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MURRAY–DARLING BASIN AUTHORITY

Determining the Namoi Sustainable Diversion Limit

Northern Basin Review Supplementary report

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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, the Northern Basin Aboriginal 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.

Contents

Introduction

The *Water Act 2007* (Cwlth) established the Murray–Darling Basin Authority (MDBA) and tasked it with preparing a Basin Plan to provide for the integrated management of the water resources of the Murray–Darling Basin. The Basin Plan includes the objective to protect and restore water-dependent ecosystems and functions with the aim of achieving a healthy working Murray–Darling Basin.

For this purpose, the Basin Plan sets limits on the amount of water that can be extracted for consumptive use. These sustainable diversion limits (SDLs) are the maximum long–term annual average quantities of water that can be taken from the basin and reflect an Environmentally Sustainable Level of Take (ESLT).

When the Basin Plan received bipartisan support in 2012, there was recognition that the knowledge about the northern basin and its specific requirements could be improved. MDBA, with the support of Basin Governments, committed to a review of the targets in the north. From 2013–16, MDBA conducted the Northern Basin Review to check if the targets set for water recovery in northern basin catchments were appropriate.

The amount of information collected during the review was immense. MDBA invested in a large body of additional scientific work to better map the relationships between water recovery and flow, and consequently between flow and the social, economic, cultural and environmental condition of the basin. MDBA also completed a large engagement program with the community to ensure that the review included the lived experience of people with their local river.

The overall finding of the review was to recommend reduced water recovery across the Northern Basin, changing from 390 to 320 GL (MDBA 2016). Furthermore, based on the extensive body of work collected during the review, it was also recommended that Basin governments invest in a series of ‘toolkit measures’ to improve water management practices and the overall outcomes achieved by the Basin Plan.

Namoi SDL — 2012 to 2017

The Basin Plan in 2012 recommended 10 GL of recovery was required in the Namoi catchment to meet local requirements, plus an additional 19 GL to meet the Namoi share of the downstream recovery component.

The original 10 GL local recovery volume recommended in 2012 was based on a single model scenario and some post-processing analysis (MDBA 2012a). MDBA therefore identified that the Namoi SDL required further testing, for which a comprehensive suite of model scenarios was completed as part of the Northern Basin Review. This work found that achieving the outcomes desired by the Basin Plan was not operationally feasible with only 10 GL of recovered water. This volume did not include the day-to-day complexities of water delivery, such as channel sharing arrangements, entitlement conditions, and delivery losses associated with sending in-channel flows through the system and to the Lower Namoi.

The modelling completed for the review allowed MDBA to examine the ability of environmental water managers to achieve the desired outcomes when they are subject to the same entitlement conditions as all other users in the system. This work, combined with the existing environmental science, found that the outcomes could only be achieved if the local recovery volume was increased to 20 GL.

MDBA analysis of the Namoi showed that the refined target of 20 GL would deliver marked improvement in river, floodplain and wetland connectivity and health. The Authority was conscious of the impact of water recovery when setting the local recovery target — the anticipated effects of this recovery on businesses and communities are described in the Northern Basin Review report (MDBA 2016) and the supporting social and economic reports referenced therein. Hence the MDBA also recommended that the Namoi need not contribute water downstream for the shared reduction amount, and the total recovery in this system would be limited to 20 GL.

Ecological and Modelling Evidence for the SDL

Both the 2012 and 2017 SDLs were based on the same ESLT method (MDBA 2011), however the 2017 recommendation is based on a significantly expanded knowledge base gathered through the Northern Basin Review. This included a review of the environmental science, a substantially expanded set of model scenarios, and detailed social and economic analyses.

An overview of the ESLT method is shown in Figure 1. Under this approach, available science is used to define the environmental water requirements of a river system, and the ability to meet these requirements is tested through the hydrologic modelling framework. Environmental water requirements are represented through site-specific flow indicators (SFIs), which effectively act as a translation matrix between flow and environmental outcome.

