NSW HEALTHY FLOODPLAINS

Floodplain harvesting entitlements for the Macquarie Valley regulated river system

Model scenarios

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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 (the department) introduced the NSW Floodplain Harvesting Policy (the policy) in 2013. The policy sets out the floodplain harvesting licensing eligibility criteria and the licensing process where licences 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.

Floodplain harvesting limits are set out in NSW water sharing plans. These limits were estimated at the time of policy introduction and are now being updated using improved information and modelling developed under the NSW Floodplain Harvesting Program.

This report describes how the Macquarie Valley regulated river system model[1] (the Macquarie Valley model) has been used to recalculate the long-term diversion limit (the 'plan limit') set in the 2016 *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source* (the Macquarie WSP), estimate individual floodplain harvesting entitlements, and demonstrate that the new floodplain harvesting water access licences will keep total diversions within the plan limit. Model scenarios have been developed that represent different combinations of levels of development, entitlements and account management rules to ensure equitable distribution of the individual floodplain harvesting entitlements.

Each scenario is run through the Macquarie Valley model, over the period 1 July 1895 to 30 June 2009[2], 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 revised plan limit and the volume of access licences and associated management rules.

Comparing results of diversions permitted under the existing plan limit against current levels of development and management rules for eligible infrastructure shows that, despite some growth in irrigation infrastructure development, long-term average total diversions have decreased by 28 GL/year, from 356.9 to 328.9 GL/year, assuming the tailwater exemption is in place. Introducing the combination of entitlements and account management rules has not materially affected the long-term average annual diversions.

The scenario modelling reported herein has been used to create an updated estimate of the plan limit for the Macquarie and Cudgegong Rivers regulated water sources. 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 total diversions are not affected, and could be managed within the plan limit should future growth in water use be required.

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] The companion Model Build Report (DPIE Water 2021a)

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

Contents

List of tables

List of figures

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 Macquarie Valley regulated river system have been described in detail in the companion Model Build report (DPIE Water 2021a).

The model has been used to recalculate the diversion limit set in the water sharing plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2016 (updated 2018) (the Macquarie WSP), and calculate floodplain harvesting licences to ensure that total diversions are within that limit.

1.1 Macquarie Valley river system model

The model of the Macquarie and Cudgegong regulated river system (Macquarie Valley 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). This includes being able to estimate the Baseline Diversion Limit (BDL) and Sustainable Diversion Limit (SDL) as required by the Basin Plan
- determine volumetric floodplain harvesting entitlements as required by the policy.

The model was developed 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[3] 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 2021a) 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 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 (Alluvium, 2019).

[3] Ref Table 36 in DPIE Water (2021a)

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 Macquarie 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.

1.2 Report purpose and structure

This report describes how the Macquarie Valley model was used to recalculate the diversion limit in the Macquarie 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 Macquarie WSP and the policy, particularly the definitions for Cap and Plan Limit scenarios, 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 Macquarie 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.

1.3 Companion reports

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

The building of the river system model which provides the data for assessing entitlements is described in companion report *Building the river system model for the Macquarie Valley regulated river system* (DPIE Water 2021a).

The use of the model results for predicting potential environmental outcomes is described in companion report *Environmental outcomes of implementing the Floodplain Harvesting Policy in the Macquarie Valley* (DPIE Water 2021b).

The three reports together serve to describe how the modelling meets the objectives of the policy.

2 Floodplain Harvesting Policy background

2.1 Purpose

Allowable limits of 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.

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 1) 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's river system models for each valley are being extended to determine all regulated river 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 estimate 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. Entitlements in the unregulated river system are determined using a separate process as outlined in the *Implementation Guideline* (DPIE 2020).

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[4].

The plan limit for the Macquarie regulated river system is established in clause 29(1) of the Macquarie WSP as the lesser of the long-term average annual extraction for this water source that would occur:

> "(a) (i) with the water storages, private water management infrastructure and cropping mix that existed in 1999/2000,
>
> (ii) the share component existing on 1 July 2004,
>
> (iii) the maximum crop area and the crop planting behaviour representative of baseline conditions used for assessment of Cap under Schedule E of the Murray-Darling Basin Agreement,
>
> (iv) the environmental water provisions specified in clause (2), (3), (6), (7), (8), (12), (16) and (22) of this Plan, and
>
> (v), the other water management rules applying on 1 July 2004
>
> or
>
> (b) the long-term average annual extraction from this water source that would occur under the baseline conditions used for assessment of Cap under Schedule E of the Murray-Darling Basin Agreement."

