HEALTHY FLOODPLAINS

Modelled downstream effects of licensing floodplain harvesting in the NSW Border Rivers Valley

Report

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Executive summary

This report quantifies the potential downstream impacts of implementing the *NSW Floodplain Harvesting Policy*.

The *NSW Floodplain Harvesting Policy* establishes a framework for licensing floodplain harvesting activities and managing of diversions in a way that brings them back within statutory limits. The licensing framework will restrict the volume of water that can be taken from the floodplain providing gains to the system through foregone diversion.

Any gains in upstream systems such as the NSW Border-Rivers (which provides on average 18% of Barwon-Darling inflows) may translate into the downstream with additional volumes originating in each of the Barwon-Darling tributary valleys contributing to connectivity between the broader northern basin system and provision of increased flows towards Menindee and into the Murray.

Modelling indicates that implementation of the Policy within the NSW Border Rivers will result in a 5.5 GL reduction in average annual floodplain harvesting diversions. This average result is not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet conditions to create overland flows. In the wettest year on record (1955) up to 110 GL of foregone diversions or 20 times the average was produced due to Policy implementation. In drier years there is very little to no floodplain harvesting.

These foregone diversions travel across the floodplain before re-entering rivers and creeks providing additional inflows to the system. The 5.5 GL of average annual foregone diversion may increase Barwon-Darling inflows by up to 1.0%. These flows attenuate, reducing in volume as they travel through the system towards the southern basin with an increase in flows of up to 0.2% at Wilcannia.

This additional volume is potentially available for extraction, contributing to water availability for downstream communities, town water supply, stock and domestic users, and irrigators. The downstream effects assessment indicates that implementing the Policy in the NSW Border Rivers alone has a very minor positive impact on water availability for licence holders in the Barwon-Darling.

The NSW Border Rivers is however the smallest valley where the Policy is being implemented. Assessing the impacts of Policy implementation should not be reliant on this Valley alone. Subsequent reports that catalogue the impact of Policy implementation in the Gwydir, Namoi, Macquarie and Barwon-Darling valleys will be made available in early 2021. Each valley will be looked at individually with additional analysis of the cumulative impact across the entire northern basin.

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1 Introduction

The *NSW Floodplain Harvesting Policy* (hereinafter called the policy) establishes a framework for the assessment and determination of floodplain harvesting water access licences. Floodplain harvesting licences define the volume of water that users can legally harvest from floodplains. Bringing floodplain harvesting into the water licensing system will enable management of diversions within the long-term average annual extraction limit (LTAAEL) and sustainable diversion limit (SDL) established in *NSW Water Sharing Plans* for each Valley.

The policy was introduced in 2013 and is now being implemented across five river valleys in the northern Murray-Darling Basin.

Floodplain harvesting estimates for each river valley are being updated and modelling shows that implementation of the policy will result in a reduction in the volume of floodplain water diverted into storages. These foregone diversions will remain in the system, travelling across the floodplain, with some of the water returning to the river. These upstream gains may translate into the downstream with additional volumes originating in the Barwon-Darling tributary valleys contributing to connectivity between the broader northern basin system and provision of increased flows towards Menindee and into the Murray.

An estimate of the volumes of water returned to the system through these foregone diversions in the Border Rivers Valley regulated river system is displayed in Figure 1 which shows the modelled change in annual volumes of water diverted, with and without the policy, over a 40-year modelling period. The water returned to the system due to policy implementation is the foregone diversion and in the left hand side of Figure 1 this water is identified by cross-hatching.

Figure 1 also shows the modelled with and without policy daily flows from the NSW Border Rivers regulated river system into the Barwon-Darling for the year 1978 as an illustration of the connection between the annual diversion volume and daily flow.

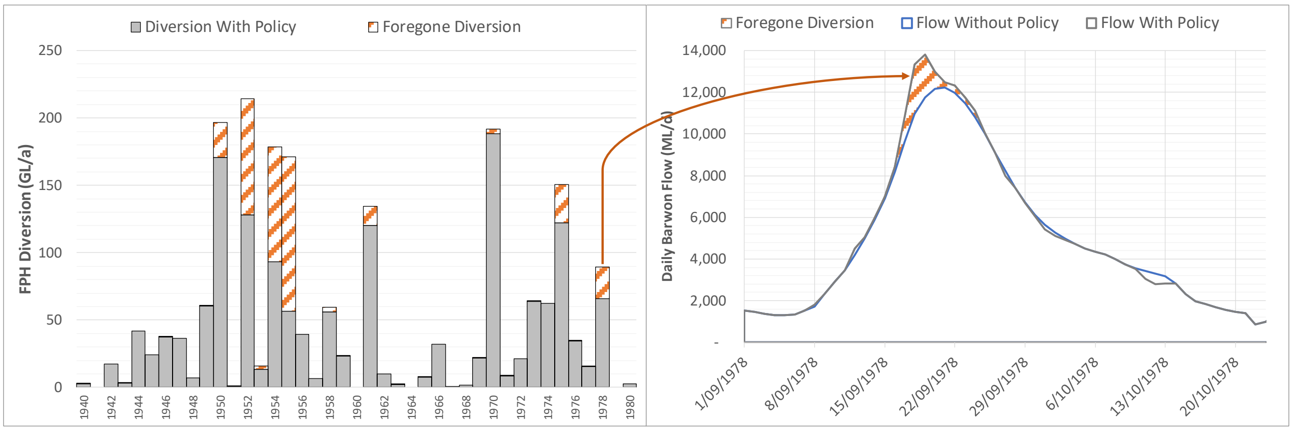

Figure 1 Modelled volumes of water (GL) returned under implementation of the policy in the NSW Border Rivers. The chart on the left shows the modelled annual floodplain harvesting diversion and the reduced diversion volumes with the policy implemented over the 40-year (1940 to 1980) simulation period. The plot on the right shows the modelled without and with policy daily flow from the NSW Border Rivers into the Barwon-Darling over the months of September and October in the 1978 water year, to illustrate when the policy has most effect, in this example on the rising hydrograph

1.1 Report purpose and structure

This report aims to provide an initial understanding of the impact on downstream water availability of reductions in upstream floodplain harvesting diversions under the policy. The impact is associated with implementation in an individual valley, in this case in the regulated river system of the Border Rivers Valley. The cumulative effect of implementation across the five northern valleys will be explored when data is available for all valleys.

Chapter 2 overviews the *Floodplain Harvesting Policy* and the river system modelling that has been undertaken to support the assessment of floodplain harvesting entitlements. It describes the current situation where water diverted from the rivers through floodplain harvesting exceeds statutory limits, setting the context for Chapter 3.

Chapter 3 presents the results of modelling the downstream impacts of implementing the policy within the NSW Border Rivers Valley. Annual average volumes and peak volumes returned to system are investigated along with their impact on access for licence holders in the downstream Barwon-Darling. This chapter includes an overview of the modelling approach adopted to produce these results.

Additional data, for example diversions disaggregated by licence type, are included in appendices.

Formatting conventions

The report uses several formatting conventions to improve the accessibility of the text for reading software. Capitalisation is used to identify the names of model scenarios, for example Current Conditions Scenario. Standard italics identify legislation, plans, document titles and direct quotes. **Bold** text is used to highlight key terms and metrics, for example **planted areas**, as an aid for the reader to navigate through the text.

1.2 Companion reports

This report describes the downstream effects of implementing the policy.

The building of the river system model which provides the data for assessing entitlements is described in the companion report *Building the river system model for the Border Rivers Valley regulated river system* (Department of Planning, Industry and Environment Water 2020a).

How the model has been used to update the *Water Sharing Plan* limit and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in the companion report *Floodplain Harvesting Entitlements for NSW Border Rivers Regulated River System: Model Scenarios* (Department of Planning, Industry and Environment Water 2020b).

The use of the model results for predicting potential environmental outcomes is described in the companion report *Environmental outcomes of implementing the Floodplain Harvesting Policy in the Border Rivers Valley* (Department of Planning, Industry and Environment Water 2020c).

These reports together serve to describe how the modelling meets the objectives of the *NSW Floodplain Harvesting Policy*.

2 Background

2.1 Floodplain harvesting policy

In 2013, the NSW Government introduced the *NSW Floodplain Harvesting Policy*. The purpose of the policy is to manage floodplain water diversions more effectively in order to protect the environment and the reliability of water supply for downstream water users whilst ensuring compliance with the requirements of the *Water Management Act 2000*. The policy also aligns with the objectives of the *National Water Initiative*, an intergovernmental commitment made by the Council of Australian Governments in 2004 to increase the efficiency of Australia's water use.

