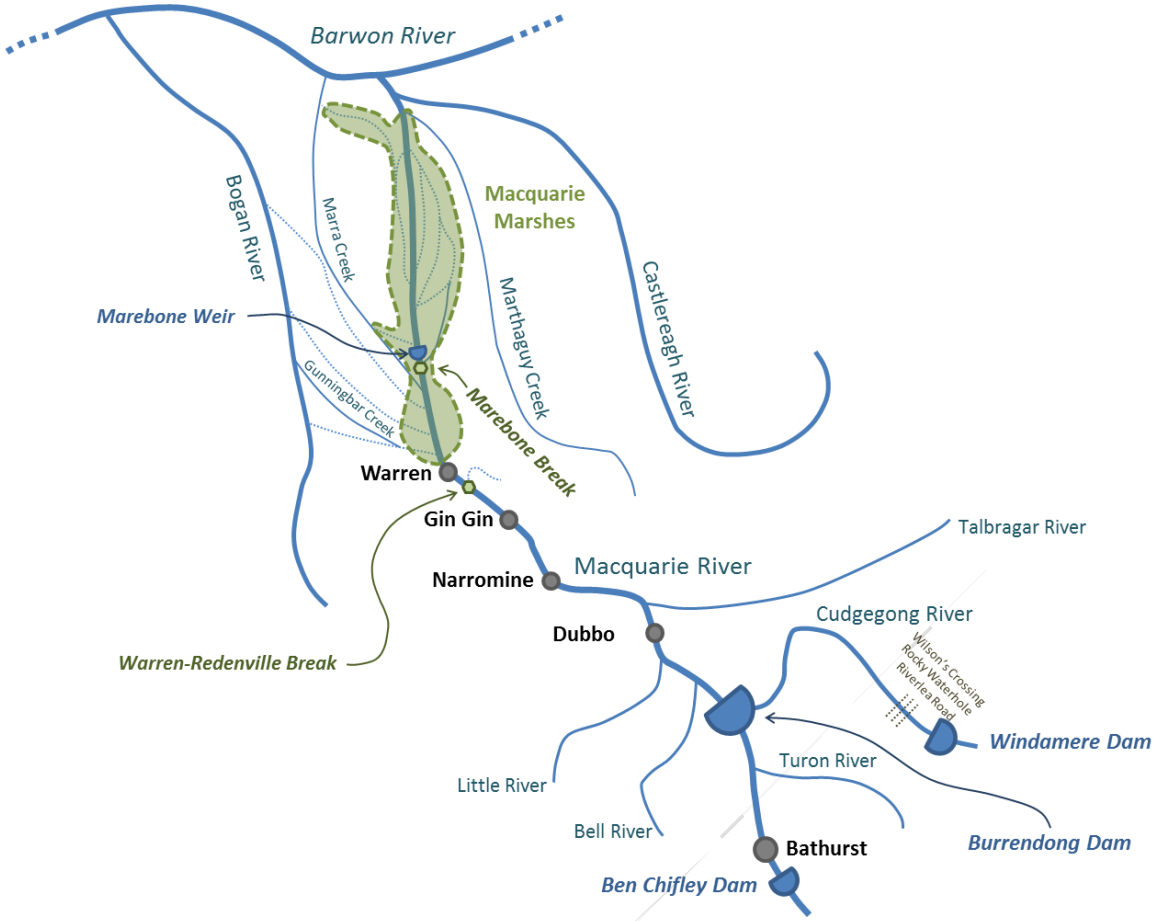

Figure 1: Schematic map of the Macquarie–Castlereagh system showing the main river features, towns, and the location of the Macquarie Marshes

Phase 1 — Guide to the Basin Plan (2010)

MDBA conducted an assessment of end-of-system flows for each catchment across the Basin. This assessment was based on the difference in end-of-system flows under baseline (i.e. 2009; pre-Basin Plan) conditions compared to without development conditions. This first estimate of recovery volume was set as a range, defined to be the recovery required to restore end-of-system flows to between 60% and 80% of without development volumes. This assessment indicated a recovery volume of between 26 and 176 GL for the Macquarie–Castlereagh catchment.