The Macquarie Valley model has been designed to be able to determine which set of development conditions and management rules ((a) or (b)) results in the lower long-term average annual diversion. The sets are configured as model scenarios and run through the model, using a long period of climate data, to estimate the long-term average annual total diversion under each scenario.

- Clause 29(1)(a) is configured as the Water Sharing Plan Scenario.
- Clause 29(1)(b) is configured as the Cap Scenario.

The Plan Limit Scenario then is whichever of these has the lower result. Both scenarios have been run and are described in Section 3.2.1.

The categories of diversions included in the plan limit definition are specified in the Macquarie WSP. The limit estimate in the Macquarie 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 is being 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).

[4] 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 critical. 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.

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[5].

This capability has been included in the rebuilt Macquarie Valley 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 on 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 Plan Limit 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 3.2.4 on the implementation of the policy.

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 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 Energy Environment and Science division.

[5] The process of assessing eligible works is described in *Guideline for the implementation of the NSW Floodplain Harvesting Policy* (DPIE 2020)

A summary of the analysis and recommendations were provided for stakeholder consultation to seek feedback (DPI 2018a) and outcomes of the consultation were published (DPI 2018b).

The proposed accounting rules for each 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 except where an overdraw is required to retain contaminated rainfall runoff from developed areas.
- The account is debited annually for all floodplain harvesting in that year, allowing for exclusions such as rainfall runoff harvesting during exempt periods.
- 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[6].
- 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.

[6] 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 Macquarie Valley (Table 1). The relationship between the scenarios is shown in Figure 2.

Table 1 Scenarios developed to implement the floodplain harvesting licensing framework in the Macquarie Valley

	Scenario name	Description, including title used in Figure 2
(a)	Plan Limit Scenario	Plan limit update There are two clauses in the plan limit definition in the WSP; the WSP limit and the Murray Darling Basin Ministerial Council (MDBMC) cap on diversions. The Plan Limit Scenario is whichever has lesser long-term average annual total diversions.
(b)	Current Conditions Scenario	Assess growth Current levels of development and management rules used to estimate the level of diversions without the licensing framework in place and determines 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)	Plan Limit Compliance Scenario	Demonstrate plan limit compliance An evolution of the Current Conditions Scenario with the floodplain harvesting licensing framework applied to bring diversions back to statutory limits, with shares of the total floodplain harvesting entitlements based on distribution of floodplain harvesting volumes from (c)

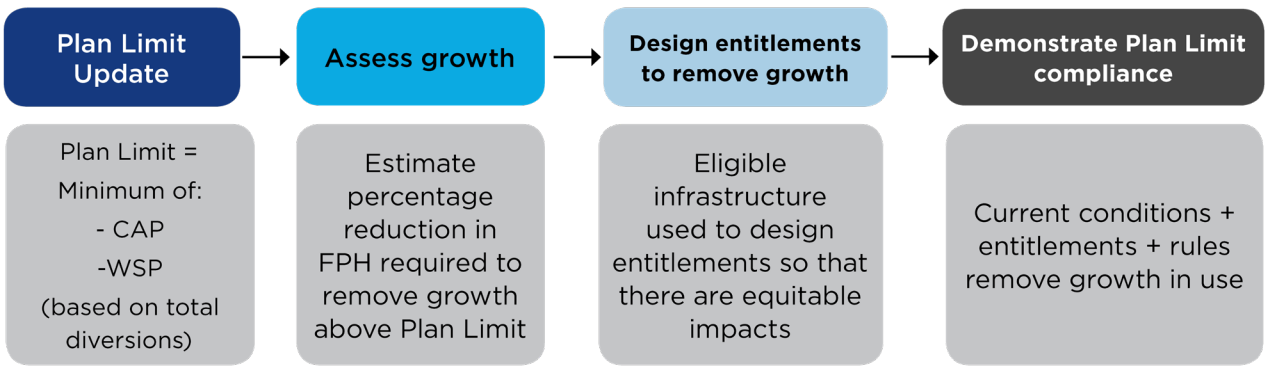

Figure 2 Process for using the model scenarios to determine floodplain harvesting entitlements. The four steps, moving from left to right, reflect the relationship between the four model scenarios

It is worth noting that some of the steps shown in Figure 2 are not required if there is no overall growth in water use, and the design of floodplain harvesting entitlements would be designed to avoid impacts to eligible floodplain harvesting properties.