The policy aims to bring floodplain harvesting under the traditional licensing framework, issuing landholders with water access licences and water supply works approvals. The licensing framework is being rolled out in the designated floodplains of five northern inland NSW valleys; the Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling. Full policy implementation is scheduled for completion by 1 July 2021.

2.2 Modelling floodplain harvesting

Water management in NSW (and globally) relies on (numerical simulation) models to provide robust and reliable estimates of what water is available, how much is needed, and how the resource can be equitably shared. NSW Department of Planning, Industry and Environment Water manages the river system models that have been developed for this purpose. A model exists for each of the regulated valleys in NSW. These models were developed to support water management and planning processes and they represent the current best understanding of catchment climate, hydrological and water use behaviours.

Floodplain harvesting simulations extend these models with a hydrological representation of the capture, diversion, storage and use of floodplain water. This representation is based on real-world information collected and collated in association with the floodplain harvesting licence determination process and calibrated flow and irrigator behaviours.

The models used by the department have been designed to support contemporary water management decisions, whether it is a rule change in a valley's *Water Sharing Plan*, or estimating long term average water balances for components such as diversions for compliance purposes. They are now being upgraded to be used to determine volumetric entitlements for floodplain harvesting and to test the impact of changes within the regulated river system.

Changes to long-term climate output or the addition of new rules for example, are used as an input into the model which then projects the outcome of those changes over an extended period. Upstream models are also connected to their downstream counterparts. These connections allow us to assess any downstream impacts of changes in one or more valleys.

The rule changes and licensing framework associated with implementation of the policy have been incorporated into the river system models for the five northern valleys. This allows comparison between the without and with policy implementation world including assessment of any change at local or regional scale.

2.3 Floodplain harvesting within statutory limits

Water taken from water sources in NSW must comply with the lesser of two statutory limits:

- long-term average annual extraction limit
- sustainable diversion limit.

These limits are described in the following sub-sections.

2.3.1 Long term average annual extraction limit (Plan limit)

The long-term average annual extraction limit (LTAAEL) is a term used in NSW water sharing plans to define the limit of water that can be taken for all purposes (including domestic and stock, urban, industrial, agricultural use and held environmental water) from each water source.

The setting of the LTAAEL restricts the overall take of water in a water source to a defined volume and constrains growth to that maximum. Water in excess of the LTAAEL is reserved for the environment and is called Planned Environmental Water[1].

Rules to assess compliance with the LTAAEL are set out in each valley's *Water Sharing Plan*, and the LTAAEL is called the Plan Limit. Assessing compliance involves calculating the average of annual extractions over a specified period. In those cases where the Plan Limit is exceeded, the Minister for Water will reduce the quantity of water than can be taken by lower priority licences in accordance with established rules.

2.3.2 Sustainable diversion limit

The sustainable diversion limit (SDL) is a term used in the Commonwealth's *Basin Plan* to define limits on total extractions for human uses from a surface water source or a group of surface water sources in the Basin. Each of the 29 river catchments and 80 groundwater areas in NSW has their own limit.

Compliance to a SDL is based on the concepts of actual and permitted take:

- **actual take** – the annual actual take is the volume of water extracted during a water year from a water source
- **permitted take** – the permitted annual take is the volume of water that is allowed to be extracted during a water year from a water source.

The difference between these two volumes is recorded on a register of take as a debit (when actual take is greater than permitted take) or a credit (when actual take is less than permitted take).

Over time, a cumulative balance accrues based on each year's credit or debit. For the first ten years of the water resource plan, if the cumulative balance reaches a debit of 20% or more of the SDL for that resource, then it is non-compliant. A reasonable excuse provision may apply in the case of non-compliance.

2.3.3 Floodplain harvesting currently in exceedance of statutory limits

Currently floodplain harvesting occurs outside an established licensing framework. This means that water can be diverted from the floodplain without volumetric limitation. Modelling indicates that over the last two decades floodplain harvesting has grown above statutory limits and it is anticipated this will be the case for the 2020/21 water year.

The river system models that are used to assess Plan Limit compliance consider all water diverted from the water source, including water diverted from the floodplain. The setting of these models to describe and assess Plan Limit compliance is managed through the creation of model scenarios. Plan Limit Compliance Scenarios have been or are in the process of being developed for the regulated river systems of the Border Rivers, Gwydir, Namoi, Macquarie, Upper Namoi and Lower Namoi valleys[2].

[1] For more information on Planned Environmental Water in the Border Rivers, and how it is modelled, the reader is referred to Section 7.5 in the companion Model Build report (Department of Planning, Industry and Environment Water 2020a).

[2] The development of the Plan Compliance Scenario for the Border Rivers is described in the companion Scenarios report (Department of Planning, Industry and Environment Water 2020b).

Modelled data are available with a high degree of confidence for the Border Rivers Valley regulated river system (Department of Planning, Industry and Environment Water 2020a). These data indicate a 6.1 GL growth above the Plan Limit for the Border Rivers (Table 1). Not all of this growth is attributed to floodplain harvesting.

Table 1 Modelled LTAAEL and current volumes (GL/year) in the NSW Border Rivers Valley regulated river system for general, high security, supplementary and floodplain harvesting licences under the Plan Limit and Current Conditions Scenarios

Development conditions	Plan Limit (GL/year)	Current Conditions (GL/year)
General and high security	92.1	92.6
Supplementary	69.2	70.0
Floodplain harvesting	38.7	43.6
LTAAEL	200.0	206.1
Growth above the Plan Limit		**6.1**

2.3.4 Outcome of returning to statutory limits

Returning the volume of water diverted within a Valley to within the Plan Limit will result in more water in the river, leading to improved environmental outcomes and increased water availability in downstream systems.

Environmental benefits

Improved environmental outcomes for floodplains is one of the key outcomes sought through implementation of the policy. Harvesting of water from floodplains reduces the volume, frequency and duration of floods and can change the timing of flood events, impacting on the health of floodplains and downstream waterways. Floodplain harvesting can also affect connectivity between a river and its local floodplain wetlands by reducing flow volume and redirecting flood flows.

DPIE Water has undertaken a valley-by-valley assessment of potential outcomes for the environment from implementing the policy. Using modelled long-term (1895–2019) changes to the hydrology of the floodplain, each valley-specific *Environmental Outcomes of Implementing the Floodplain Harvesting Policy* report[3] considers the predicted ecological responses to changed floodplain harvesting volumes after licensing floodplain harvesting.

Key hydrological metrics and environmental water requirements were used to test and identify these outcomes for assets (e.g. location) and values (e.g. species) including native fish, native vegetation, waterbirds, important ecosystem functions and wetlands.

Most assessed environmental water requirements are achieved more frequently under the Plan Limit Compliance Scenario than under the Current Conditions Scenario, i.e. model without licensing of floodplain harvesting. Improvements are seen in the number of flow days, frequency and timing of floods for native fish, waterbirds and floodplain vegetation.

[3] For example, the Border Rivers report (Department of Planning, Industry and Environment Water 2020c). For more information on the key findings and recommendations, the reader is referred to each valley specific *Environmental Outcomes of Implementing the Floodplain Harvesting Policy* report on the department's website.

Increased water availability in downstream systems

Whilst the environmental outcomes assessment looks at changes in the volume of water at the localised, within-valley scale, implementation of the policy is also predicted to increase the volume of water reaching downstream water sources. This volume is potentially available for extraction, contributing to water availability for downstream communities, town water supply, stock & domestic users and irrigators. Implementation of the policy in each of the four Barwon-Darling tributary systems has a cumulative effect with each valley providing contributions to overall Barwon-Darling inflows.

3 Assessing the downstream effects of policy implementation

Growth in floodplain harvesting has led to a level of take that, in the NSW Border Rivers, is above statutory limits. When the licensing framework is established, floodplain harvesting licences will be subject to a volumetric limit that returns overall take to within the long-term average annual extraction limit (LTAAEL) set in each valley's Water Sharing Plan. This means that some of the water previously diverted through floodplain harvesting will be foregone. These foregone diversions will remain in the system, travelling across the floodplain, with some of the water returning to the river and continuing downstream.