Compiling all catchment-recovery volumes across the Basin provided a total of 3,856 GL. Recognising the uncertainty in this analysis, the Authority initially recommended a Basin-wide recovery volume in the range 3,000 to 4,000 GL — scaling all catchment recoveries down to achieve a total of 3,000 GL provided a lower estimate of 20 GL for the Macquarie–Castlereagh system.

The methodology underlying this estimate contained a number of weaknesses, as was acknowledged by MDBA at the time. Firstly, by assessing only end-of-system flows, the method did not consider the individual water requirements of environmental assets throughout each catchment (i.e. the Macquarie Marshes in this case). Secondly, this approach did not take into account the variation of environmental water requirements throughout the flow regime. For instance, some catchments would require more water dedicated to low flow & riparian outcomes, whereas others would require more water

dedicated towards floodplain outcomes. And finally, this approach did not recognise that some parts of the flow regime (i.e. high flows) cannot be directly influenced through water recovery.

For this reason, MDBA consider these values (20 to 176 GL) to be a first-pass estimate only, since superseded through the use of better information and refined assessment methods.

Phase 2 — Basin Plan Development (2012)

Following the publication of the 2010 Guide-era recovery volume estimates, MDBA further developed the method to assess the environmentally sustainable level of take (the ESLT method; MDBA 2011). This method addressed the weaknesses listed above— namely, it allowed environmental water requirements to be informed by site-specific ecological science (e.g. at the Macquarie Marshes) and to be flow regime-specific.

Under this approach, environmental water requirements are represented through site-specific flow indicators (SFIs). These indicators are used to build a pattern of environmental water use in the models, and are also used to translate flow outcomes into environmental outcomes. The ESLT approach underlies all Basin Plan hydrologic modelling, including the scenarios completed for the Northern Basin Review.

At the time of modelling (2011) 84 GL had already been recovered for the environment under the Basin Plan, hence the first step was to complete a model scenario testing whether this volume satisfied local environmental water requirements. It was found that the SFIs for the Macquarie Marshes were satisfied with this recovery volume, and that the baseflow shortfalls were largely addressed (MDBA 2012). Based partly on this information, but also on other lines of evidence, the Authority in 2012 recommended that no further recovery was required from this catchment.

Phase 3 — Northern Basin Review (2016)

During the Northern Basin Review, public consultation, combined with emerging social and economic information, indicated that water recovery had adversely affected communities in the Macquarie catchment, notably in the regions of Warren and Trangie. This information, combined with the SFI results from the extant Basin Plan scenario, indicated to the Authority that 2012 recommendation was not satisfying the requirements of a triple-bottom line outcome.

As part of the Northern Basin Review, the MDBA had completed a number of whole-of-North model scenarios exploring alternative recovery volumes (MDB 2016a). These scenarios included a variety of spatial recovery patterns across the Northern Basin, comprising Macquarie–Castlereagh recovery volumes in the range 55 to 104 GL (dark blue bars in Figure 2). The Authority requested a closer examination of these scenarios to map the environmental, social and economic outcomes.

MDBA were also notified (by Macquarie Food & Fibre) of a developing breakout at Mumblebone impacting on the regulated flow constraint and therefore leading to uncertainty around the ability of regulated release to help meet SFIs. Hence additional scenarios were modelled to test the impact of this reduced flow constraint level. These ‘Macquarie-only’ model runs included the reduced flow constraint and represented three levels of recovery: 40, 60 and 83 GL (existing recovery), marked yellow in Figure 2.

3. Methodology

The methodology of the Macquarie-only runs was consistent with other NBR scenarios and is described in detail in section 5 of the NBR modelling report. The only difference related to the generation of environmental demands for local outcomes. For the NBR whole-of-north scenarios the flow constraint was set at 4,000 ML/d at Marebone i.e. regulated releases from Burrendong Dam were limited so that flows do not exceed 4,000 ML/d at Marebone. For the three additional Macquarie scenarios this flow constraint was lowered to 3,200 ML/d in line with current operating practices (as of 2015/16). Figure 2 details all the modelled recovery volumes in the Macquarie catchment.

