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# Floodplain harvesting entitlements for the Barwon-Darling unregulated river system

Model scenarios

May 2022



# Acknowledgement of Country

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## More information

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# Contents

<b>Executive summary</b> .....	<b>5</b>
<b>1 Introduction</b> .....	<b>7</b>
1.1 Barwon-Darling Valley river system model .....	7
1.2 Report purpose and structure .....	8
1.3 Companion report.....	8
<b>2 Floodplain Harvesting Policy background</b> .....	<b>10</b>
2.1 Purpose.....	10
2.2 Implementation.....	10
2.3 Definition and estimates of diversion limits .....	11
2.4 Eligible works capability assessment and determination of entitlements.....	12
2.5 Proposed accounting rules .....	12
<b>3 Scenarios: use and data</b> .....	<b>14</b>
3.1 Overview .....	14
3.2 Descriptions of scenarios .....	15
3.3 Data for scenarios .....	18
<b>4 Results</b> .....	<b>22</b>
4.1 Plan Limit Scenario results .....	22
4.2 Growth in use assessment .....	22
4.3 Plan Limit compliance results .....	23
4.4 Entitlement distribution .....	24
<b>5 Conclusions and future work</b> .....	<b>25</b>
<b>6 References</b> .....	<b>26</b>
<b>Appendix A Illustration of accounting rules</b> .....	<b>28</b>
<b>Appendix B Worked example for development levels (scenarios)</b> .....	<b>30</b>
<b>Appendix C Model version</b> .....	<b>32</b>
<b>Appendix D Glossary and abbreviations</b> .....	<b>33</b>

# List of tables

Table 1 Scenarios developed to implement the floodplain harvesting licensing framework in the Barwon-Darling Valley .....	14
Table 2 Total valley-scale entitlements for scenarios (shares) .....	18
Table 3 On-farm development data types and sources of information used for each scenario.....	19
Table 4 On farm estimates of development for scenarios .....	19
Table 5 Modelled long-term (1895 to 2009) average total diversion (GL/year) under the Plan Limit Scenario.....	22
Table 6 Modelled long term (1895 to 2009) average diversions (GL/year) under the Plan Limit and Current Conditions scenarios to determine growth in use .....	23
Table 7 Modelled long term (1895 to 2009) average diversions (GL/year) under the Plan Limit Compliance Scenario compared to the Plan limit.....	23
Table 8 Example of annual floodplain harvesting (ML/year) under 5-year accounting rules.....	28
Table 9 Hypothetical property works and their sizings under the various model scenarios.....	30
Table 10 Abbreviations and acronyms used in this report .....	33
Table 11 Terms used in this report .....	33

# List of figures

Figure 1 Stages in floodplain harvesting implementation .....	10
Figure 2 Process for using the model scenarios to determine floodplain harvesting entitlements. The four steps, moving from left to right, reflect the relationship between the four model scenarios.....	15
Figure 3 Distribution of change in floodplain harvesting diversions for individual properties under the Individual Impacts Scenario .....	24
Figure 4 Example property with multiple storages and intakes.....	31

# Executive summary

In 2008 the NSW Government announced that water users harvesting water from floodplains would need a licence and approval to use the water harvesting works that they had installed. To facilitate this, the Department of Planning, Industry and Environment introduced the NSW Floodplain Harvesting Policy (the policy) in 2013. The policy sets out the floodplain harvesting licensing eligibility criteria and the licensing process that will ultimately define the volume of water (overbank and rainfall-runoff) that users can legally harvest from floodplains. The policy is now being implemented across the northern NSW Murray-Darling Basin.

Formulaic water source limits for all forms of take including Floodplain harvesting are set out in NSW Water Sharing Plans. Volumetric estimates of these limits are being updated using improved information and modelling developed under the NSW Floodplain Harvesting Program.

This report describes how the Barwon-Darling Valley river system model<sup>1</sup> has been used to re-estimate the long-term diversion limit (the 'plan limit') set in the 2012 Water Sharing Plan for the Barwon-Darling Unregulated River Water Source, estimate individual floodplain harvesting entitlements, and demonstrate that the new floodplain harvesting entitlements and water sharing rules will restrict floodplain harvesting where required to bring total diversions within the plan limit. Model scenarios have been developed that represent different combinations of levels of development, entitlements and water sharing rules.

Each scenario is run through the Barwon-Darling river system model, over the period 1 July 1895 to 30 June 2009<sup>2</sup>, to calculate an estimate of long-term average annual total diversion. Issues such as compliance with the plan limit, equitable distribution of entitlements and risk of growth in use are considered when evaluating the combination results to determine the volume of access licences and associated management rules.

Comparing results of diversions permitted under the existing plan limit against those under current levels of development and management rules shows that the long-term average annual floodplain harvesting diversion has increased from 10.9 GL/year to 21 GL/year<sup>3</sup>. However, the long-term average annual total diversion for the water source has only increased marginally by 0.8 GL/year (from 195.4 to 196.2 GL/year). Introducing the combination of entitlements and account management rules will reduce floodplain harvesting enough to bring the long-term average annual diversion for the water source within the plan limit. This is primarily due to the exclusion of a small number of ineligible works in the process of determining floodplain harvesting entitlements. The individual impact scenario shows that the licensing framework will not significantly reduce floodplain harvesting from eligible works.

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<sup>1</sup> Companion Model Build Report (DPE Water 2022)

<sup>2</sup> 1895–2009 period is based on the 2012 Murray-Darling Basin Plan assessment period and refers to water years rather than calendar years

<sup>3</sup> Assumes that the proposed rainfall runoff exemption for water collected in irrigation tailwater drains is in place

The scenario modelling reported herein has been used to update the plan limit estimate for the Barwon-Darling unregulated river water source. It has also been used to determine floodplain harvesting entitlements. Evaluation of results shows that the proposed entitlements and account management rules can equitably manage floodplain harvesting such that the total diversion complies with the plan limit and future growth is appropriately managed to achieve that result.

While all care has been taken in this modelling and the work undertaken has substantially improved the estimation of floodplain harvesting, uncertainty can be further reduced with better information through ongoing monitoring of harvesting volumes and management practices, and better representation of return flows from floodplains to river channels.

# 1 Introduction

In 2008 the NSW Government announced that water users harvesting water from floodplains would need a licence and an approval to use the works. To facilitate this, the Department of Planning, Industry and Environment (the department) developed the *NSW Floodplain Harvesting Policy* (the policy). The policy was introduced in 2013 and is now being implemented across the northern NSW Murray Darling Basin. The policy sets out the floodplain harvesting licensing eligibility criteria and the licensing process.

Floodplain harvesting licences define the volume of water that users can legally harvest from floodplains. Bringing floodplain harvesting into the water licensing system will ensure the volume of total diversions stays within the limits established in NSW water sharing plans (WSPs) for each valley.

NSW WSPs set out how much, and how, water is shared between users within the state. They define how limits to total diversions, including for floodplain harvesting, are to be calculated in each valley, and include estimates for these limits. The floodplain harvesting estimate is now being updated using improved data and methods developed under the NSW Floodplain Harvesting Program.

The updated data and modelling for the Barwon-Darling Valley river system have been described in detail in the companion Model Build report (DPIE Water 2022a).

The model has been used to re estimate the diversion limit set in the *Water Sharing Plan for the Barwon-Darling Unregulated River Water Source 2012*, referred to as the Barwon-Darling WSP, and calculate floodplain harvesting licences to ensure that total diversions are within that limit.