This assessment explores the difference in diversions at the valley scale, considering the current unconstrained situation and what would occur post policy implementation in each of the five northern inland valleys. The volumetric difference between the scenario with unconstrained floodplain harvesting (the Current Conditions Scenario) and the with policy implementation scenario (the Valley Scale Compliance Scenario) is the **foregone diversions**. The volume of foregone diversions in each valley is then an input to the downstream Barwon-Darling river system model to assess the downstream impact of these contributions.

Foregone diversions from each valley are input in the model at the point where the valley intercepts the Barwon-Darling, added to the in-river volume that flows from the outlined tributary valleys (Figure 2). These foregone diversions pass through the Barwon-Darling adding to water availability and attenuating as they flow south west into the Murray system.

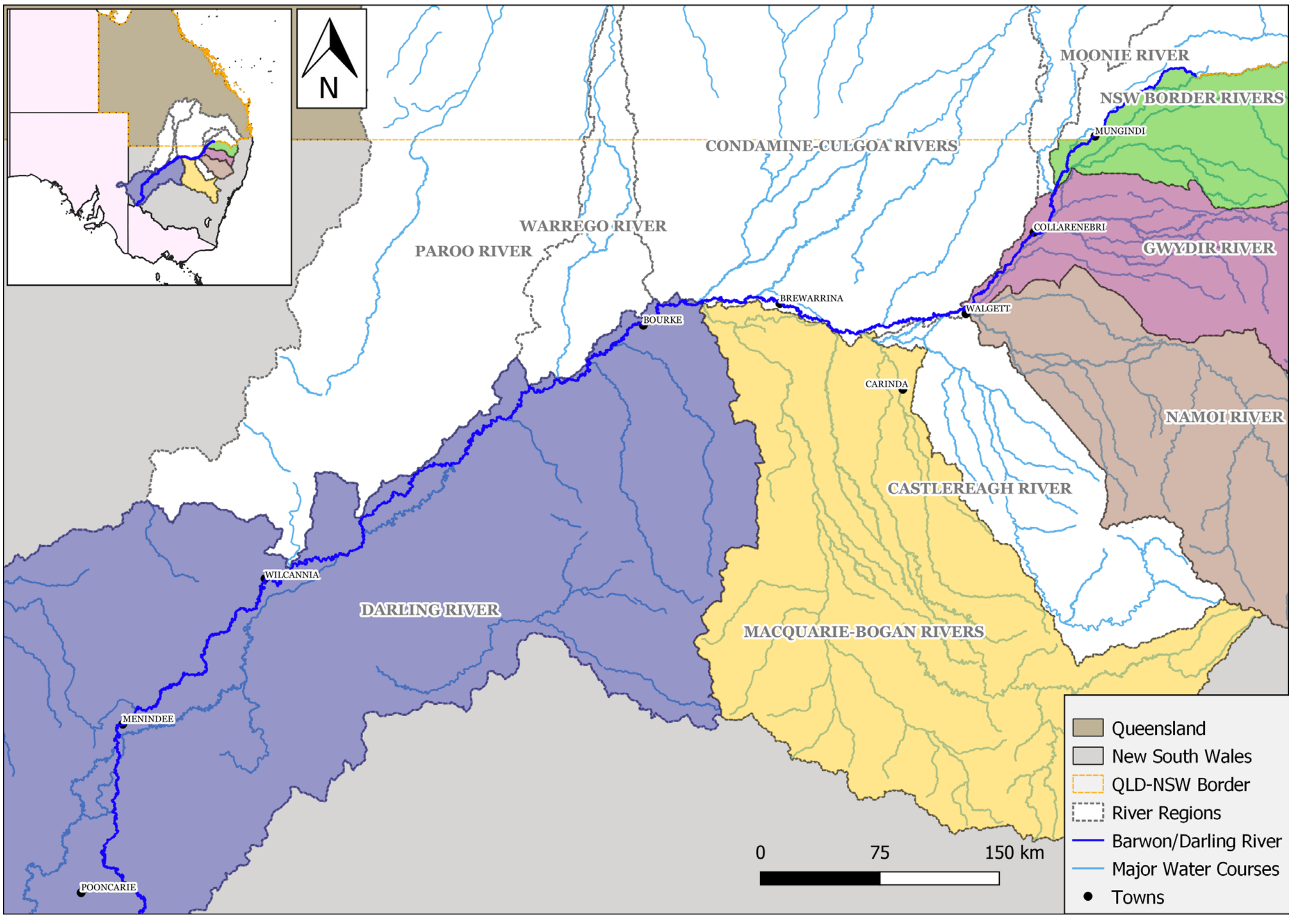

Figure 2 Map showing the Barwon-Darling tributary Valley links

An assessment of this increased extraction opportunity and water allocations for downstream water users was undertaken at water source scale using the Barwon-Darling model. As the foregone diversions attenuate as they cross the floodplain, reducing in size before they return to the river, the model was tested using a plausible range of assumed return flow proportions. This sensitivity analysis considers the full range of results (0% of forgone diversions return to river to 100% of foregone diversions return to river) that may be expected following implementation of the policy.

3.1 Inputs and assumptions

Models simulate highly complex physical processes. These processes have many inputs, outputs, dependent factors and feedback loops. Each source of data comes with a set of assumptions and a level of uncertainty around how well this information reflects the real world.

The work undertaken to support the implementation of the policy has already substantively reduced uncertainty in the river system models. All datasets have been extensively reviewed to ensure the best quality available data are used. Multiple lines of evidence such as remote sensing and hydraulic modelling have been used, where possible, to substantiate the data, as has comparing datasets to published literature. Uncertainty can be further reduced with better information. This will require ongoing measurement and monitoring of harvesting volumes and management practices, and better representation of return flows from floodplains to river channels.

All hydrologic assessment modelling was undertaken using the department's river system models developed in either the Integrated Quality and Quantity Model (IQQM) or eWater Source software. These models produce timeseries of floodplain diversion in each valley under the Current Conditions Scenario and the Valley Scale Compliance Scenario that are then input to the downstream effect's assessment model. These timeseries were provided for the period 01/07/1895 to 30/06/2009, consistent with the benchmark climate period defined in the Basin Plan.

3.1.1 Assumptions and sources of uncertainty in the river system models

The downstream effects assessment has been generated using DPIE Water river system models. As described in the previous section, all care has been taken to ensure that these river system models are reliable and robust – they have been rigorously tested and refined subject to the DPIE Water's risk assessment framework. As the assessment described herein utilises these river system models, it is subject to the same suite of assumptions and sources of uncertainty.

Assumptions and sources of uncertainty in the river system models are documented in the Model Build report for each Valley[4].

3.1.2 Assumptions and sources of uncertainty for downstream effects assessment

A limitation of the current river system models (mainly as a result of insufficient data) is that they do not model return flows. As a result, assumptions about return flows must be made to be able to assess downstream effects. The simplest assumptions to make are that:

- 100% of foregone diversions return to the river (i.e. all non-harvested water returns from the floodplain to the river)
- 100% of that returning water contributes to end-of-system flows (i.e. 100% of returned floodplain water flows unaltered to the end of system).

[4] For example, the Border Rivers Model Build report (Department of Planning, Industry and Environment Water 2020a). Reports for each Valley are available from the department's website.

These assumptions effectively route the foregone diversions directly to the end-of-valley-system outflow, regardless of where they occur in the tributary valley. Local effects such as the complexities of floodplain connectivity and the real potential for water to return to river, as well as in-stream flow attenuation along the length of the tributary catchments, are not currently modelled.

Put simply, any additional flow associated with foregone diversion is assumed to add directly to inflows from that Valley directly into the Barwon-Darling river system.

This is of course a simplification of the real world: in reality, end-of-valley flows would not increase linearly with an increase in the volume of foregone diversions within each Valley. Other natural processes such as evaporative losses, aquifer recharge and other local and/or catchment hydrological processes would influence the total volume and timing of flow reaching the end of the system.

Adoption of these assumptions maximises the volume of additional flow reaching the Barwon-Darling providing insight into the maximum possible effect of implementing the policy. As the downstream effects assessment is intended to provide insights in the potential scale of change after implementation of the policy, and not to provide definitive volumetric outcomes, adoption of these assumptions is justified.

However, a sensitivity test was undertaken to assess the impact of these assumptions on model results. The test assumed that 50% of foregone diversions return to river as opposed to 100%. Results for both 100% and 50% return flows are reported in Table 6 to Table 9 in Appendix A

Modelling is based on the best available data and as this improves, assumptions can be refined to provide increasingly improved estimates of the changes that could be expected through implementation of the policy.