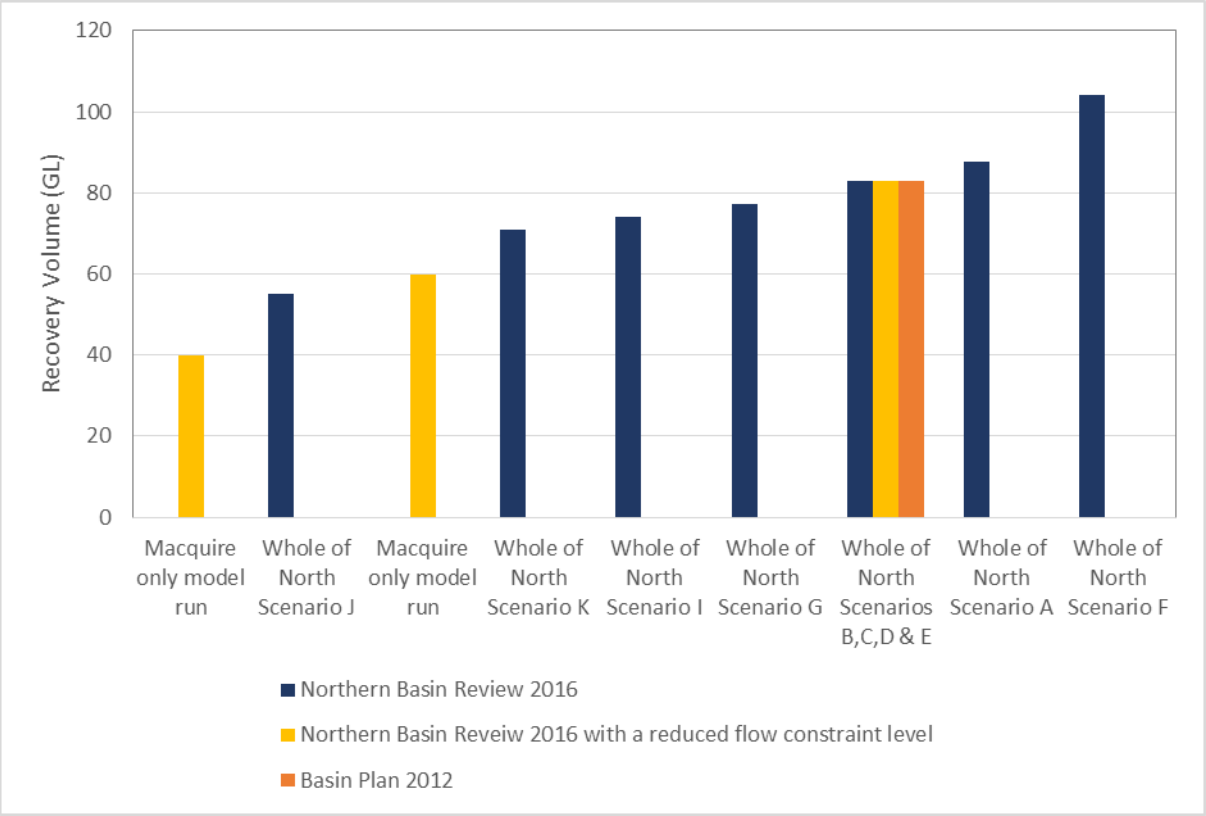

Figure 2: Summary of all modelled recovery volumes in the Macquarie-Castlereagh catchment

4. Results and Discussion

Table 1 and Table 2 detail the SFI results for all Macquarie models runs performed as part of the Northern Basin Review. It can be seen that the volume of water recovery has a much more significant impact on SFI achievement than the reduced flow constraint. This is largely due to the volumetric nature of Macquarie Marsh SFIs i.e. unlike most other SFIs across the Basin, they are not reliant on a specific flow rate for a specific duration, rather they are simply tied to a required volume during a certain time frame.