Ecological Science

The environmental water requirements for the Namoi are captured in three SFIs, listed in Table 1. The Namoi SFIs were defined in 2010–12 and are described in the accompanying report (MDBA 2012b). The information base underlying these SFIs is broad and complex. They are not targeted to a single aspect of the riverine ecology, instead they seek to capture all aspects, including:

- ecosystem functions (such as nutrient cycling) which underlie an effective food web;
- inundation requirements of riparian and floodplain vegetation;
- life cycle requirements of fish, birds and other aquatic species; and
- the need for a healthy Namoi River to regularly connect downstream to the Barwon–Darling River.

As part of the Northern Basin Review, MDBA invested in a set of new environmental science work, targeted to the Condamine–Balonne and Barwon–Darling catchments. As assessment of this work indicated that the basis for the Namoi SFIs remained relevant and fit-for-purpose for the ESLT, no additional environmental science for this catchment was undertaken throughout the review. Effort was instead concentrated on testing different recovery options through the hydrologic modelling framework.

Table 1: Summary of the Namoi site-specific flow indicators (from MDBA 2012b)

Flow event - threshold, duration, season (as gauged on the Namoi River at Bugilbone)	Proportion of years with a successful event		
	Target	Without Development	Baseline
500 ML/Day for a total duration of 75 days (with a minimum duration of 25 consecutive days) between Jul and Jun	41–55%	69%	33%
1800 ML/Day for a total duration of 60 days (with a minimum duration of 6 consecutive days) between Jul and Jun	29–39%	49%	30%
4000 ML/Day for a total duration of 45 days (with a minimum duration of 7 consecutive days) between Jul and Jun	22–25%	32%	16%