3.2 Valley-specific assessment – Border Rivers

To date, return flow impact assessment has been undertaken for the NSW Border Rivers Valley under two scenarios:

- without policy implementation (Current Conditions Scenario)
- with policy implementation (Valley Scale Compliance Scenario).

Assessment for the remaining valleys will be undertaken throughout early 2021 as modelling data becomes available.

The Border Rivers Valley is located in southern Queensland and northern New South Wales. The Valley has several rivers that straddle the Queensland and NSW border and is one of the most northern of the Basin catchments. The Macintyre River (which becomes the Barwon River downstream) forms the main trunk of the regulated river system. Its tributaries rise west of the Great Dividing Range and continue to run westward before gradually merging to form the Barwon River upstream of Mungindi.

3.2.1 Annual average diversions

Modelled timeseries of floodplain harvesting diversions in the Border Rivers were provided for before (DPIE Water 2020a) and after (DPIE Water 2020b) implementation of the policy. Their difference allows assessment of the downstream impacts of licensing floodplain harvesting.

Table 2 provides a summary of the modelled change in annual floodplain harvesting diversions in the Border Rivers under the policy. Results indicate a 13% reduction in average annual floodplain harvesting diversions under the policy, with diversions reduced from about 44 GL/year to about 38 GL/year. The assumption of 100% return flows returns an additional ~5.5 GLto the Border Rivers system per year on average.

Table 2 Total annual diversions and annual end-of-system flow without and with implementation of the policy in the NSW Border Rivers Valley

Results	without policy (GL)	with policy (GL)	Change (GL)	Change (%)
Total annual FPH diversion	43.6	38.1	-5.5	-12.7%
Annual end-of-system flow	538.3	543.8	+5.5	+1.0%

Floodplain harvesting diversions in the NSW Border Rivers are estimated to represent about 8.1% of total end-of-Valley-system flow without policy implementation. The chart in Figure 3 shows the modelled annual floodplain harvesting diversions and end-of-system flow volumes without the policy being implemented, over the 115-year climate period. It can be seen from Figure 3 that floodplain harvesting diverts a small proportion of the total end-of-system flow in most years. The estimated 5.5 GL/year that would be returned to the river system under the policy contributes 1.0% of the total end-of-system flow.

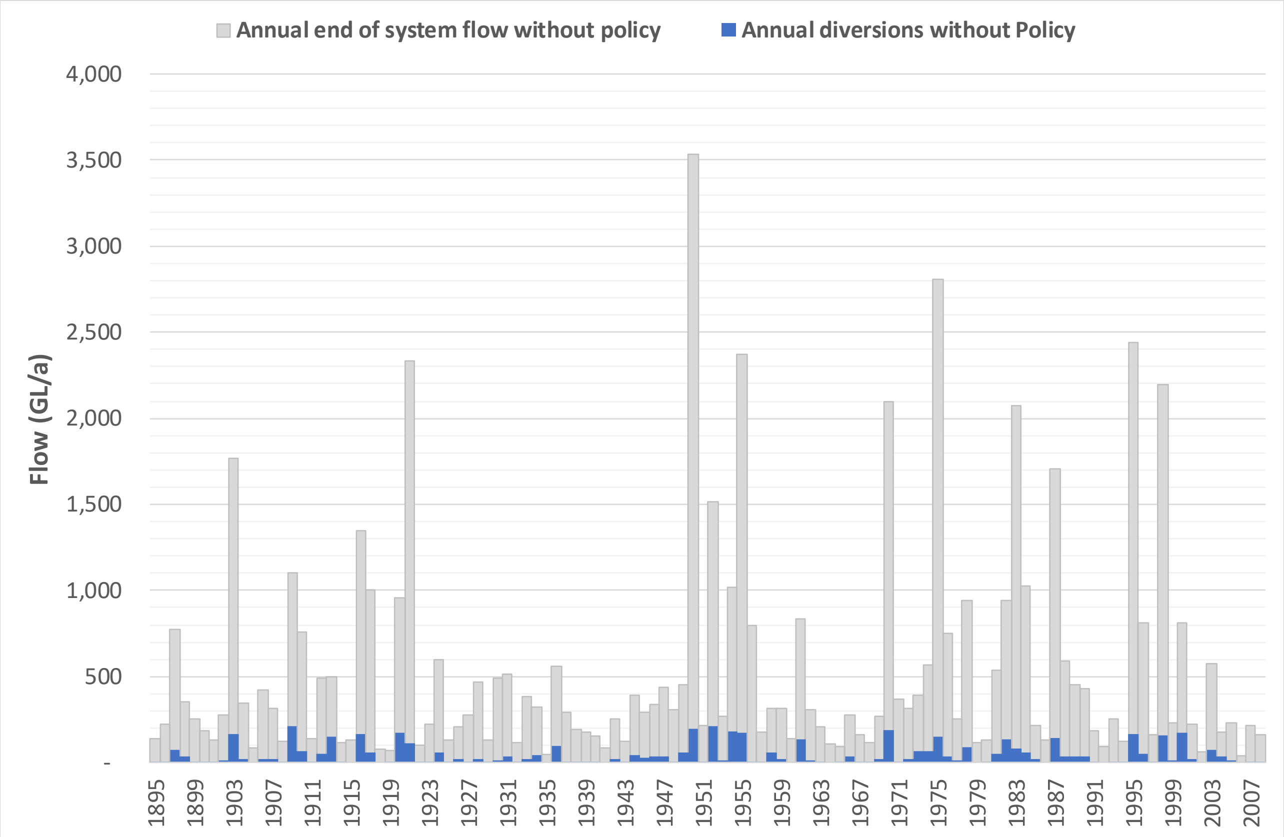

Figure 3 Modelled annual end of system flow and floodplain harvesting diversions in the Border Rivers Valley over the 115-year climate record (1895–2009). Each annual bar shows the floodplain harvesting diversions and the flow at the Border Rivers Valley end-of-system without the policy being implemented

3.2.2 Years of most effect

The effect of policy implementation is not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet to very wet conditions to create overland flows. In drier years very little to no floodplain harvesting takes place (as can be seen in Figure 4). This variability is masked when reporting average annual results (such as in Table 2), making it important to report at annual time step.

Figure 4 shows the modelled floodplain harvesting volumes and foregone diversions with the policy implemented. The blue represents the modelled annual floodplain harvesting volumes after the licensing framework is established. The grey represents the volume of diversions that is forgone after licensing. Conversely this volume can be thought of as the additional amount that would be diverted if licensing is not implemented.

These foregone diversions are ranked (Figure 5) from largest effect to least illustrating the estimated proportion of years in which the policy will have impact and the magnitude of that impact.