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## 1.1 Barwon-Darling Valley river system model

The existing model of the Barwon-Darling Valley river system (the Barwon-Darling model) was built to support the policy and planning development and implementation in this water system, including its contribution to the Murray-Darling Basin Plan 2012 (Basin Plan).

The existing model has been updated to better represent floodplain harvesting and to determine volumetric floodplain harvesting entitlements as required by the policy.

The model was updated using multiple lines of evidence and best available industry data to ensure that the assessment of floodplain harvesting capability at each irrigation property is realistic. Assessment criteria<sup>4</sup> measured how well the model reproduced system behaviour, that is inflows, diversions and flow distribution, necessary to meet the modelling objectives, and whether model performance was better or worse than an alternate model. The Model Build report (DPIE Water 2022a) provides evidence and assessments to demonstrate that the model has made the best use of available data and methods to produce the estimates of limits to diversions required for

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<sup>4</sup> Ref Table 24 in DPE Water (2022)

implementation of the policy. In addition, the quality of the model build process (as described in the Model Build report) has been favourably assessed through several rounds of independent external review, with findings publicly available (for example, see Alluvium, 2019).

### 1.1.1 Model scenarios

Meeting policy purposes required configuring and running a set of defined model scenarios. Scenarios reflect a particular level of development and management rules in the river system, usually at a point in time. The scenarios to be discussed in this report have been qualitatively defined by the Barwon-Darling WSP and, separately, by the policy.

Scenarios are developed as modifications to the inputs to the base river system model and checked against observed data. When run over long-term climate sequences, the modified model can then simulate long-term average annual diversions under the level of development and management rules described in each scenario.

The modifications to create these scenarios are described in this report.

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## 1.2 Report purpose and structure

This report describes how the Barwon-Darling model was used to re estimate the diversion limit in the Barwon-Darling WSP and estimate individual floodplain harvesting entitlements. This includes discussion of the relevant policy instruments, how models are used to implement these, and how development levels and water management rules (the two key components of the scenarios) were determined.

Section 2 introduces the key elements of the Barwon-Darling WSP and the policy, particularly the definitions for Cap Scenario, and the framework for establishing floodplain harvesting entitlements.

Section 3 describes the scenarios and their data requirements in more detail and how they have been combined to estimate floodplain harvesting entitlements.

Section 4 presents the modelled results, summarised at whole of river system scale as required by the Basin Plan and the policy. Results are categorised by (1) determining the Barwon-Darling WSP's diversion limit, (2) growth in use assessment, (3) plan limit compliance, and (4) entitlement distribution. Summary information on individual entitlements is reported, including estimated changes in diversions as a consequence of implementing these entitlements.

Section 5 concludes with an assessment of how the requirements of the policy have been addressed, along with identification of future work.

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## 1.3 Companion report

How the model has been used to update the plan limit estimate and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in this report.



The updating of the river system model which provides the data for assessing entitlements is described in companion report *Building the river system model for the Barwon-Darling Valley unregulated river system* (DPE Water 2022).

Together, these two reports serve to describe how the modelling meets the objectives of the *NSW Floodplain Harvesting Policy*.

# 2 Floodplain Harvesting Policy background

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## 2.1 Purpose

Allowable limits for water diversions in NSW's regulated rivers and the Barwon-Darling are determined in WSPs established under the 2000 *NSW Water Management Act*. Following accreditation of NSW Murray-Darling Basin Water Resource Plans by the Commonwealth Water Minister on advice from the Murray-Darling Basin Authority, WSPs will be amended to ensure these limits will also reflect the Sustainable Diversion Limit set out in the Basin Plan. These limits allow for flows in the river and on associated floodplains that provide for environmental outcomes and a level of reliability to downstream water users.

Unconstrained harvesting of water from floodplains has resulted in growth in diversions above those limits in some valleys, resulting in reduced downstream and lateral flow with consequent impacts on reliability of water supply to downstream water users including the environments of the river and its floodplains and wetlands.

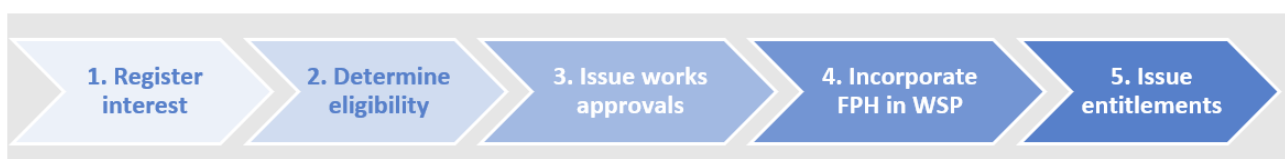
The purpose of the policy is to protect the environment and the reliability of downstream water supply by managing the diversion of water for consumptive use through floodplain harvesting. These diversions will be managed to be within authorised long-term average annual extraction limits (LTAAELs). **This LTAAEL is referred to as the 'plan limit'.**

The policy ensures compliance with the 2000 *NSW Water Management Act* which requires all diversions to be taken under an appropriate water access licence, a basic landholder right or a licence exemption. The policy also meets the objectives of the National Water Initiative by bringing these floodplain harvesting diversions into the water access entitlement framework.

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## 2.2 Implementation

The policy provides a framework for licensing floodplain harvesting diversions (comprising overbank flow harvesting and rainfall runoff harvesting), setting out five stages (Figure 11) of the administrative process for eligibility for a floodplain harvesting entitlement, from registration of interest through to the issue of entitlements. The *Implementation Guideline* (DPIE 2020) provides further detail on this process.



**Figure 1 Stages in floodplain harvesting implementation**

The Department of Planning and Environment's (the department's) river system models for each valley are being extended to determine all regulated river and Barwon-Darling Valley floodplain harvesting entitlements, through:

- updating estimates of the plan limit defined in each valley's WSP
- assessing floodplain harvesting capability of eligible works
- using the eligible works capability assessment to equitably determine entitlements such that total diversions can be managed within the plan limit.

The role of the models in stages 4 and 5 is described in the following sections. Their revision and estimates of plan limits rely on information collected in stages 1, 2 and 3.

The entitlements process described here is restricted to the regulated river system and the Barwon-Darling Valley. Entitlements in the other unregulated river systems are determined using a separate process as outlined in the *Implementation Guideline* (DPIE 2020).

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## 2.3 Definition and estimates of diversion limits

The policy requires that total diversions do not exceed the plan limit. This also means that total diversions cannot exceed that allowed for under the Cap<sup>5</sup>.

The plan limit for the Barwon-Darling Valley unregulated river system is established in clause 33(2) of the Barwon-Darling WSP as:

“The long-term average annual extraction limit for the water source is the long-term average annual extraction from the water source that would occur under Cap baseline conditions as agreed under the Murray-Darling Basin Agreement at the commencement of this Plan.”

The Barwon-Darling Valley model has been designed to be able to determine the long-term average annual diversion under these conditions. The Cap baseline conditions are configured as a model scenario and run through the model, using a long period of climate data, to estimate the long-term average annual total diversion under the scenario.

This is the Plan Limit Scenario and is described in Section 3.2.1.

The categories of diversions included in the plan limit definition are specified in the Barwon-Darling WSP. The plan limit estimate in the Barwon-Darling WSP is based on the department's river system model that was in use at that time. This included an estimate of floodplain harvesting; however this was not a reliable estimate as that part of the model was not sufficiently developed for that purpose.