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 (DPIE Water 2021a). The Model Build report should be read in conjunction with this report for further detail on how that scenario was developed and model performance assessed. Changes from the 2008/09 Scenario are described in Section 3.3.

3.2.1 Plan Limit Scenario

The plan limit is to be assessed through two separate scenarios as defined in the Macquarie WSP and as described in Section 2.3. Depending on results, one of these scenarios becomes the Plan Limit Scenario. This is reported in Section 4.1.

Table 2 The two scenarios used to assess the plan limit

Scenario name	Description
Water Sharing Plan (WSP) Scenario	Reflects the level of development at June 2000, the maximum crop areas and crop mix at June 1994 and management arrangements set out in the Macquarie WSP
Cap Scenario	Reflects agreements made under the Murray Darling Basin Ministerial Council Cap on diversions. For the Macquarie Valley, as for most valleys in the basin, this refers to the development levels and management arrangements in place at 1993/94

The varying levels of development and management rules that should be used in each scenario are summarised in Table 3. Both scenarios have been built from the 2008/09 Scenario – this means that all other parameters are the same as those used in that scenario and as described in the companion Model Build report (DPIE Water 2021a).

The Cap Scenario has been initially configured using farm infrastructure and water management rules in place in 1993/94, but with deliberately conservative crop area planting assumptions that produce total valley crop areas that are well below the previously calibrated cap model. Despite using these initial conservative assumptions, long-term average diversions under the Cap Scenario are still higher than the WSP Scenario. The additional work to calibrate the Cap Scenario will be finalised before the determination of floodplain harvesting licences.

Table 3 Levels of development and management rules used in the Cap and WSP scenarios

Component	Cap Scenario	WSP Scenario
On-farm storage (OFS) capacity	30 June 1994	30 June 2000
OFS pumps	30 June 1994	30 June 2000
Developed area	30 June 1994	30 June 2000[1]
River pumps	30 June 1994	30 June 2000
Water management rules	1993/94	As per the WSP
Resource assessment	Annual accounting	Carryover accounting as per WSP

[1]The maximum area of crops is still constrained to 1994 levels as required by the Macquarie WSP.

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 Macquarie and Cudgegong regulated river system, and existing management arrangements as defined under the Macquarie 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.

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.

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 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. For the Macquarie Valley, these scenarios are the same.

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.

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[7]. 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 Compliance Scenario)

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
- 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 use the distribution of shares as at 199/94 and 2000 respectively. The Eligible Development Scenario and the 2008/09 Scenario use the distribution of shares at 1 July 2009. The Current Conditions Scenario uses the distribution of shares at 30 June 2016. The total volumes are very similar (Table 4).

Table 4 Total Valley scale entitlements for scenarios (shares)

Entitlement type	CAP Scenario	WSP Scenario	Eligible development Scenario	Current Conditions Scenario
Local water utilities / high security[1]	41,792	41,792	41,792	41,792
General security	620,000	632,814	632,716	632,716
Supplementary access	N/A[2]	51,017	50,326	50,326

[7] The utility program was developed outside of the Macquarie Valley model for efficiency (run-time) reasons.

[1]Excludes entitlements for the towns outside of the regulated river system.

[2]Supplementary licences were not issued until 2004. However, the off-allocation access for general security licences that was replaced by Supplementary access licences was limited to a maximum of 50,000 ML each year.

A significant amount of NSW entitlement was purchased by the Commonwealth and NSW governments for environmental water use[8]. This entitlement has continued to be represented as a consumptive water use with an irrigation pattern in the Current Conditions Scenario as not enough is known regarding how this Held Environmental Water (HEW) will be used for environmental watering. This issue has been addressed in other reporting for Basin Plan compliance. We plan to explicitly represent how HEW is used in future versions of the model.

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

[8] The Water Licensing System (WLS) data for the 2019/2020 water year indicates that 174,643 ML of general security shares, and 9,744 ML of supplementary access shares are held by the NSW and Commonwealth governments for environmental water use. The combined total represents around 25% of the total shares in the Macquarie Valley regulated river system.