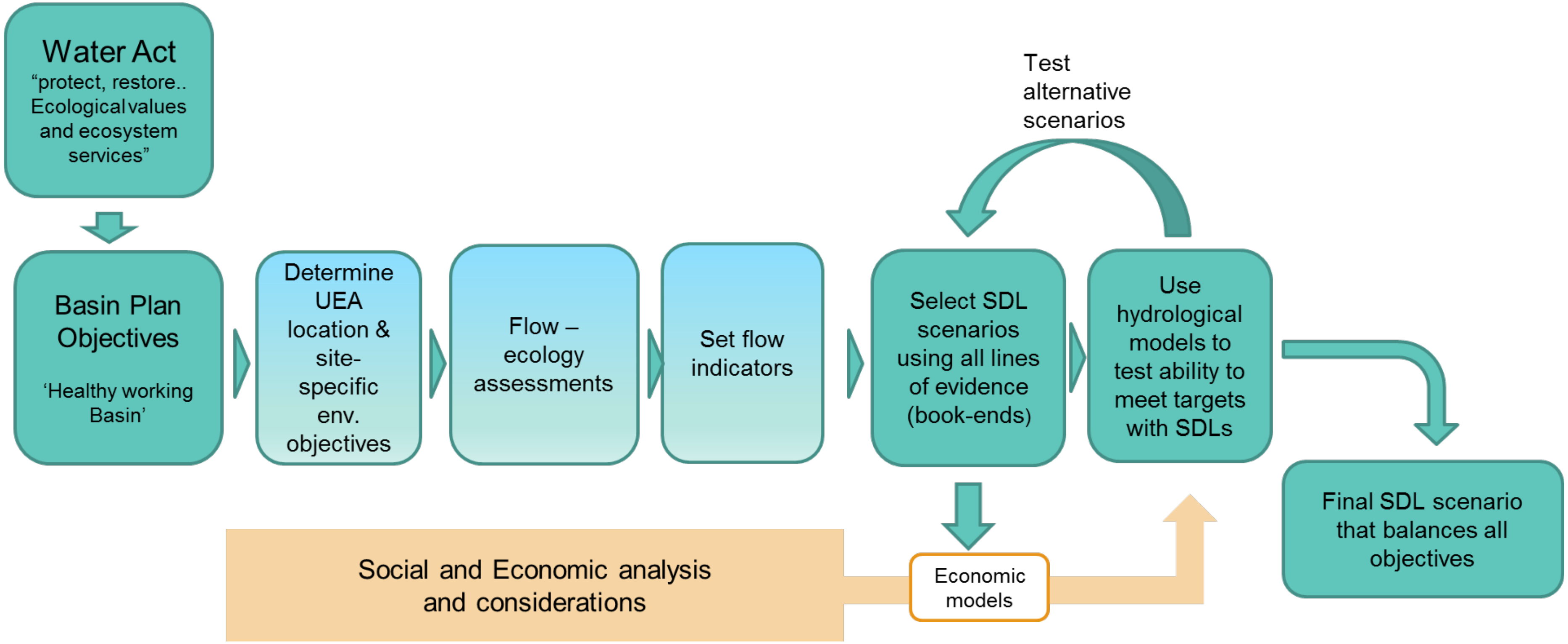

Figure 1: Overview of the ESLT method

Table 2: Namoi site-specific flow indicator results from NBR modelling

Flow event — threshold, duration, season (as gauged on the Namoi River at Bugilbone)	Proportion of years with a successful event						
	Target	Without Development	Baseline (0 GL)	Scenario D (13 GL)	Scenario K (20 GL)	Scenario B (24 GL)	Scenario A (28 GL)
500 ML/Day for a total duration of 75 days (with a minimum duration of 25 consecutive days) between Jul and Jun	41–55%	69%	33%	40%	45%	46%	45%
1800 ML/Day for a total duration of 60 days (with a minimum duration of 6 consecutive days) between Jul and Jun	29–39%	49%	30%	32%	32%	32%	32%
4000 ML/Day for a total duration of 45 days (with a minimum duration of 7 consecutive days) between Jul and Jun	22–25%	32%	16%	19%	22%	22%	22%

Baseline result and target not met
Improvement from baseline, but target not met
High uncertainty target met
Low uncertainty target me

Model Scenarios

As part of the Northern Basin Review, MDBA completed a large set of model scenarios exploring different water recovery options and alternative approaches to managing environmental water across the Northern Basin. The method underlying these scenarios, and the results and analysis are described in the NBR modelling report (MDBA 2017).

The completion of each model scenario followed the same overall process: recover a volume of water for the environment, and then release this water for environmental needs. Environmental outcomes were assessed using the SFIs and other hydrologic analyses related to cease-to-flow periods, dry spells, and whole-of-flow regime comparisons.

Basin Plan modelling includes a standard approach to represent environmental water use, and a full description of the method can be found in the modelling report (section 5.2 in MDBA 2017). In summary, the modelled environmental watering strategy reflects the general approach adopted by environmental water holders in reality — during dry periods, the water holder will concentrate on delivering baseflows and low flows to maintain resilience in the ecosystem, while during wetter periods the water holder will enhance environmental outcomes by supplementing existing flows with additional releases to achieve in-channel freshes, bankfull or overbank events.

Translating these general principles into a detailed day-by-day environmental watering pattern required a set of assumptions about future behaviour, and these assumptions can be found in the modelling report. For the Namoi model, environmental water was used in most years to achieve baseflow and low flow outcomes, and additional water was delivered towards SFI flows only when conditions allowed (i.e. about two or three times per decade).

Under specific conditions, any remaining environmental water was used to enhance the connection between the Namoi and the rest of the Northern Basin by passing additional flow downstream to the Barwon–Darling River. Achieving whole-of-Basin river connectivity is a key requirement of the Basin Plan, as it improves water quality, passes nutrients through the system, and allows fish to migrate (e.g. from the Barwon–Darling River upstream into the Namoi).

Five Namoi scenarios were completed representing water recovery volumes of 0, 13, 20, 24 and 28 GL. Water balance and SFI results for these scenarios can be found in the modelling report (MDBA 2017). A summary of the SFI results is given in Table 2 (a more detailed breakdown can be found in Appendix A of MDBA 2017).