A revised estimate of the plan limit has been made as part of implementation of the policy. The same estimate will be used for the Baseline Diversion Limit (BDL) under the Basin Plan – consequently, the BDL estimate used by the Murray-Darling Basin Authority will also be updated, and by inference, the Sustainable Diversion Limit (SDL).

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<sup>5</sup> The Cap is as defined in Schedule E of the *Murray Darling Basin Agreement* and as agreed under the *Murray Darling Basin Ministerial Cap on Diversions*.

As results are averaged (i.e. the long-term average annual extraction), the time period is important. To comply with the Basin Plan, the period 01/07/1895 to 30/06/2009 is used for calculating long-term averages for the implementation of the policy.

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## 2.4 Eligible works capability assessment and determination of entitlements

The policy states that the determination of individual entitlements will not be based on history of use. Instead, determination is informed by a capability assessment that considers the works (physical infrastructure) used for floodplain harvesting and the opportunity to access floodplain flows based on location and climatic variability. Note that the assessment includes only those works deemed eligible for consideration<sup>6</sup>.

This capability has been included in the updated Barwon-Darling model.

Growth in total diversions **above** the plan limit is addressed through two steps:

- Firstly, growth resulting from ineligible works is addressed by not including those works in the capability assessment or in the design of the entitlements
- Secondly, to bring total diversions back within the plan limit, entitlements are designed so that, in conjunction with the account management rules, each irrigation property has a uniform reduction in the long-term average non-exempt portion of floodplain harvesting.

If total diversions are **below** the plan limit, then the entitlements will be designed so that there is no impact. The assessment of impact in both cases is based on eligible works only.

To implement the above, 4 model scenarios are required to assess:

- the plan limit (called the Plan Limit Scenario)
- current infrastructure (called the Current Conditions Scenario)
- eligible works (called the Eligible Development Scenario)
- implementation of the policy (called the Valley Scale Compliance Scenario).

These scenarios are described in Section 3.

Determination of entitlement volumes depends on the accounting rules used. The proposed accounting rules are discussed in the following section. The method to calculate entitlements is further described in Section 2.2 on the implementation of the policy.

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## 2.5 Proposed accounting rules

Accounting rules affect the sizing of entitlements; for example, if there is no carryover, larger entitlements are required to achieve the objectives of the policy. The amount of floodplain harvesting over the long term is affected by climate variability. These all need to be taken into

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<sup>6</sup> The process of assessing eligible works is described in *Guideline for the implementation of the NSW Floodplain Harvesting Policy* (DPIE 2020)

account when designing entitlement volumes and account management rules. We undertook extensive analysis of combinations of entitlements and account management rules.

Issues such as equitable reductions and risk of growth in use were considered when evaluating the combinations of entitlement volumes and accounting rules. This process was overseen by an NSW interagency working group including the Department of Primary Industries (Fisheries), Department of Primary Industries (Agriculture) and the department's Environment and Heritage division. A summary of the analysis and recommendations were provided for stakeholder consultation to seek feedback (DPI 2018a).

The proposed accounting rules for each floodplain harvesting entitlement are:

- 100% of an entitlement to be credited annually to the account, up to a maximum value of 500% of the entitlement.
- Annual floodplain harvesting is limited to the balance left in the account.
- The account is debited annually for all floodplain harvesting in that year.
- Any unused balance can be carried over into the next water year subject to the 500% account limit.

These proposed rules, along with some additional initialisation rules, will be further described during water sharing plan consultation. Appendix A illustrates how these accounting rules work.

NSW has introduced a partial rainfall runoff harvesting exemption to the *policy*, which means that there will be times when rainfall runoff harvested from the farm is not required to be accounted for against the licence. This provision is taken into account by removing exempted harvesting from results when determining the entitlement. The exemption is also reflected in the modelling of accounting rules. For modelling purposes:

- exempt rainfall runoff harvesting is defined as that which occurs from fallow or cropped areas on days when no water is being harvested from outside the irrigation property<sup>7</sup>.
- non-exempt rainfall runoff harvesting is considered part of floodplain harvesting and as such will be included in the floodplain harvesting results in this report.

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<sup>7</sup> Draft regulation under the *Water Management Act 2000*, publicly exhibited in October 2020. Rainfall run-off from undeveloped land on a farm is not exempt and is modelled separately to run-off from developed land on the farm.

# 3 Scenarios: use and data

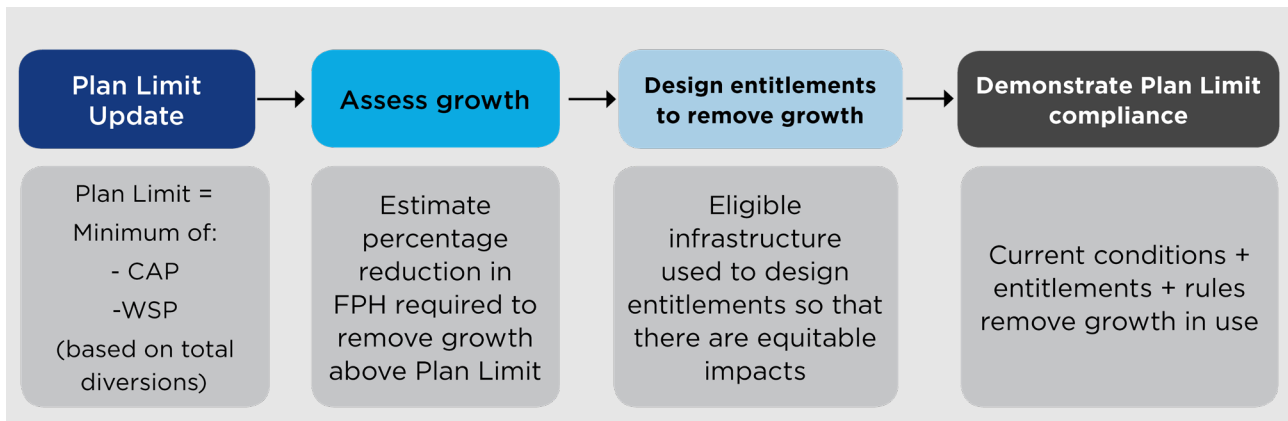
## 3.1 Overview

The intent of the policy is to bring floodplain harvesting into the water licensing framework, including managing any growth above statutory limit through a combination of entitlement volumes and account management rules as noted in Section 2.5. These two factors combined are hereafter referred to as the ‘floodplain harvesting licensing framework’.

Four scenarios have been developed to implement this framework in the Barwon-Darling model (Table 1). The relationship between the scenarios is shown in Figure 22.

Table 1 Scenarios developed to implement the floodplain harvesting licensing framework in the Barwon-Darling Valley

	Scenario name	Description, including title used in Figure 22
(a)	Plan Limit Scenario	Plan limit update This plan limit is defined by the Murray Darling Basin Ministerial Council (MDBMC) Cap on diversions
(b)	Current Conditions Scenario	Assess growth The latest available levels of development and management rules used to estimate the current level of diversions without the licensing framework in place and determine the reduction, if any, required to comply with the plan limit
(c)	Eligible Development Scenario	Design entitlements In accordance with the policy, this Scenario is based on the levels of farm infrastructure development that were present or otherwise eligible as at 3 July 2008. It is used to determine individual shares of the total volume of floodplain harvesting entitlements
(d)	Valley Scale Compliance Scenario	Demonstrate plan limit compliance An evolution of the Current Conditions Scenario with the floodplain harvesting licensing framework applied to bring diversion back to statutory limits, with shares of the total floodplain harvesting entitlements based on distribution of floodplain harvesting volumes from (c)



**Figure 2 Process for using the model scenarios to determine floodplain harvesting entitlements. The four steps, moving from left to right, reflect the relationship between the four model scenarios**

It is worth noting that some of the steps shown in Figure 22 are not required if there is no overall growth in water use, where this is the case, floodplain harvesting entitlements will be designed to avoid impacts to properties based on eligible works.