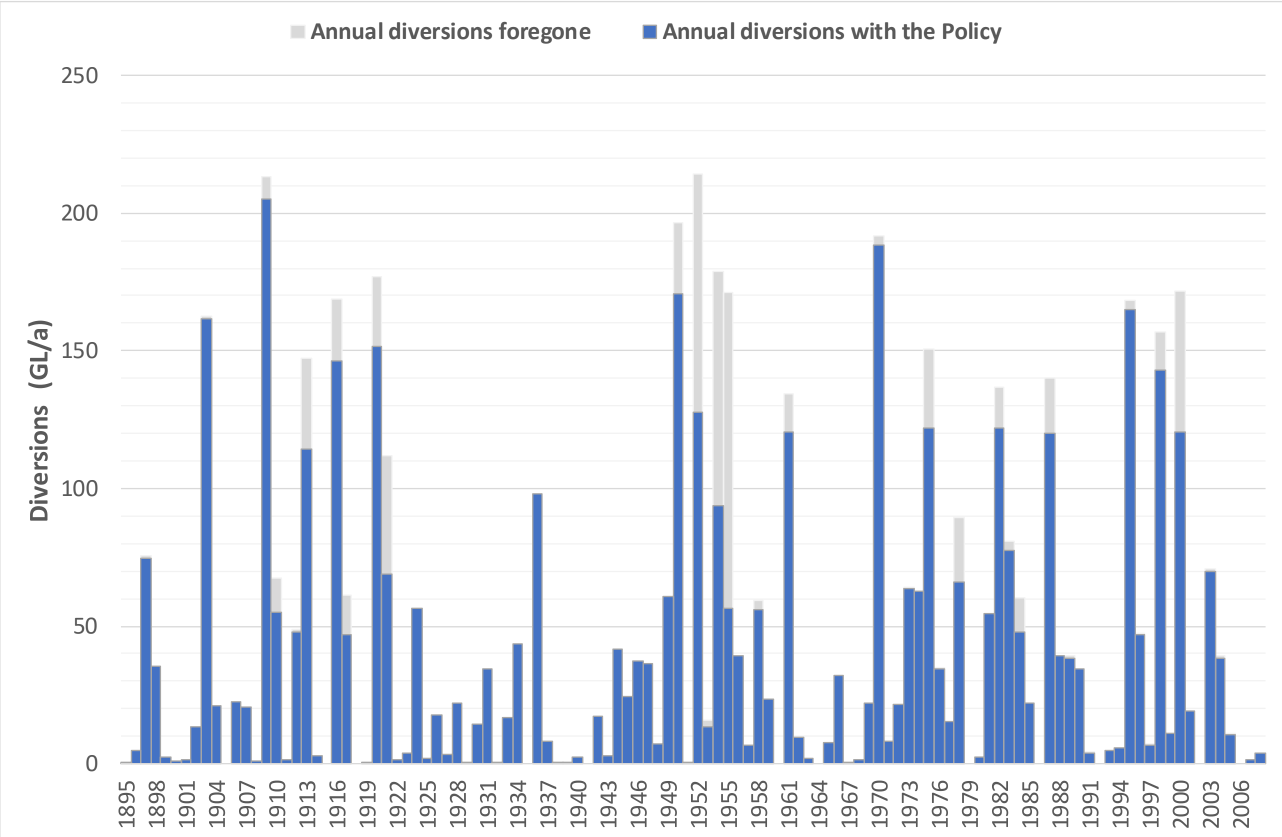

Figure 4 Modelled annual floodplain harvesting diversions with the policy implemented over the 115-year climate record for the Border Rivers Valley. Each annual bar shows the floodplain harvesting diversions and the foregone diversions with the policy implemented

Under the policy, end-of-system flow volumes are predicted to show some increase in about 50% of years, with the largest volumetric effect in wet to very wet years and over consecutive wet years.

In about 10% of the years, equivalent to the size of a 1:10 year flood event, implementing the policy is predicted to provide an increase in end-of-system flows of more than 19 GL, or more than three times the average (5.5 GL). In the top 5% of wet years, equivalent to a 1:20 year flood, implementing the policy is predicted to provide an increase in end-of-system flows of more than 33 GL or more than 6 times the average. In the wettest year on record (1955) a maximum floodplain harvesting foregone diversion of about 110 GL is predicted (Figure 4).

Under consecutive years with frequent and/or large volume overland flow events, the potential exists under the policy for account limits to ‘cap out’ during a water year. This cap may be realised before storages are completely full. These storages would have been filled in the modelled without policy scenario, i.e. the Current Conditions Scenario. A relative volume of free storage space remains for use in the following water year which would not have existed otherwise.

With subsequent credit to the annual account at the beginning of the following water year and this remaining free storage volume, the potential exists for greater floodplain harvesting under subsequent flood events than would have been the case before implementation of the policy. Nevertheless and taking this into account, total diversions over multiple years under the policy are predicted to remain equivalent to or lower than modelled diversions without the policy implemented.

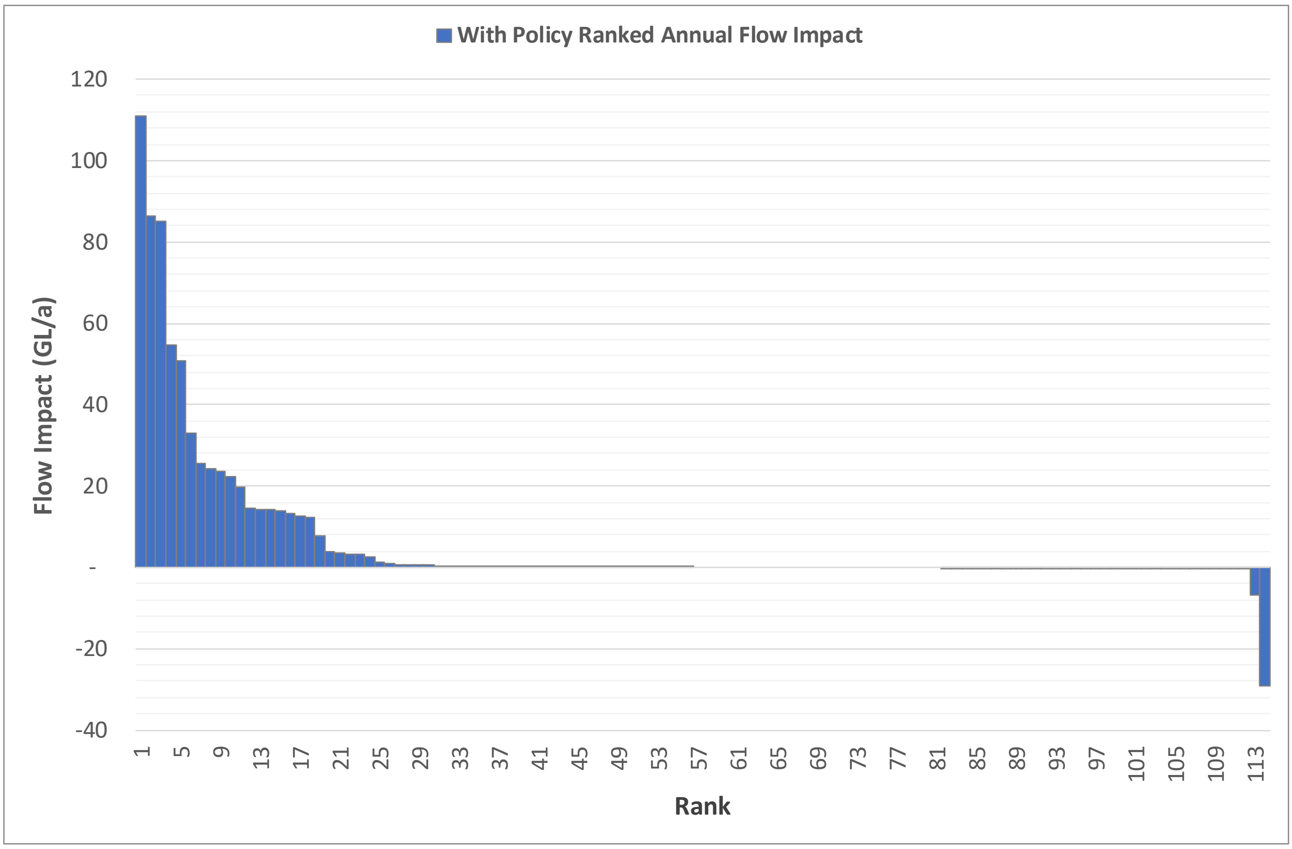

Figure 5 Modelled end of system ranked change in annual end-of-system flow volume with the policy implemented for the Border Rivers Valley

3.2.3 Sensitivity test

A high-level sensitivity assessment was undertaken (Table 3) with results under base (100%) and sensitivity (50%) assumptions for returned flow volumes. Results provide initial insights into the scale of impact that local effects such as aquifer recharge, vegetation and evaporation, local floodplain connectivity and river channel routing could have on the estimated/expected outcomes of floodplain harvesting policy implementation.

Table 3 Modelled average annual end of system flow volumes without the policy and with the policy under assumptions of 100% and 50% return flows for the NSW Border Rivers Valley

Scenario	Average annual end-of-system flow (GL)	Floodplain harvesting reduction (i.e. foregone diversion) (GL)
Without policy (current)	538.3	Not applicable
With policy and 100% return flow assumption	543.8	5.5
With policy and 50% return flow assumption	541.1	2.8

3.3 NSW Northern Basin assessment

Modelling of the Barwon-Darling river system was undertaken for a series of scenarios:

1. without policy implementation in any valley (Current Conditions Scenarios)
2. with policy implementation in the Border Rivers (Valley Scale Compliance Scenario)

This initial assessment report quantifies the impacts that licensing floodplain harvesting in the Border Rivers is predicted to have on the downstream Barwon-Darling system. Impacts stemming from the tributary valleys are assessed individually and cumulatively.

Future extensions to this report will include the modelled impacts of licensing in the remaining four valleys; Gwydir, Namoi, Macquarie and Barwon-Darling, as well as the cumulative influence of all five valleys.