Table 1 SFI results of Macquarie model scenario with a flow constraint of 4,000 ML/d at Marebone

SFI Parameters						Reference Scenarios		Whole of North Scenarios						
								F	A	B,C,D & E	G	I	K	J
								4000 ML/d flow constraint						
SFI	Volume (GL)	Period (Months)	Season	High Uncertainty	Low Uncertainty	Without Development	Baseline	104 (GL) recovered	87.6 (GL) recovered	83 (GL) recovered	77.2 (GL) recovered	74 (GL) recovered	71 (GL) recovered	55 (GL) recovered
1	100	5	Jun- Apr	80%	85%	91.2%	79.8%	87.7%	86.0%	85.1%	84.2%	85.1%	86.0%	81.6%
2	250	5	Jun- Apr	40%	50%	65.8%	35.1%	53.5%	50.0%	49.1%	50.9%	46.5%	48.3%	45.6%
3	400	7	Jun- Apr	30%	40%	48.2%	27.2%	43.0%	38.6%	40.4%	37.7%	36.8%	34.2%	34.2%
4	700	8	Jun - May	17%	17%	18.4%	16.7%	18.4%	18.4%	18.4%	18.4%	18.4%	17.5%	17.5%

Table 2 SFI results of Macquarie model scenario with a flow constraint of 3,200 ML/d at Marebone

SFI Parameters						Reference Scenarios		Macquarie Only Scenarios		
								3,200 ML/d flow constraint		
SFI	Volume (GL)	Period (Months)	Season	High Uncertainty	Low Uncertainty	Without Development	Baseline	83 (GL) recovered	60 (GL) recovered	40 (GL) recovered
1	100	5	Jun- Apr	80%	85%	91.2%	79.8%	88.6%	86.0%	86.8%
2	250	5	Jun- Apr	40%	50%	65.8%	35.1%	43.0%	41.2%	39.5%
3	400	7	Jun- Apr	30%	40%	48.2%	27.2%	34.2%	30.7%	28.1%
4	700	8	Jun - May	17%	17%	18.4%	16.7%	18.4%	17.5%	16.7%

SFI Achievement Colour Key
Low uncertainty target achieved
High uncertainty target achieved
Target not achieved