These scenarios are described in more detail in Section 3.2, including how the modelled implementation of the licensing framework equitably distributes impacts.

## 3.2 Descriptions of scenarios

This section gives a general description of each model scenario. All scenarios have been adapted from the 2008/09 Scenario described in the Model Build report (DPE Water 2022). The Model Build report should be read in conjunction with this report for further detail on how the 2008/09 Scenario was developed and model performance assessed. Changes from that scenario are described in Section 3.3.

The modelling results for the Barwon-Darling Valley river system are strongly influenced by the outflows from the valley models of upstream tributaries. However, many of the major tributaries to the Barwon-Darling Valley have significant water use occurring that has changed over the period of climatic records. To ensure that long-term inflows to the Barwon-Darling model are appropriate for each scenario being modelled, the outflows from upstream valley models have been used as model inputs. The model scenarios for each tributary valley model that have been used for each Barwon-Darling model scenario are also described in the following subsections.

### 3.2.1 Plan Limit (CAP) Scenario

The plan limit is to be assessed through the Murray Darling Basin Ministerial Council’s Cap Scenario as defined in the Barwon-Darling WSP and as described in Section 2.3. The Cap Scenario (referred to as the Plan Limit Scenario in this report) reflects the agreement made under the MDBMC Cap on diversions. For the Barwon-Darling Valley, as for most valleys in the basin, this refers to the development levels and management arrangements in place at 1993/94. This updated MDBMC Cap Scenario (the Plan Limit Scenario) has been prepared using the updated Barwon-Darling model for assessing growth in water use under the Barwon-Darling WSP, and for determining floodplain harvesting licences. This modelling work will be separately reviewed and accredited by the Murray-

Darling Basin Authority for assessing compliance with the Sustainable Diversion Limit under the Basin Plan.

The irrigation infrastructure development levels and management rules that should be used in this scenario are those that were in place during the 1993/94 water year. This scenario has been built from the existing 1993/94 Scenario – this means that the majority of other parameters are the same as those used in that scenario and as described in the companion Model Build report (DPE Water 2022).

The upstream tributary models used to simulate inflows into the Barwon-Darling Valley river system are all from the relevant 1993/94 Scenario in each NSW valley, or the Baseline Diversion Limit for each Queensland valley, as accredited by the Murray-Darling Basin Authority.

### 3.2.2 Current Conditions Scenario

This scenario uses the best available information on the most recent known levels of irrigation infrastructure and entitlements in the Barwon-Darling Valley river system, and existing management arrangements as defined under the Barwon-Darling WSP. The information is described in Section 3.3.

Apart from infrastructure and entitlements, the Current Conditions Scenario is the same as the 2008/09 Scenario.

The licences held by environmental water users (Held Environmental Water, HEW) do not use water in the Current Conditions Scenario as these licences have not been used to take water<sup>8</sup>. This configuration of HEW has also been used in other reporting for *Basin Plan* compliance. However, to recognise the share of the plan limit attributable to HEW for the growth in use assessment in Section 4.2, an assumed long-term average use for HEW that is based on the Long-term Diversion Limit Equivalent (LTDLE) factors<sup>9</sup> for the licence shares is added to the model results. We plan to explicitly represent how HEW is used in future versions of the model.

This scenario is used to estimate diversions **prior** to implementing the floodplain harvesting licensing framework so as to assess whether there has been growth in total diversions compared to the plan limit. It will require ongoing monitoring by the department to ensure that development levels are kept up to date and to assess whether there have been behaviour changes, for example changed cropping practices and efficiency of irrigation.

The upstream tributary models used to simulate inflows into the Barwon-Darling Valley river system are all from the relevant scenario in each NSW and Queensland valley prepared to represent the Baseline Diversion Limit for Water Resource Plan accreditation by the Murray-Darling Basin Authority.

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<sup>8</sup> As Barwon-Darling unregulated river licences are effectively a share of the plan limit (Cap), simply buying and holding these licences will still reduce diversions from the river.

<sup>9</sup> The Barwon-Darling unregulated river licences have an LTDLE factor of 1.0, as described in the Water Reform Technical Report: Derivation of LTDLE factors in NSW (DPIE 2018)



### 3.2.3 Eligible Development Scenario

This scenario is used to estimate the floodplain harvesting that would have occurred **with only eligible infrastructure**. This is used to determine the distribution of floodplain harvesting entitlements, as was described in Section 2.4.

All information on eligible works is provided by the NSW Natural Resources Access Regulator (NRAR) who conducted the eligible works assessment against the eligibility criteria in the policy on behalf of the department.

It is the same as the 2008/09 Scenario, with the inclusion of any eligible infrastructure that was approved, but not yet constructed in 2008/09 and the exclusion of any ineligible infrastructure at that time.

The upstream tributary models used to simulate inflows into the Barwon-Darling Valley river system are all from the relevant scenario in each NSW and Queensland valley prepared to represent the Baseline Diversion Limit (BDL) for Water Resource Plan accreditation by the Murray-Darling Basin Authority. The only exception is the Border Rivers valley, where observed flows have been used at Mungindi. The Border Rivers BDL model represents Queensland water use based on full use of entitlements, rather than at current levels, and modelled flows at Mungindi were found to systematically degrade the representation of historical small-medium flow events in the Barwon-Darling model. Other tributary models have not been found to affect flows in this way.

### 3.2.4 Plan Limit Compliance Scenarios

Plan limit compliance is assessed using two model scenarios to assess compliance at two scales – individual and valley.

For both of these scenarios, the upstream tributary models used to simulate inflows into the Barwon-Darling Valley river system are all from the relevant scenario in each NSW and Queensland valley prepared for Water Resource Plan accreditation by the Murray-Darling Basin Authority.

#### **Individual entitlements (Individual Impact Scenario)**

Entitlements were calculated by analysing the results from the Eligible Development Scenario using a utility program to simulate the effect of the proposed accounting rules on floodplain harvesting<sup>10</sup>. The utility estimates the entitlement which would be required, in conjunction with the accounting rules, to achieve any required impact on long term floodplain harvesting diversions.

The utility assumes that the same impact should apply to each individual entitlement. To test this, the entitlements and proposed accounting rules have been added into the Eligible Development Scenario to create a new scenario, the Individual Impact Scenario.

This process of designing the entitlement and assessing the impact of the rules takes into account the partial rainfall runoff harvesting exemption. The exemption is described in Section 2.5.

#### **Valley scale (Valley Scale Compliance Scenario)**

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<sup>10</sup> The utility program was developed outside of the Barwon-Darling Valley model for efficiency (run-time) reasons.

This scenario uses the Current Conditions Scenario and proposed accounting rules and individual floodplain harvesting entitlements in accordance with the policy to demonstrate modelled diversions comply with the plan limit, which is set for the valley.

This scenario is not used to report on individual impacts as there may be other issues, such as entitlement changes, that cause changes in results compared to the Eligible Development Scenario.

## 3.3 Data for scenarios

The sources and characteristics of data for each model component are detailed in the companion Model Build report. Most of the data discussed relates to model calibration (data such as climate, inflows, water diversions, transmission losses) and are therefore the same for each scenario. The model components that may vary between scenarios are:

- distribution of entitlements (other than the floodplain harvesting entitlements to be determined)
- the level of irrigation infrastructure development in place
- crop planting decision assumptions
- management rules at the relevant point in time.