3.3.1 Impact of policy implementation in the NSW Border Rivers Valley

Two sets of metrics are used to quantify the potential impact:

1. annual flows at key locations down through the system
2. annual flows at end-of-system disaggregated by licence type.

By location

Table 4 and Figure 6 provide quantification of potential changes in the Barwon-Darling due to policy implementation in the NSW Border Rivers Valley at the key gauge locations of:

- Border Rivers end-of-system (i.e. inflows to the Barwon-Darling)
- Darling River at Bourke
- Darling River at Wilcannia.

Table 4 Potential changes in annual mean flow without and with the policy implemented at three key locations in the NSW Border Rivers Valley. Locations are shown in Figure 6

Location	Without policy annual mean flow (GL)	With policy annual mean flow change (GL)	With policy annual mean flow change (%)
Border Rivers inflow	538.3	+5,.5	+1.0%
Bourke (425003)	1,864.4	+4.4	+0.2%
Wilcannia (425008)	1,383.1	+2.8	+0.2%

An important message from these results is that the predicted benefits of policy implementation effectively decrease as flow moves down through the system, with natural channel losses such as local aquifer recharge, seepage and evaporation/riparian evapotranspiration and consequent reduction in the effect on flow outcomes at downstream locations. The relative effect of policy implementation also decreases you move downstream as the same volume represents a smaller percentage of the total flow volume which has increased after contribution of inflow from other major tributaries such as flow from the Warrego and Paroo Rivers from the north.

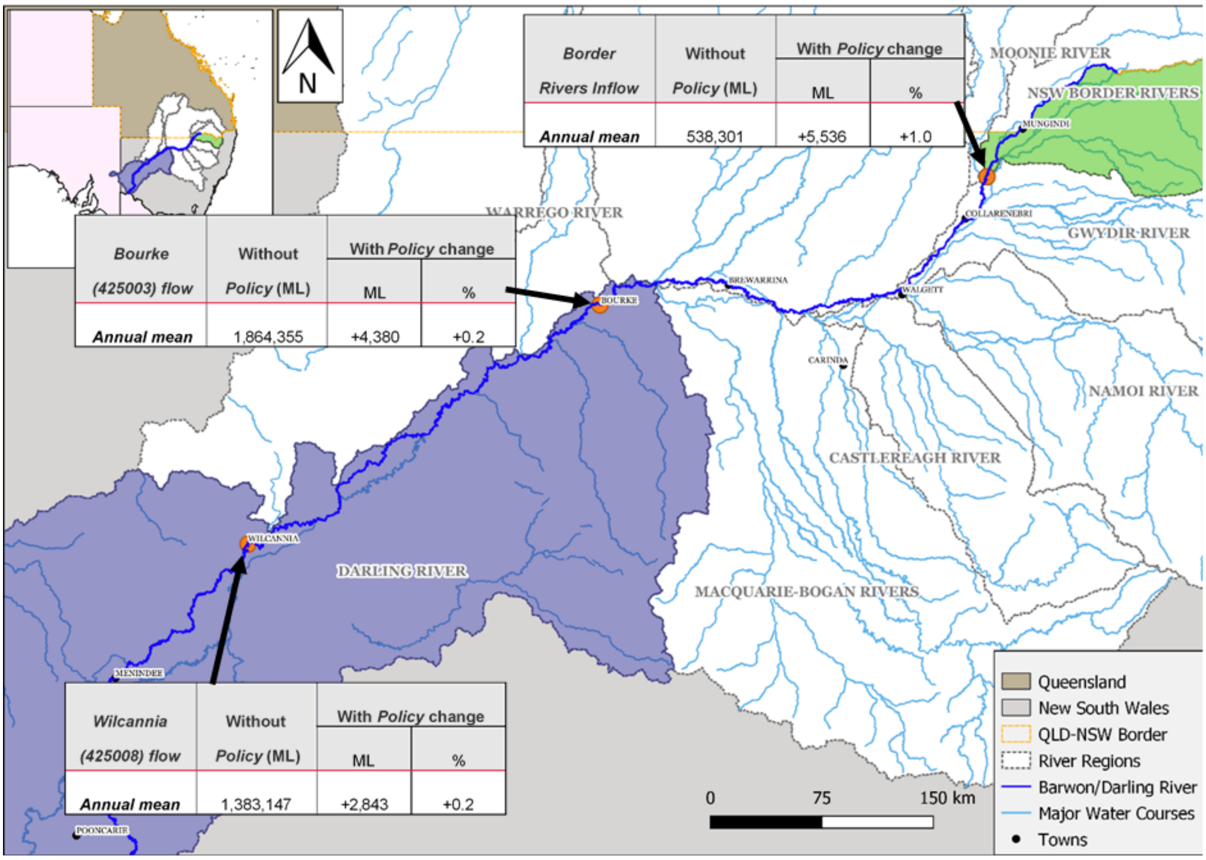

Figure 6 Map of the Barwon-Darling system, showing modelled flow metrics at 3 key locations for potential downstream outcomes of policy implementation in the NSW Border Rivers Valley

Figure 7 to Figure 9 provide further illustrative detail of the change in flow and policy implementation outcomes at these three locations along the Barwon-Darling main reach. Comparing outcomes between locations indicates:

- As flows attenuate moving through the system, incremental impacts of upstream policy implementation as a proportion of total flow decrease: as summarised in Table 4 and Figure 6 and illustrated comparatively in Figure 7 to Figure 9 (noting difference in scale of the y-axis between figures), the volume and percentage effect of policy implementation within the NSW Border Rivers Valley is expected to decrease as flow moves further downstream, with an estimated change in long-term average annual flow decreasing from 1.0% at Border Rivers end-of-system down to some 0.2% at Wilcannia.

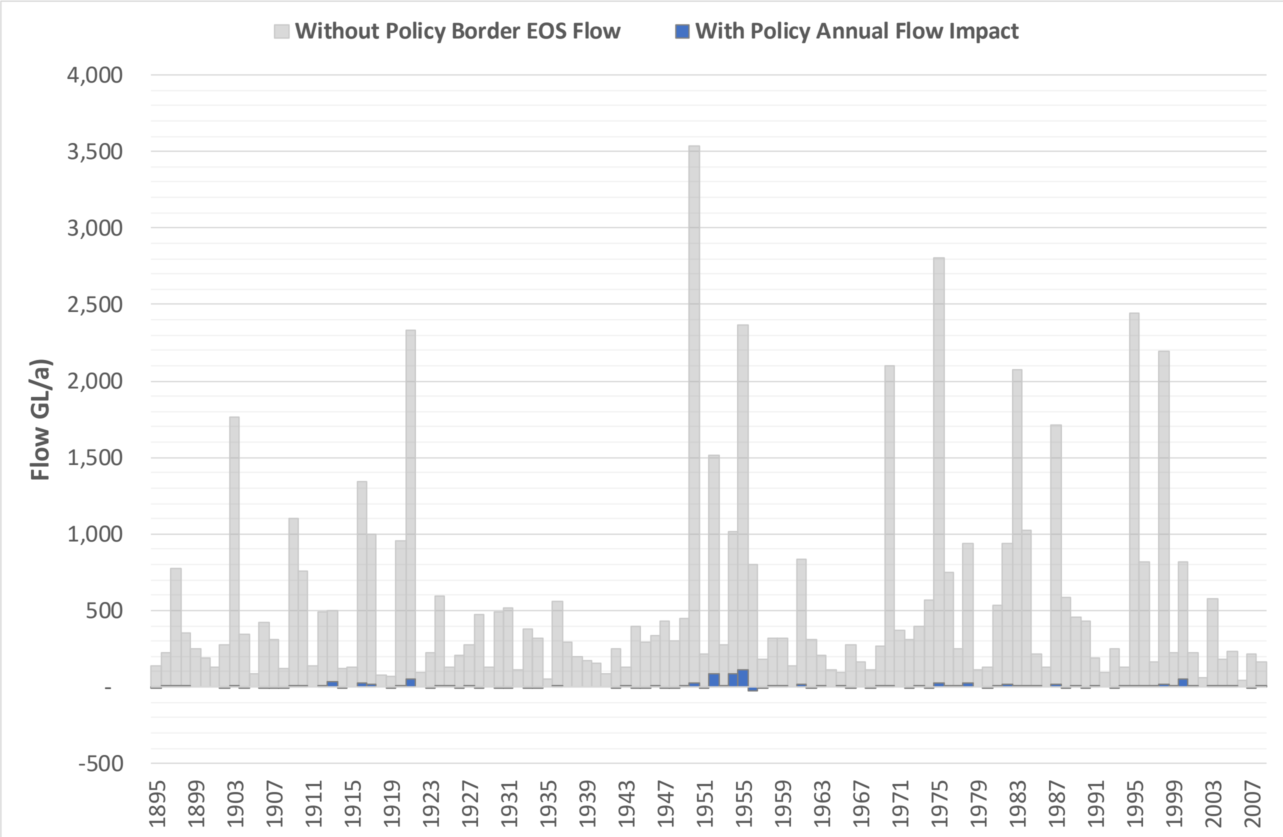

Figure 7 Modelled annual flows at the Border Rivers end-of-system over the 115-year climate record without and with policy implementation in the NSW Border Rivers Valley