An examination of Table 2 indicates a step change occurs between 13 and 20 GL recovery[1], such that the frequency requirements for the 500 and 4000 ML/d flow indicators are satisfied with the higher recovery volume. Further examination of the results indicated that the primary driver for the step change was the 4000 ML/d flow indicator. At this flow level, water passes into some of the anabranches and creeks in the Lower Namoi, inundating riparian and low-level floodplain vegetation

[1] This table also indicates that recovery volumes greater than 20 GL would not provide additional environmental flows, however this is because no additional SFI events were requested in these higher volume scenarios — instead, water recovered beyond 20 GL was targeted towards downstream connectivity and assisting with environmental outcomes in the Barwon–Darling.

and washing nutrients back into the river system, hence achieving this flow is important for achieving the ecological outcomes desired by the Basin Plan. Under baseline (i.e. pre-Basin Plan) conditions these events occurred in 16% of years — that is, during wet years when unregulated flows are passing through the Lower Namoi. With 20 GL recovery, the modelling found that environmental water delivery could supplement flows in other years and increase this value to 22% (i.e. the lower end of the desired frequency range).

Sensitivity Testing

Further sensitivity analysis of modelling results was conducted to more precisely isolate the recovery volume required to achieve the 4000 ML/d SFI, and hence better inform the Authority's decision-making process regarding the Namoi SDL.

As with all entitlement holders, the environmental water holder is bound by the entitlement framework in which individual allocation is based on entitlement volume, carryover, and water availability. These conditions are also reflected in the model, hence increasing the recovery volume gives the modelled entitlement water holder greater scope to influence flow. This relationship is demonstrated graphically for the 4000 ML/d event in Figure 2. Satisfying the target frequency requires seven additional events over the 114-year modelled time period — five events can be added with 19 GL recovery, seven with 20 GL recovery.

This 19-to-20 GL result was a strong indicator that 20 GL recovery represented a genuine step change for achieving the ecological outcomes desired by the Basin Plan.

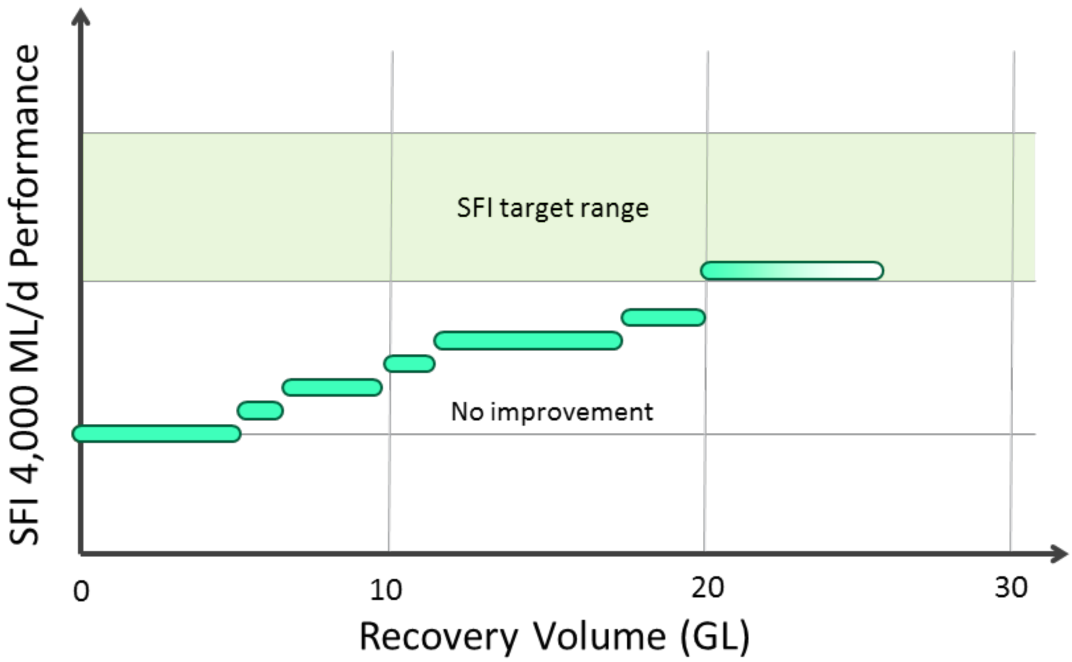

Figure 2: Ability to deliver 4000 ML/d SFI events as a function of recovery volume

As described in the modelling reports (MDBA 2012, 2017), adding events to the modelled environmental release pattern is achieved through the environmental event selection tool. This tool inherently includes an element of foresight, such that the modelled operator is able to accurately predict flows in the days ahead and release environmental water accordingly. However, the model inherently accounts for this foresight by adding uncertainty to the release pattern. Furthermore, river operators are continuing to invest in forecast technology to better predict how a flow pulse will travel down a regulated river system. This effect of this foresight on the chosen SDL is therefore considered to be negligible.