The data required for each of these components is summarised below.

### 3.3.1 Entitlements

The distribution of entitlements information comes from departmental databases. All scenarios use the distribution of shares associated with the development conditions associated with that scenario. The Cap and the Water Sharing Plan scenarios both use the distribution of shares as at 1993/94. The Eligible Development Scenario and the 2008/09 Scenario uses the distribution of shares as at 1 July 2009. The Current Conditions Scenario uses the distribution of shares as at 30 June 2014. The volumes are shown in Table 2.

Table 2 Total valley-scale entitlements for scenarios (shares)

Entitlement type	Plan Limit Scenario	2008/09 Scenario	Current Conditions Scenario
Local Water Utilities	Not modelled <sup>1</sup>	Not modelled <sup>1</sup>	Not modelled <sup>1</sup>
Domestic and stock	Not modelled <sup>1</sup>	Not modelled <sup>1</sup>	Not modelled <sup>1</sup>
Unregulated River Licences <sup>2</sup>	0	0	1,488
Unregulated River Class A	11,430 <sup>3</sup>	9,856	9,856
Unregulated River Class B	229,010 <sup>3</sup>	133,069	133,069
Unregulated River Class C	216,285 <sup>3</sup>	45,746	45,746

<sup>1</sup> There are 5,373 shares issued to local water utilities along the Barwon-Darling Valley river system, and 968 shares for domestic and stock. The small volumes of use associated with these licences have been represented implicitly in the river transmission losses within the model.

2 There is one licence in this category that was issued following completion of a stock and domestic pipeline water savings project. This licence is held by the NSW government for environmental water use.

3 Entitlements associated with water users that were active in 1993/94 and included in the model. There was approximately 63,000 ML of additional entitlement that was inactive in 1993/94.

A significant amount of entitlement has been purchased by the Commonwealth and NSW governments for environmental water use<sup>11</sup> in the Barwon-Darling Valley.

### 3.3.2 Development levels for scenarios

The farm development levels refer to the physical attributes of an irrigation property that provide ongoing capability to use water; specifically

- the area of the property that can be irrigated
- the additional area from which rainfall runoff can be harvested
- volumetric capacity of on-farm storages
- the rate at which water can be pumped both from the river as well as separately for floodplain harvesting.

Table 3 summarises the data types and sources of information used in each scenario.

**Table 3 On-farm development data types and sources of information used for each scenario**

Farm development type	Plan Limit Scenario	Data sources
On-farm storage capacity (GL)	30 June 1994	LIDAR / storage survey
On-farm storage pump capacity (ML/d)	30 June 1994	NRAR works data <sup>2</sup>
Floodplain harvesting intake rate (ML/d)	30 June 1994	NRAR works data <sup>2</sup>
Installed river pump capacity (ML/d)	30 June 1994	NRAR works data <sup>2</sup> , or Farm survey <sup>3</sup>
Maximum irrigable area (ha)	30 June 1994	Farm survey <sup>3</sup> , or remote sensing <sup>4</sup>
Undeveloped farm area (ha)	30 June 1994	Farm survey <sup>3</sup> , or remote sensing <sup>4</sup>

1 Eligible works as defined by NRAR, which may include some storages developed after 2008

2 NRAR works data is data collected under the policy, primarily from site inspections

3 The Farm Survey dataset covers water years from 1993/94 to 2012/13 but does not include all years in between and does not specify exact dates. It did include 1993/94 and 99/00 so we have used that data for the Plan Limit Scenario.

4 Remote sensing has been used to check developed and irrigated areas for selected properties and, where appropriate, as part of reviewing submissions to the farm-scale validation process. This process, including the function of the Healthy Floodplains Review Committee, is further described in the Implementation Guideline (DPIE, 2020).

The valley total data used for each scenario is summarised in Table 4. These data include all individually modelled water users in the Barwon-Darling Valley river system.

**Table 4 On farm estimates of development for scenarios**

<sup>11</sup> 30,359 ML of licence shares are held by the NSW and Commonwealth governments for environmental water use as at 30 June 2020. The combined total represents approximately 15% of the total shares in the Barwon-Darling Valley unregulated river system

Farm development description	Plan Limit Scenario	Eligible Development Scenario	Current Conditions Scenario
Permanent on-farm storage capacity (ML)	209,887	276,235	224,741
Temporary on-farm storage capacity (ML)	550	4,850	4,850
Installed river pump capacity (ML/d)	6,485	9,816	8,686
Maximum irrigable area (ha)	28,371	39,350	30,315

### On farm storage capacity

We identified at an early stage that floodplain harvesting results are very sensitive to on farm storage capacities. Significant effort has been put into improving the accuracy of this information by using LIDAR or photogrammetry data with verification against a sample of surveyed storages (Morrison and Chu, 2018). Where survey data were available, it was reviewed as part of a submissions process and adopted where suitable. This process, including the function of the Healthy Floodplains Review Committee, is further described in the Implementation Guideline (DPIE 2020).

NRAR determined which of these storages were eligible under the policy and this information was used in the Eligible Development Scenario.

We determined which storages existed at earlier dates by using Landsat satellite imagery.

### Pump capacity

Pump flow rates for ‘major’ irrigators measured during tests undertaken by WaterNSW have been used to configure pump capacities. Pump capacities for earlier scenarios have been taken from earlier farm surveys.

On-farm storage pump capacity was estimated using NRAR works data. This data was developed based on on-site inspections that documented the size and type of work, including any upgrades. For a given pump type and size, a standard set of rates were adopted to determine the total on farm storage pump capacity<sup>12</sup>.

NRAR determined which pumps should be included in the Eligible Development Scenario. The on-farm storage capacity for earlier dates was based on the analysis of which storages existed at that date. Where there was no evidence that the storage existed at that date, the capacity of the associated lift pumps associated with that storage was not included in the Plan Limit Scenario. Farm survey data was also reviewed for information on pump upgrades.

The rate of intake of floodplain harvesting water into the property is generally set to the on-farm storage pump rate. Exceptions to this include either a lower rate where the intake is restricted by pipe capacities, or a higher rate to represent gravity filling of significant buffer storages<sup>13</sup>.

A worked example, with diagram, to describe how the storage capacity, pump capacity and floodplain harvesting capacity were determined for different scenarios is provided in Appendix B.

### Developed and undeveloped areas

<sup>12</sup> Rates are described in Appendix E of the companion Model Build Report (DPE Water 2022).

<sup>13</sup> These rate exceptions are further described, with examples, in Appendix E of the companion Model Build Report (DPE Water 2022).

The developed area refers to the area developed for irrigated cropping. The developed areas have been estimated using Landsat remote sensing, and undeveloped areas are based on farm survey data for most floodplain harvesting properties, and remote sensing for a small number of properties with runoff from larger undeveloped areas.

The rainfall–runoff from each type of area is configured separately in the model as described in the companion Model Build report (DPE Water 2022).

Remote sensing has been used to estimate irrigated areas and, where appropriate, as part of reviewing submissions to the farm-scale validation process. This process, including the function of the Healthy Floodplains Review Committee, is further described in the Implementation Guideline (DPIE 2020). For other relatively small water users, this information was based on earlier survey data as per the existing IQQM Water Sharing Plan model.