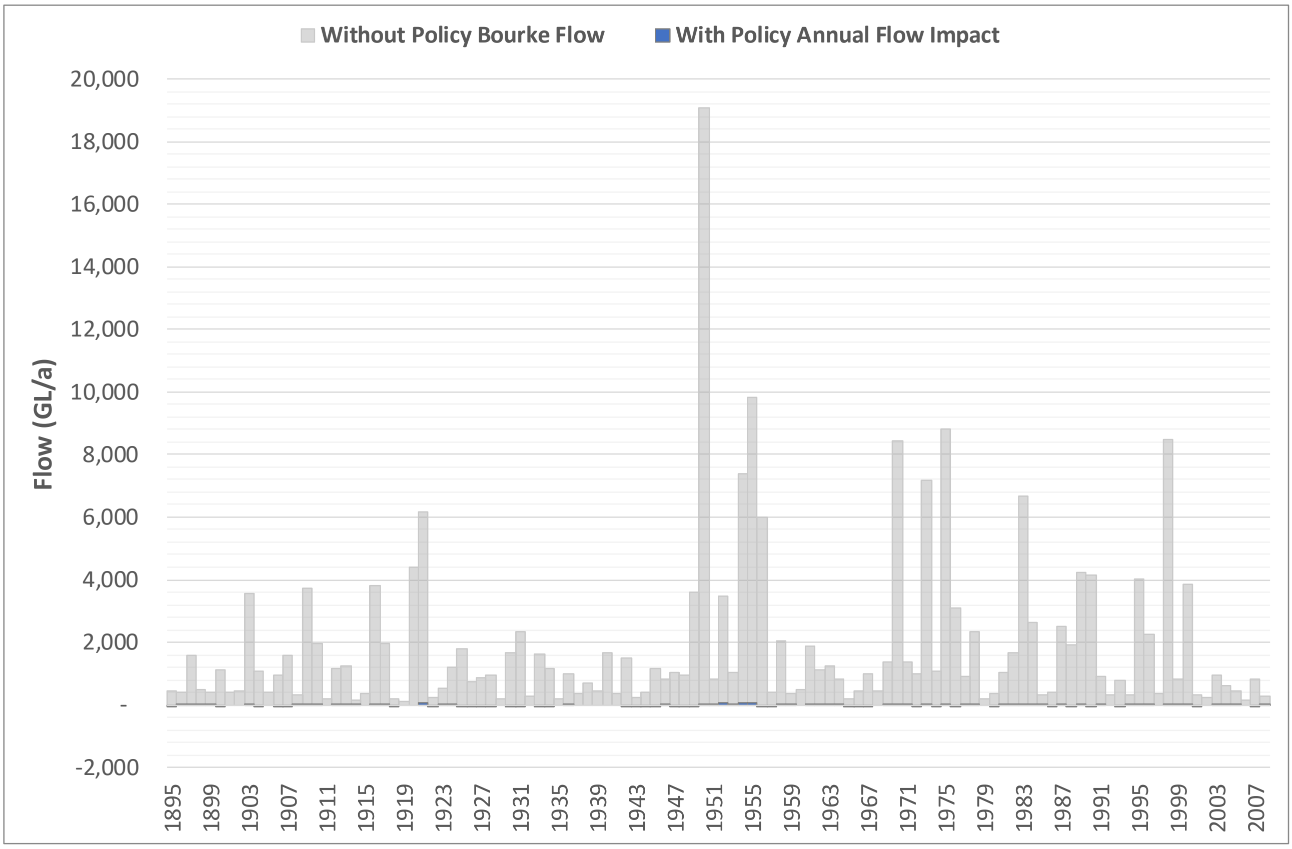

Figure 8 Modelled annual flows at Bourke (425003) over the 115-year climate record without and with policy implementation in the NSW Border Rivers Valley

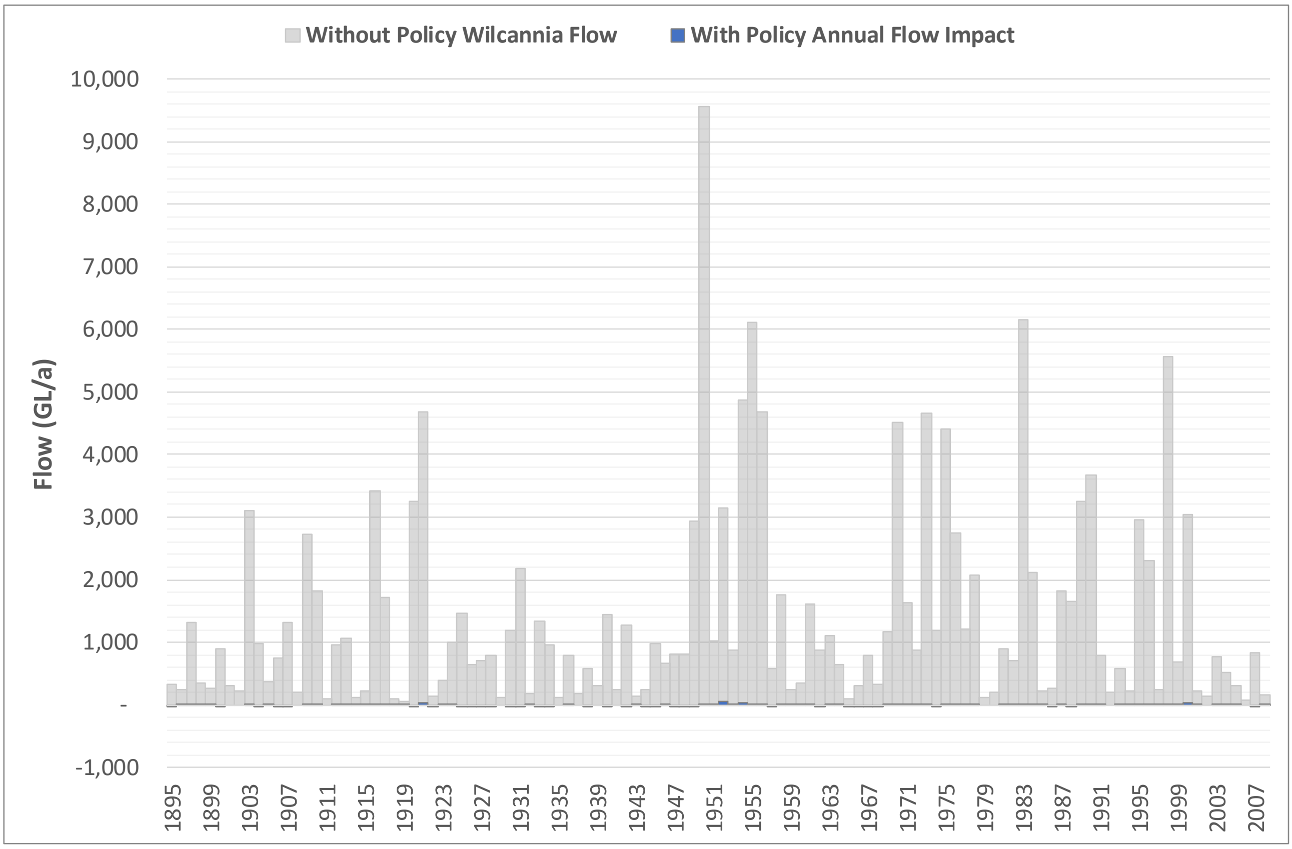

Figure 9 Modelled annual flows at Wilcannia (425008) over the 115-year climate record without and with policy implementation in the NSW Border Rivers Valley

By licence class

As a further set of information providing insights into potential effects of policy implementation, Table 5 summarises modelled annual outcomes as a result of implementing the policy in the NSW Border Rivers Valley for each licence class in the Barwon-Darling *Water Sharing Plan*:

- general security Class A
- general security Class B
- high security Class C
- floodplain harvesting.