The distribution of the added events over the 114-year time period is displayed in Figure 3 for the 20 GL recovery scenario. The green/orange events were added through environmental watering; the blue events were already present in the baseline model. The numbers at the top of the graph show the recovery volume required to include each event in the demand time series.

This graph demonstrates that some of the added events break lengthy dry periods, specifically those delivered with 10, 11, 18 and 20 GL of recovery. Breaking these periods is important for maintaining the health of riparian and flood-dependent vegetation in the Lower Namoi (MDBA 2012b).

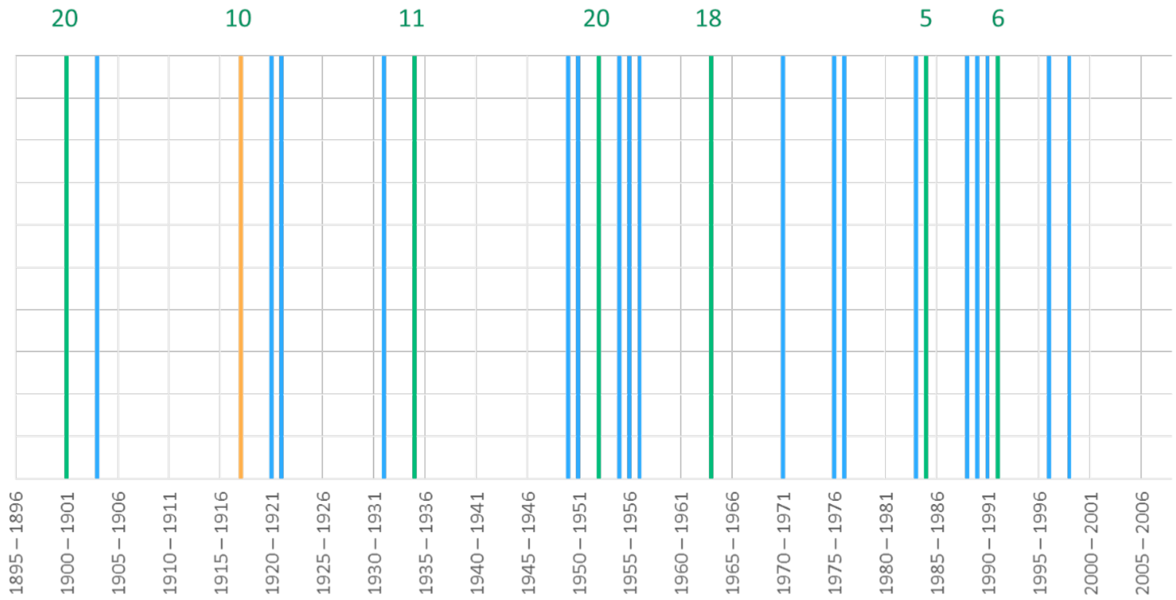

Figure 3: 4000 ML/d SFI events distributed over the 114-year modelling time period. Blue events were already present in the baseline model (i.e. unregulated flow events in wet years); green and orange events were added by environmental water in the 20 GL recovery scenario. The numbers at the top refer to the recovery volume required to request each event.

MDBA have also investigated the sensitivity of SFI results to the designated threshold of 4000 ML/d. As stated in the EWR report (MDBA 2012b), the analysis by Foster (1999) indicated that the anabranches along the Lower Namoi are inundated at flows between 3300 and 4500 ML/d. Based partly on this information, but also on other sources, MDBA determined that a flow of 4000 ML/d is likely to meet the requirements of key water dependent vegetation communities.