### **3.3.3 Crop model and planting decisions**

Irrigation water use is estimated using a crop model component which: (i) estimates how much area is planted in that year based on water availability; and (ii) estimates irrigation water demand on the basis of daily climate data. The crop area planting component was derived by combining published data, farm surveys and remote sensing as described in the companion Model Build report.

The crop model and planting decisions parameters and settings are based on those in the 2008/09 Scenario described in the companion Model Build report, adjusted where appropriate to improve the model's reproduction of observed behaviour.

### **3.3.4 Management rules**

All scenarios, with the exception of the Plan Limit Scenario, include the 2012 Barwon-Darling WSP rules as described in the companion Model Build report.

The Plan Limit Scenario includes a range of water management rules that pre-date the Barwon-Darling WSP, including water access conditions, licences, and account management rules.

The proposed floodplain harvesting accounting rules are included in the two scenarios which test the impact of these rules; i.e. the Valley Scale Compliance Scenario and the Individual Impact Scenario.

# 4 Results

The key results from running the scenarios through the Barwon-Darling model relate to long-term average annual diversions prior to and with the estimated entitlements. These are reported in summary tabular and graphical format at valley scale in this section.

Diversions are reported for each entitlement category for the 1895 to 2009 Basin Plan comparison period and include annual time series graphs for total diversions. From this reporting, we are able to provide some commentary on key differences between scenarios.

The versions of the model used to run the scenarios are listed in Appendix C.

This report has been completed prior to final decisions on eligibility being made for a small number of minor floodplain harvesting infrastructure, and this is not expected to make a noticeable difference to the model results presented in this report. The modelling will be updated for the final decisions on these infrastructure prior to the determination of individual licences.

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## 4.1 Plan Limit Scenario results

For the Barwon-Darling Valley, the Water Sharing Plan Scenario is the Plan Limit Scenario (Table 5), which defines the earlier 1993/94 Cap and the plan limit, and is referred to hereafter as the Plan Limit Scenario.

Table 5 Modelled long-term (1895 to 2009) average total diversion (GL/year) under the Plan Limit Scenario

Diversion component	Plan Limit Scenario
Unregulated river licences	184.5
Floodplain harvesting	
Overbank flow harvesting	9.6
Exempt rainfall runoff (RR) harvesting	6.8
Non-exempt rainfall runoff harvesting	1.3
<b>Total (less exempt RR)</b>	195.4
<b>Total</b>	<b>202.2</b>

---

## 4.2 Growth in use assessment

The Plan Limit Scenario and Current Conditions Scenario were both configured in the Barwon-Darling model and run for the period of climate record (1889 to 2018). Results for the benchmark climate period defined in the Basin Plan (1 July 1895 to 30 June 2009) for categories of diversions were calculated and are summarised in Table 6.

**Table 6 Modelled long term (1895 to 2009) average diversions (GL/year) under the Plan Limit and Current Conditions scenarios to determine growth in use**

Diversion component	Plan Limit Scenario	Current Conditions Scenario
Unregulated river licences	184.5	175.2 <sup>1</sup>
Floodplain harvesting		
Overbank flow harvesting	9.6	18.6
Exempt rainfall runoff harvesting	6.8	3.8
Non-exempt rainfall runoff harvesting	1.3	2.4
<b>Total (less exempt RR)</b>	<b>195.4</b>	<b>196.2</b>
<b>Total</b>	<b>202.2</b>	<b>200.0</b>

<sup>1</sup>This includes 30.4 GL as the assumed use of HEW, based on a LTDLE factor of 1 for Barwon-Darling Valley unregulated river licences (DPIE 2018).

With the tailwater exemption in place, these results show that, whilst current conditions floodplain harvesting has increased by 10.1 GL/year (93%) above that for the Plan Limit Scenario, the overall growth in water use has only been 0.8 GL/year (0.3%).

Without the tailwater exemption in place, these results show that floodplain harvesting has increased by 7.1 GL/year above the level in the Plan Limit Scenario, and overall water use has decreased by 2.2 GL/year.

## 4.3 Plan Limit compliance results

The implementation of the Valley Scale Compliance Scenario (Section 3.2.4) has slightly reduced the long-term average annual diversions under floodplain harvesting, primarily due to the exclusion of a small number of ineligible works when determining floodplain harvesting entitlements. As a result, the overall diversions in the Barwon-Darling Valley river system have been brought back to the plan limit levels as reported in Table 7.

**Table 7 Modelled long term (1895 to 2009) average diversions (GL/year) under the Plan Limit Compliance Scenario compared to the Plan limit**

Diversion category	Plan Limit Scenario	Plan Limit Compliance Scenario
Unregulated river licences	184.5	175.6
Floodplain harvesting		
Overbank flow harvesting	9.6	17.7
Exempt rainfall runoff harvesting	6.8	4.1
Non-exempt rainfall runoff harvesting	1.3	2.1
<b>Total (less exempt RR)</b>	<b>195.4</b>	<b>195.4</b>
<b>Total</b>	<b>202.2</b>	<b>199.5</b>

## 4.4 Entitlement distribution

The entitlements have been designed to have no impact on eligible floodplain harvesting diversions. Impacts on individuals were tested using the Plan Limit Individual Impacts Scenario<sup>14</sup>. This test allowed us to isolate all other changes which may have occurred in recent years (e.g. changes in other entitlement products, or ineligible works). The results confirm that there are no impacts on individual properties over the long-term period.

Under implementation of this scenario, no reduction in the non-exempt floodplain harvesting diversion component is required for individual eligible properties over the 1895 to 2009 reporting period to ensure total valley diversions are within the plan limit.

Figure 3 shows the change in percentage of non-exempt floodplain harvesting diversions pre and post the licensing framework (in both cases using the Eligible Development Scenario) across the 28 properties or groups of properties<sup>15</sup>. The model indicates that nearly all properties have no impacts.

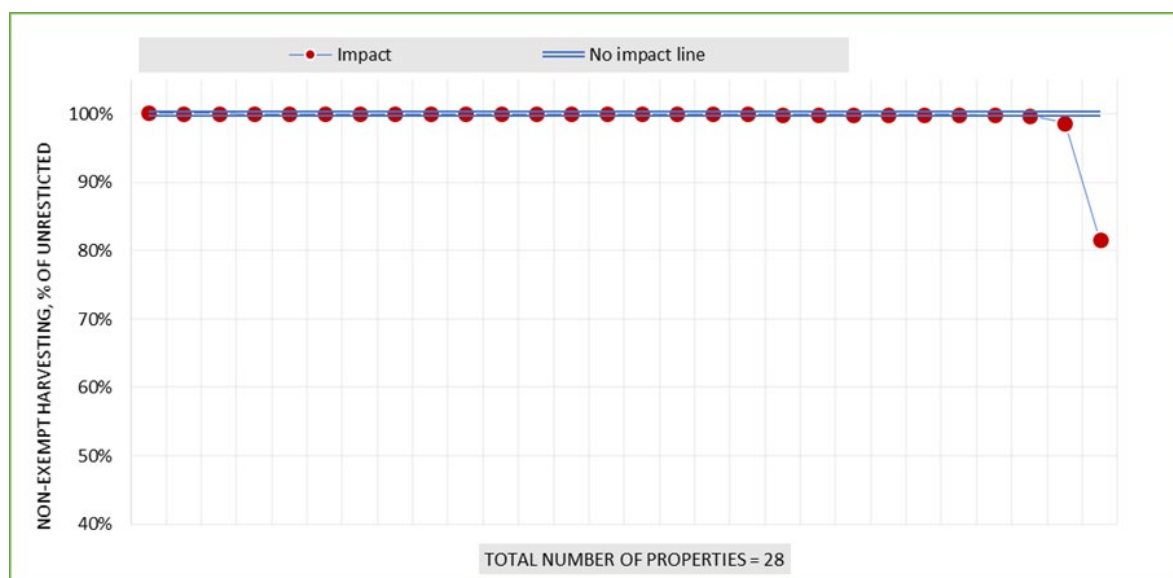


Figure 3 Distribution of change in floodplain harvesting diversions for individual properties under the Individual Impacts Scenario

The x-axis is the number of individual eligible properties represented in the Barwon-Darling model (each data point represents individual property as modelled). The one property with the larger impact (82%) has a very small (2 ML/year) floodplain harvesting entitlement.