The impact on availability for downstream licence classes has been undertaken under the base assumption of 100% return. Additional results (3-, 5- and 10-year outcomes) are provided in Appendix A , and include results under base (100% return flows) and sensitivity (50%) return flows).

As a general outcome, assessment results indicate potentially minimal impacts on each licence class, though floodplain harvesting diversion may see some minor benefits. This can be related to the years of greater policy impact being associated with wetter years within which extraction opportunities are already utilised.

Table 5 Barwon-Darling diversion summary results – Border Rivers

Mean annual diversion	Base case (without policy) (GL)	With policy *(GL)*	Impact *(%)*
Class A	6.3	6.3	< ±0.1%
Class B	115.6	115.6	< ±0.1%
Class C	45.7	45.7	< ±0.1%
Floodplain harvesting	17.7	17.8	+0.6%

4 References

Legislation, policies and plans

Basin Plan 2012. https://www.legislation.gov.au/Details/F2012L02240

(NSW) *Water Management Act 2000* No 92. Last updated 2020. https://legislation.nsw.gov.au/~/view/act/2000/92/

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National Water Initiative 2004. https://www.agriculture.gov.au/water/policy/nwi

Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2009. Last updated 2018. https://legislation.nsw.gov.au/~/view/regulation/2009/218. Referred to in this report as the *NSW Border Rivers WSP*

Reports and journal articles

Department of Primary Industries (2012) *Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources*. NSW Department of Primary Industries. Publication number 12_256.

Department of Planning, Industry and Environment Water (2020a) Building the Border Rivers Valley river system model: *Conceptualising, constructing and calibrating the DPIE Water river system model for the Border Rivers Valley*. NSW Department of Planning, Industry and Environment.

Department of Planning, Industry and Environment Water (2020b) Floodplain *harvesting entitlements for NSW Border Rivers Valley regulated river system: model scenarios*. NSW Department of Planning, Industry and Environment.

Department of Planning, Industry and Environment Water (2020c) *Environmental outcomes of implementing the Floodplain Harvesting Policy: Border Rivers*. NSW Department of Planning, Industry and Environment.

Appendix A Modelled annual flows by licence class

Table 6 Modelled annual, 3-, 5- and 10-year extractions for Barwon-Darling A Class licences, without and with the policy implemented, with base (100%) and sensitivity (50%) return flow assumption

Class A	Without policy (ML)	With policy (100% return flows) (ML)	With policy (50% return flows) (ML)
Annual			
Mean	6,340	6,340	6,340
Median	6,496	6,496	6,496
Max	8,112	8,112	8,112
Min	2,958	2,958	2,958
3-year			
Mean	19,054	19,054	19,054
Median	19,368	19,368	19,368
Max	21,322	21,323	21,323
Min	13,787	13,787	13,787
5-year			
Mean	31,813	31,813	31,813
Median	32,129	32,129	32,129
Max	35,079	35,080	35,080
Min	25,935	25,935	25,935
10-year			
Mean	63,825	63,825	63,825
Median	64,000	64,000	64,000
Max	68,340	68,340	68,340
Min	55,421	55,412	55,412

Table 7 Modelled annual, 3-, 5- and 10-year extractions for Barwon-Darling B Class licences, without and with the policy implemented, with base (100%) and sensitivity (50%) return flow assumption

Class B	Without policy (ML)	With policy (100% return flows) (ML)	With policy (50% return flows) (ML)
Annual			
Mean	115,603	115,592	115,599
Median	119,030	118,614	118,631
Max	220,013	220,056	220,029
Min	9,265	9,265	9,265
3-year			
Mean	347,022	346,988	347,008
Median	356,932	356,985	356,961
Max	444,728	444,660	444,721
Min	211,508	210,846	210,880
5-year			
Mean	579,691	579,632	579,667
Median	592,642	592,557	592,690
Max	680,252	679,835	679,918
Min	382,997	383,050	382,999
10-year			
Mean	1,164,640	1,164,512	1,164,588
Median	1,177,875	1,178,234	1,178,234
Max	1,264,342	1,264,377	1,264,325
Min	961,628	961,754	961,700

Table 8 Modelled annual, 3-, 5- and 10-year extractions for Barwon-Darling C Class licences, without and with the policy implemented, with base (100%) and sensitivity (50%) return flow assumption

Class C	Without policy (ML)	With policy (100% return flows) (ML)	With policy (50% return flows) (ML)
Annual			
Mean	45,717	45,714	45,718
Median	49,257	49,230	49,234
Max	112,359	112,905	112,945
Min	566	566	566
3-year			
Mean	137,658	137,648	137,660
Median	141,295	141,260	141,268
Max	201,783	201,777	201,779
Min	64,007	64,001	63,832
5-year			
Mean	229,742	229,725	229,746
Median	230,279	230,279	230,280
Max	298,577	298,272	298,560
Min	159,636	159,637	159,637
10-year			
Mean	460,070	460,037	460,081
Median	461,408	461,399	461,402
Max	544,694	544,694	544,694
Min	383,658	383,398	383,404

Table 9 Modelled annual, 3-, 5- and 10-year extractions for Barwon-Darling Floodplain Harvesting licences, without and with the policy implemented, with base (100%) and sensitivity (50%) return flow assumption

Floodplain harvesting	Without policy (ML)	With policy (100% return flows) (ML)	With policy (50% return flows) (ML)
Annual			
Mean	17,698	17,810	17,750
Median	9,265	9,266	9,183
Max	93,816	93,774	93,744
Min	-	-	-
3-year			
Mean	53,322	53,664	53,482
Median	39,654	39,726	39,697
Max	153,803	155,630	154,740
Min	198	198	198
5-year			
Mean	89,749	90,330	90,020
Median	85,197	86,226	85,584
Max	203,217	209,744	205,764
Min	4,187	4,187	4,187
10-year			
Mean	185,019	186,218	185,579
Median	192,171	194,374	193,541
Max	335,526	341,487	338,268
Min	53,523	53,523	53,523

Appendix B Glossary

Abbreviation/ acronym	Expansion
IQQM	Integrated Quantity Quality Model
LTAAEL	Long term average annual extraction limit. The average of annual extractions from the water source over the period for which an assessment is carried out. (Source: https://www.waternsw.com.au/customer-service/service-and-help/tips/glossary#l)
SDL	Sustainable diversion limit. How much water, on average, can be used in the Basin by towns, communities, industry and farmers. Source: https://www.mdba.gov.au/basin-plan-roll-out/sustainable-diversion-limits
WSP	Water Sharing Plan. Set the rules for how water is allocated in a valley for the next 10 years. Source: https://www.industry.nsw.gov.au/water/plans-programs/water-sharing-plans/how-water-sharing-plans-work

Term	Description
2020/21 water year	A water year runs from 1 July to 30 June, in this example from 1 July 2020 to 30 June 2021. A slash is used to identify this and to be consistent with all Basin plan legislation. (2020-2021 would refer to the two years 2020 and 2021)
A, B and C class licences	These water access licences are specific to the Barwon-Darling unregulated river system. They give access to water between agreed thresholds, with A class licences having access at the lowest flow threshold, B class licences having access at a higher flow threshold, and C class licences having access at the highest flow threshold. These licence classes are described in Department of Primary Industries (2012)
NSW Border Rivers WSP	Shortened term for the *Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2009*
Current Conditions Scenario	Model scenario that uses the best available information on most recent known levels of irrigation infrastructure and entitlements (derivation for each valley described in companion Scenarios report)s
Plan limit compliance and Plan Limit Compliance Scenario	Plan limit compliance is assessed at two scales – individual and valley, Valley scale compliance is modelled using the Valley Scale Compliance Scenario which is then referred to as the Plan Limit Compliance Scenario (derivation for each valley described in companion Scenarios reports)
Plan Limit Scenario	Model scenario that is the lower of the level of development at a particular date or agreements made under the Murray Darling Basin Ministerial Council on diversions (derivation for each valley described in companion Scenarios reports)
The policy	Shortened term for the *NSW Floodplain Harvesting Policy*

Term	Description
Valley Scale Compliance Scenario	Model scenario that uses the Current Conditions Scenario and proposed accounting rules and individual floodplain harvesting entitlements to demonstrate modelled diversions comply with the Plan Limit, which is set for the valley (derivation described in companion Scenarios report)