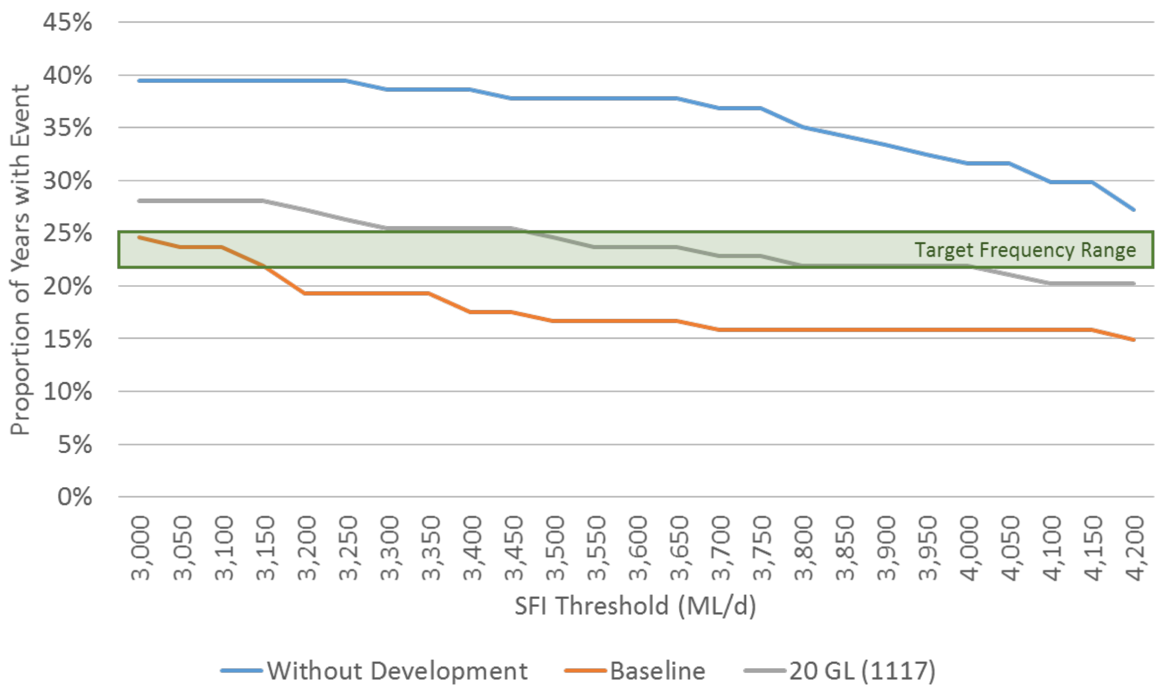

Figure 4: Sensitivity testing of flow indicator results against threshold. All other aspects of the 4000 ML/d SFI have been held constant.

Figure 4 shows the dependency of flow indicator results on the nominated threshold. The results are shown for without development, baseline and the 20 GL recovery scenario. In this analysis, all SFI criteria have been held constant except for the flow threshold.

Variability in channel features along the river will mean that for some sections, less than 4000 ML/day will lead to inundation of vegetation communities. These sections will be inundated more frequently than those with higher benches and bankfull channel features. However, it is important to note that the desired frequency of inundation is partly set by the without development scenario (MDBA 2012b). Hence, if alternative information indicated that a threshold less than 4000 ML/d would deliver the desired ecological outcomes, the SFI target frequency range shown in Figure 4 would adjust in response to the new flow threshold.