<sup>14</sup> As described in Section 3.2.4, the Individual Impacts Scenario was created by adding the entitlements and accounting rules to the Eligible Development Scenario.

<sup>15</sup> Those Irrigation farms that were assessed as eligible for floodplain harvesting entitlements are all represented in the model individually or as a group, along with a further 9 irrigation farms that were not eligible, or are not currently operating. The remaining, generally smaller, farms and other water users have been aggregated in the model within the reach they are located. As a result, 28 individual eligible floodplain harvesting farms within the Barwon-Darling WSP area were represented using Irrigator nodes. (Sourced from Section 6.2.2 DPIE Water 2022a)



# 5 Conclusions and future work

Water Sharing Plans (WSPs) made under the *Water Management Act 2000* define how the limits to extractions are to be calculated within NSW water sources. The WSPs include an estimate of these limits which are also used as estimates of the Baseline Diversion Limit (BDL) and included in the Basin Plan. The Basin Plan allows for BDL estimates to be revised whenever a demonstrably better estimate is available.

The river system models used for the original WSPs and BDL estimates represent river diversions and flows to the best available standard of accuracy at that time and were independently reviewed as fit for that purpose; however, the floodplain harvesting diversions were not well represented.

As part of the *NSW Floodplain Harvesting Policy*, there has been significant investment in data and modelling to quantify floodplain harvesting more accurately. This has been incorporated into the updated Barwon-Darling model. The development of the model has been described in the companion Model Build report (DPE Water 2022).

The model has been used to create an updated estimate of the Long-Term Average Annual Extraction Limit (LTAAEL), or plan limit, as defined by the Barwon-Darling WSP. This model will also be used to determine floodplain harvesting entitlements in the Barwon-Darling Valley unregulated river system. Through the analyses in this report, we have demonstrated that the proposed entitlements and accounting rules can equitably manage floodplain harvesting such that total diversions are managed within the required limits.

The work undertaken as part of implementing the policy has substantially reduced uncertainty in our estimates for floodplain harvesting. Despite this improvement, uncertainty can be further reduced with better information. The companion Model Build report (DPE Water 2022) lists several areas of future work. Four key areas of improvement are:

- Review of floodplain harvesting measurement data following implementation of the policy to determine whether any further model improvements are required
- Water use data from the current upgrading of water use meters across the Barwon-Darling Valley
- Continued update of the Current Conditions Scenario, including consideration of irrigation behaviour changes and management of held environmental water
- Better representation of return flows from floodplains to river channels. This will require further research to develop a methodology for addressing this limitation in the models.

# 6 References

## Legislation, policies and plans

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[https://www.industry.nsw.gov.au/\\_\\_data/assets/pdf\\_file/0017/143441/NSW-Floodplain-harvesting-policy.pdf](https://www.industry.nsw.gov.au/__data/assets/pdf_file/0017/143441/NSW-Floodplain-harvesting-policy.pdf). Referred to in this report as the policy

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[https://www.industry.nsw.gov.au/\\_\\_\\_data/assets/pdf\\_file/0010/271936/Storage-bathymetry-model-update-and-application-gwydir.pdf](https://www.industry.nsw.gov.au/___data/assets/pdf_file/0010/271936/Storage-bathymetry-model-update-and-application-gwydir.pdf)

# Appendix A Illustration of accounting rules

Table 8 illustrates how the proposed 5 yearly floodplain harvesting accounting rules would work over a short term (17 years), noting that the actual design of entitlements uses long term results. The example also does not include some of the account initialisation rules.

The example is for an entitlement of 3,850 ML. Table 8 shows, for every year:

- unrestricted usage is the volume (ML/year) that could be harvested given eligible works, if no rules were in place
- opening and closing accounts keep track of the accounting rules; the account limit of 500% of entitlement is applied
- restricted usage is how much could have been harvested with eligible works after the accounting rules are in place

**Table 8 Example of annual floodplain harvesting (ML/year) under 5-year accounting rules**

Year	Unrestricted usage (based on eligible works) (A)	Opening account (B)	Restricted usage (C)	Closing account (D)
1	2,658	19,250	2,658	16,592
2	586	19,250	586	18,664
3	90	19,250	90	19,160
4	0	19,250	0	19,250
5	13,592	19,250	13,592	5,658
6	0	9,508	0	9,508
7	11,979	13,358	11,979	1,379
8	0	5,229	0	5,229
9	10,615	9,079	9,079	0
10	8,344	3,850	3,850	0
11	407	3,850	407	3,443
12	0	7,293	0	7,293
13	4,723	11,143	4,723	6,421
14	138	10,271	138	10,133
15	0	13,983	0	13,983
16	6,838	17,833	6,838	10,994
17	226	14,844	226	14,618
<b>Total</b>	<b>60,197</b>		<b>54,166</b>	

Column (B) is calculated by adding 100% of the entitlement to the closing account balance from the previous water year, with the maximum balance limited to 500% (5 times 3,850 = 19,250 ML).

Column (C) is calculated by taking the lesser of the unrestricted usage at column (A) or the opening account balance for that year at column (B).

Column (D) is calculated by subtracting the restricted usage at Column (C) from the opening account balance for that year at column (B).

This entitlement, in conjunction with the rules, resulted in total floodplain harvesting over the period being reduced by 10%. This is a hypothetical example, for illustrative purposes. In reality, the entitlement volumes and the rules have been determined so that the reduction in floodplain harvesting is sufficient to return total valley diversions back within the plan limit in valleys where that is required.

You can see that in most years the accounting rules have no impact on harvesting; it is only in a cluster of wetter years that there are impacts.

# Appendix B Worked example for development levels (scenarios)

The following describes an example property where there are multiple storages and floodplain harvesting intake points. Figure 45 is a schematic of the property. Data in this example are hypothetical, for the purposes of illustrating the modelling method.

The property has multiple works:

- Two eligible storages with a total estimated pump capacity of 720 ML/day based on the works installed. Both storages were present at June 1994.
- One ineligible storage built after 2008. The lift pumps associated with this storage have an estimated combined capacity of 360 ML/day.
- There are multiple pipes which bring water in from the channels into the developed part of the farm and allow delivery to the storages. The total capacity of these pipes was estimated at 768 ML/day assuming a 0.2m head.

For the Eligible Development Scenario, the on-farm storage pumps were considered the limiting factor. For the Current Conditions Scenario, the intake pipes are smaller in capacity and hence are adopted for the intake rate (Table 9).