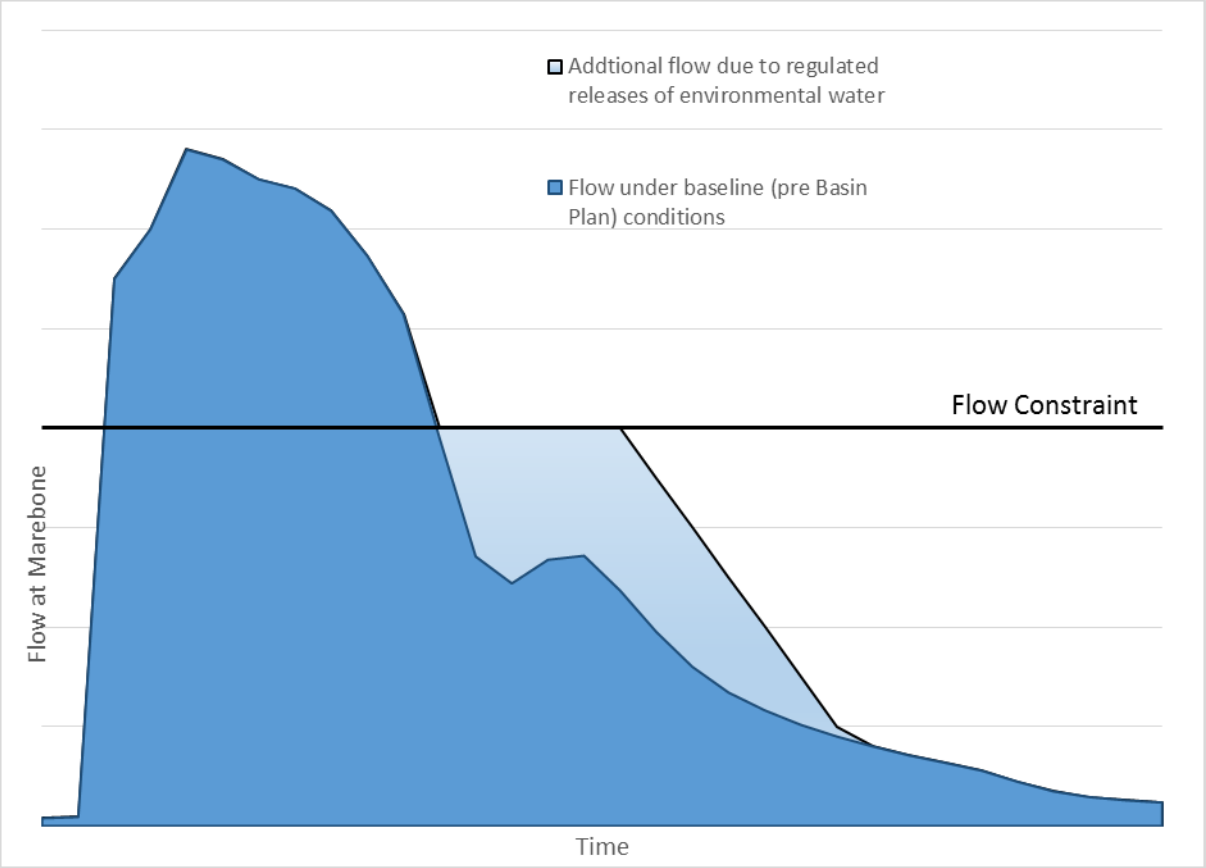

Figure 3 Stylised hydrograph of SFI delivery in the Macquarie Marshes

Figure 3 shows a stylised representation at SFI event delivery in the Macquarie marshes. The required volumes are not made up entirely of environmental water, rather environmental water deliveries are used to supplement existing unregulated flows to ensure the required volume thresholds are met. Reducing the flow constraint simply adds to the required duration of regulated environmental water releases. There is only one instance across the historical climate sequence where reducing the flow constraint at Marebone resulted in a previously deliverable SFI event transforming into an undeliverable as the event can no longer be delivered within the required seasonality parameters.

5. Conclusion

Flow Constraint

Based on the Macquarie-only scenarios, reducing the flow constraint at Marebone from 4,000 to 3,200 ML/d has had a minimal impact on the ability of regulated releases to meet SFIs in the Macquarie model.

Latest information suggests that the Mumblebone operational constraint may continue to change in response to channel morphology changes. Local river operators may therefore be required to alter operational decisions, and this could impact the delivery of environmental water in this system. However, Basin Plan modelling indicates that unless this constraint

undergoes significant additional change, the desired environmental outcomes can be achieved.

Recovery Volume

An examination of Table 1 and Table 2 indicates that the SFIs can be achieved with a recovery volume of 55 GL (and greater), but are no longer achieved with a recovery of 40 GL.

As described in section 5 of the NBR hydrologic modelling report (MDBA 2016), environmental watering is represented in Basin Plan model scenarios through the use of demand series. These demand series request environmental water to be released from storage in a specific pattern to meet the Macquarie Marshes SFIs. If the recovery volume is reduced, the number of SFI-based releases that can be requested are similarly reduced.

A sensitivity analysis of the demand series indicated that the number of available events rapidly decreased when the recovery volume was reduced below 55 GL. Furthermore, the SFI results in Table 1 and Table 2 contain inherent uncertainty — the SFIs are indicators of the environmental outcomes that can be achieved with water recovered for the environment, they are not a point of truth. Furthermore, the modelling represents one possible method for delivering environmental water, but in practice environmental water managers will make decisions that are informed by better local information, but are also subject to operational conditions that can only be partially represented in a model.

An examination of the ecological science underlying the SFIs, combined with feedback from local environmental water managers in the Macquarie catchment, indicated that further reducing the recovery volume below 55 GL would introduce an untenable level of risk for the environmental outcomes desired by the Basin Plan.

Based on this information and the associated social and economic analysis for these scenarios, the Authority recommended that the 65 GL local recovery volume set in 2012 be reduced to 55 GL.

6. References

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MDBA (2016a) Hydrologic Modelling for the Northern Basin Review

MDBA (2016b) Environmental Outcomes of the Northern Basin Review

MDBA (2016c) Northern Basin Review - Technical overview of the socioeconomic analysis, MDBA publication no: 40/16

MDBA (2016d) The triple-bottom line framework: A method for assessing the, economic, social and environmental outcomes of sustainable diversion limits for the northern basin