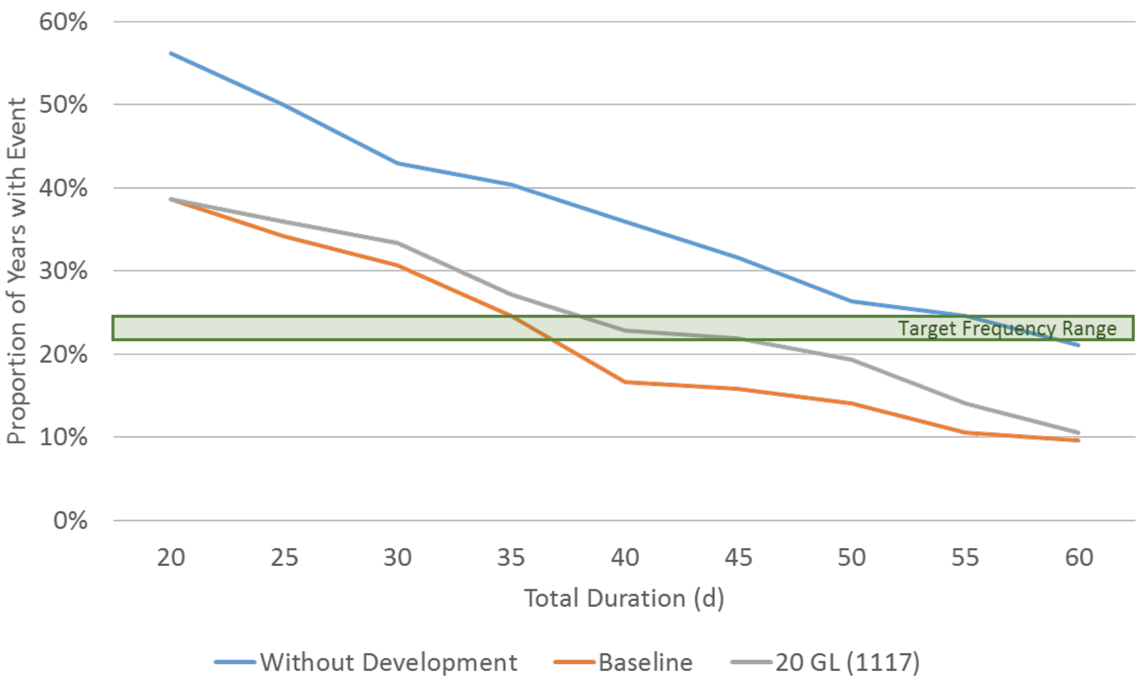

Figure 5: Sensitivity testing of the flow indicator results against duration. All other aspects of the 4000 ML/d SFI have been held constant.

A further sensitivity analysis was conducted to investigate the relationship between event duration and frequency, shown in Figure 5. Changing the duration would have significant effects on the achieved frequency of events. As described in MDBA (2012b), the 45 day period is based on flood duration requirements for native vegetation in the Lower Namoi. Furthermore, similar to the threshold sensitivity above, if new information suggested a shorter duration was required, then the target frequency would adjust in response to the without development result — that is, the green bar moves up or down depending on the desired duration.

Managing Uncertainty

Science inherently contains uncertainty. The determination of the ESLT and setting of SDLs was an evidence-based process incorporating the best available science and knowledge, but MDBA has always acknowledged that the evidence base contains some uncertainty.

MDBA's approach to this issue has been twofold. Firstly, the process used to define the long-term, macro-scale settings (such as SDLs) in the Basin Plan systematically includes uncertainty as a consideration. Secondly, the Basin Plan has been designed such that on-ground implementation can adapt as new knowledge comes forward. Examples of this adaptive management approach include the environmental watering plan and water resource plan processes, described respectively in Chapters 8 and 10 of the Basin Plan.

Regarding the setting of SDLs, section 10 of the ESLT report (MDBA 2011) contains an extensive discussion of the uncertainties related to environmental water requirements and modelling, and how these have been considered in the decision-making process. The Northern Basin Review report (MDBA 2016) also discusses the decision-making framework, specifically how multiple lines of evidence were combined to mitigate uncertainty. A good example of this uncertainty mitigation approach was the inclusion of toolkit measures in the final recommendation — these measures are generally targeted towards those issues for which the available scientific information may be uncertain, but experience-based feedback from the community and experts indicated action was required.