Table 9 Hypothetical property works and their sizings under the various model scenarios

Parameter	Plan Limit (Cap) & WSP Scenarios	Eligible Development Scenario	Current Conditions Scenario
On farm storage capacity (ML)	6,520	6,520	10,822
On farm storage pumps (ML/d)	720	720	1,080
Floodplain harvesting intake rate (ML/d)	720	720	768

The capacity of pumps and pipes are all determined using farm inspection works data provided by NRAR and standard rates for each type and size of work. This is described further in Appendix G4 of the companion Model Build report (DPE Water 2022). In some cases there was additional information about upgrades to pumps on storages. This information was sometimes contained in the farm survey or NRAR notes; these were reviewed and adopted where relevant for historical scenarios.

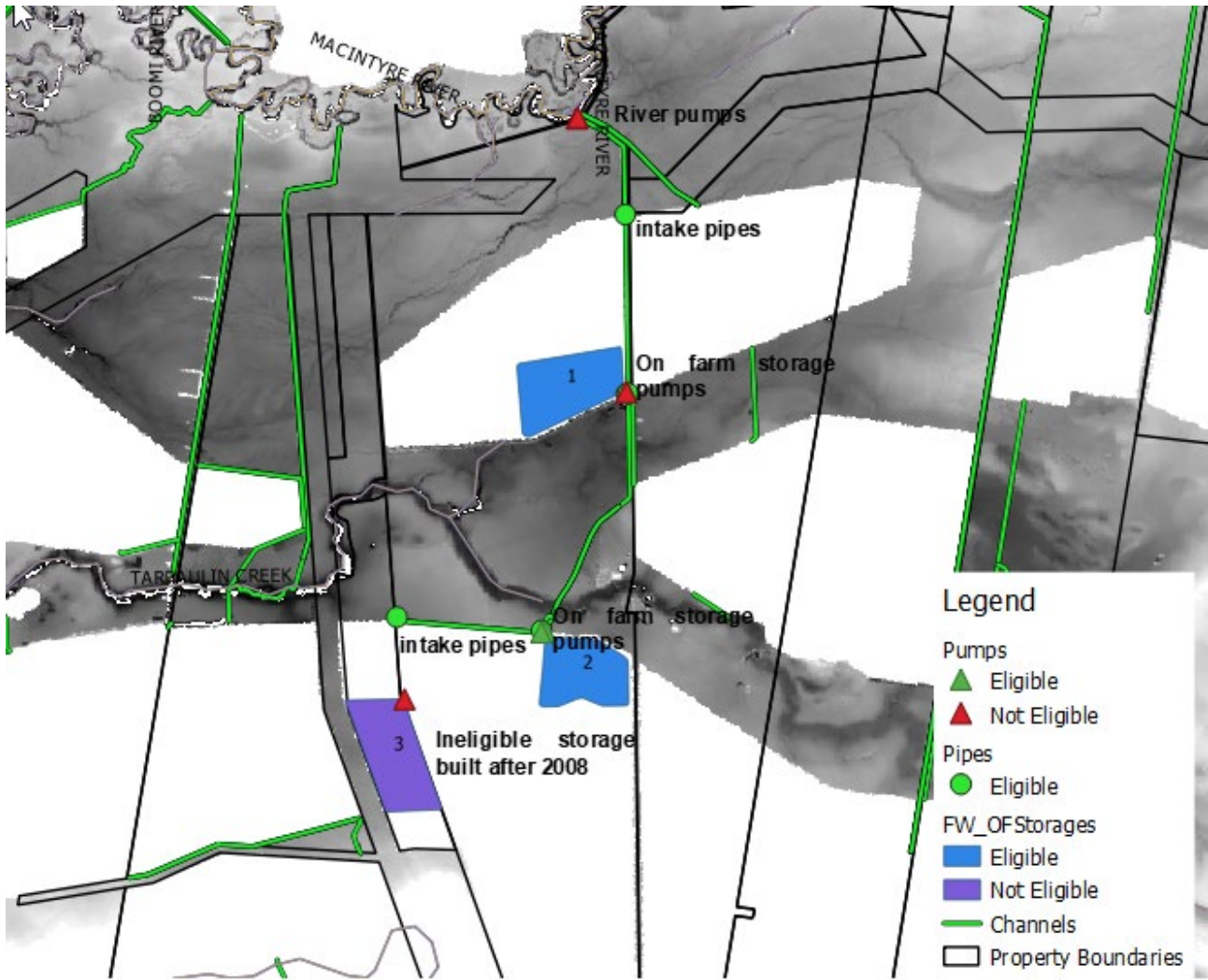


Figure 4 Example property with multiple storages and intakes

# Appendix C Model version

All Scenarios have been developed with the following version of the model:

IQQM Version 7.103.0 RC4

Each Scenario is implemented by selecting a different Scenario input set contained within this file. These are as follows.

Scenario	Filename
Plan limit (Cap Scenario)	CAP_FPH_013.sqq
Current infrastructure	Current_FPH_12.sqq
Eligible development	0809_pbp_63.sqq
Current infrastructure with floodplain harvesting rules	Cur_BD_FPH_12_fphlic



# Appendix D Glossary and abbreviations

Table 10 Abbreviations and acronyms used in this report

Acronym	Expansion
BDL	Baseline diversion limit
LTADEL	Long term average annual extraction limit
LTDLE	Long term diversion limit equivalent (factors)
MDBMC	Murray-Darling Basin Ministerial Council
NRAR	NSW Natural Resources Access Regulator
SDL	Sustainable diversion limit
WSP	Water Sharing Plan

Table 11 Terms used in this report

Term	Description
2008/09 Scenario	Model baseline scenario representing floodplain harvesting works in place in 2008/09. The derivation of this baseline scenario is described in companion Model Build report
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 Basin legislation. (2020-2021 would refer to the range of years, 2020 and 2021)
Cap Scenario	Model scenario that reflects agreements made under the Murray Darling Basin Ministerial Council Cap on diversions. Candidate for the Plan Limit Scenario (details in Section 3.2.1)
Current Conditions Scenario	Model scenario that uses the best available information on most recent known levels of irrigation infrastructure and entitlements (details in Section 3.2.2)
Eligible Development Scenario	Model scenario used to estimate the floodplain harvesting that would have occurred with only eligible infrastructure (details in Section 3.2.3)
Long-term average annual extraction limit (LTADEL)	The upper limit on the average of annual extractions from the water source over the period for which an assessment is carried out. (Source: <a href="https://www.waternsw.com.au/customer-service/service-and-help/tips/glossary#l">https://www.waternsw.com.au/customer-service/service-and-help/tips/glossary#l</a> )
Long term diversion limit equivalent (LTDLE) factors	Factors used to describe the proportion of the Plan Limit that a licence represents. (DPIE 2018)
OFS	On-Farm Storage, which can be used to store water that has been taken from the river or floodplain, to capture tailwater and runoff from the farm areas developed for irrigation, and to harvest rainfall runoff from nearby land.
Plan Limit	The authorised long-term average annual extraction limit as defined in the Water Sharing Plan

Term	Description
Plan limit compliance	Compliance with the plan limit, which is assessed using long-term modelling.
Plan Limit Scenario	Model scenario that results in the lower long-term average diversions from either the conditions set out in the Water Sharing Plan or agreements made under the Murray Darling Basin Ministerial Council Cap on diversions (derivation for each valley described in Section 3). Selected from the Cap Scenario and the WSP Scenario
The policy	Shortened term for the <i>NSW Floodplain Harvesting Policy</i>
Water Sharing Plan (WSP) Scenario	Model scenario that reflects the level of development specified in the Water Sharing Plan. For the Barwon-Darling unregulated river system, this is the level of development and management arrangements at 1993/94. This is the same as the Cap Scenario for this valley (details in Section 3.2.1)