The ecological and hydrological analysis techniques developed for the Basin Plan implicitly include uncertainty. The Namoi EWR report (MDBA 2012b) describes the ecological uncertainties specific to this catchment, however the method for dealing with these uncertainties was adopted consistently for all Basin-wide SFIs — the desired frequency is defined as a range rather than a simple (and deceptively certain) target. The lower end of this range relates to a threshold below which there is expected to be a loss of health or resilience of ecological communities, or the inability of species to reproduce frequently enough to sustain populations. The upper end relates to a high likelihood that the environmental objectives and targets will be achieved.

Basin Plan modelling indicates that the Namoi SDL corresponds to the lower end of this frequency range for all SFIs (Table 2).

Furthermore, as described in Section 5 of the Basin Plan Hydrologic Modelling report (MDBA 2012a), events delivered by environmental water in the model have a 10% allowance in both duration and flow threshold to be considered successful. The purpose of this allowance is to recognise that the model has uncertainty when delivering flows that, if delivered in reality, would likely be addressed through dynamic river operator responses to monitored flow condition.

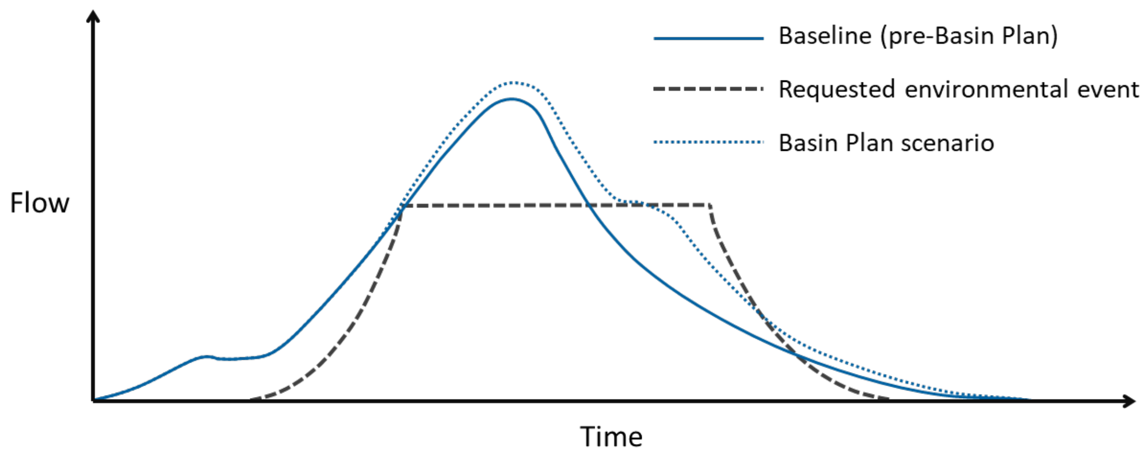

Figure 6: Example of a model response to a demand series. The dashed line traces a desired environmental event, the dotted line is the model attempting to deliver the event. In this case, the Basin Plan event is deemed 'successful' through a 10% allowance.

This allowance is demonstrated graphically in Figure 6. The solid line represents the flow prior to the Basin Plan, the dashed line is the desired environmental event to be met through additional storage releases, and the dotted line is the resulting flow. In this case, even though the dotted line has not fully met the desired flow, it is considered a successful event.

For the Namoi 20 GL scenario, the orange event shown in Figure 3 was considered successful as a result of the 10% allowance; the green events were successful without requiring a 10% allowance.

Conclusions

The Northern Basin Review allowed MDBA to re-examine the 2012 Basin Plan settings incorporating new information and knowledge. For the Namoi system, the additional modelling indicated that achieving the desired environmental outcomes was not feasible with only 10 GL of water recovery, and that a volume of 20 GL was instead required. Further analysis of the modelling results indicated that this 20 GL threshold represented a genuine step change in achievable environmental outcomes, especially those associated with in-channel fresh and anabranch connection flow events.

The ESLT approach implicitly includes uncertainty in environmental science (SFI frequency range) and the hydrologic modelling approach (10% allowance in SFI criteria). The inclusion of this uncertainty acknowledges that on-ground implementation is likely to provide outcomes better than could be represented through the modelling framework as river operators and environmental water holders learn and improve their ability to respond to prevailing flow and climatic conditions.

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