Table 5 On-farm development data types and sources of information used for each scenario

Farm development type	Plan Limit Cap Scenario	Plan Limit WSP Scenario	Eligible Development & Individual Impact scenarios	Current Conditions & Valley Scale Compliance scenarios	Data sources
On-farm storage capacity (GL)	30 June 1994	30 June 2000	3 July 2008[1]	2020	LIDAR / storage survey
On-farm storage pump capacity (ML/d)	30 June 1994	30 June 2000	3 July 2008[1]	2020	NRAR works data[2]
Floodplain harvesting intake rate (ML/d)	30 June 1994	30 June 2000	3 July 2008[1]	2020	NRAR works data[2]
Installed river pump capacity (ML/d)	30 June 1994	30 June 2000	3 July 2008	2014	NRAR works data[2], or Farm survey[3]
Maximum irrigable area (ha)	30 June 1994	30 June 1994	3 July 2008	2014	Farm survey[3], or remote sensing4
Undeveloped farm area (ha)	30 June 1994	30 June 2000	3 July 2008	2014	Farm survey[3], or remote sensing[4]

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

2 NRAR works data are 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 does include 1993/94 and 99/00 so we have used that data for the Cap and WSP scenarios.

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 6. These data include all regulated Water User Nodes in the Macquarie regulated river system (there is one unregulated water user node in the model that is not included in reporting of model results).

Table 6 Estimates for on-farm development levels for scenarios

Farm development description	Plan Limit Cap Scenario	Plan Limit WSP Scenario	Eligible Development Scenario	Current Conditions Scenarios
On-farm storage capacity (GL)	71	135	144	174
On-farm storage pump capacity (ML/d)	4,259	14,185	14,534	14,437
Floodplain harvesting intake rate (ML/d)	5,654	19,903	20,269	21,017
Installed river pump capacity (ML/d)	12,588	16,134	19,028	19,096
Maximum irrigable area (ha)	122,075	134,523	131,350	131,350
Undeveloped farm area for eligible properties (ha)	77,297	101,175	101,175	101,175

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

Installed river pump capacity was based on farm survey data for all floodplain harvesting properties, and on earlier survey data for other relatively small water users.

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[9].

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.

[9] Rates are described in Appendix G of the companion Model Build Report (DPIE Water 2021a)

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[10].

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

The developed area refers to the area developed for irrigated cropping. Both developed and undeveloped areas were based on farm survey data for all floodplain harvesting properties.

The rainfall runoff from each type of area is configured separately in the model as described in the companion Model Build report (DPIE Water 2021a)

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 (NSW 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, and adjusted where appropriate to improve the model's reproduction of observed behaviour.

3.3.4 Management rules

All scenarios, with the exception of the Cap Scenario, include the Macquarie WSP rules as described in the companion Model Build report.

The Cap Scenario includes a range of water management rules that pre-date the Macquarie WSP, including supplementary access rules, environmental flow rules, and allocation 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.

[10] These rate exceptions are further described, with examples, in Appendix G of DPIE Water (2021a).

4 Results

The key results from running the scenarios through the Macquarie Valley 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.

4.1 Plan Limit Scenario results

The *Water Sharing Plan Scenario* has a smaller long term average annual total diversion than the *CAP Scenario* (Table 7). This means that the *Water Sharing Plan Scenario* defines the plan limit and is referred to hereafter as the *Plan Limit Scenario*.

Table 7 Long term average annual total diversion under the Plan Limit CAP and Plan Limit Water Sharing Plan scenarios

Diversion component	Long term average (GL/y)	
	CAP Scenario[1]	*Water Sharing Plan Scenario*
General and High Security	323.4	301.7
Supplementary access	24.1	13.7
Floodplain harvesting	14.0	41.5
Overbank flow harvesting	3.4	19.6
Non-exempt rainfall runoff harvesting	8.4	13.0
Exempt rainfall runoff harvesting	2.2	8.9
Total	**361.6**	**356.9**

[1]The CAP Scenario has been initially configured using farm infrastructure and water management rules in place in 1993/94, but with deliberately conservative crop area planting assumptions. The long-term average diversion of 361.6 GL/year reported in Table 7 is well below the long-term average diversions of 447 GL/year[11] (excluding floodplain harvesting) produced by the MDBA accredited Cap model. It is clear that, when the CAP Scenario calibration is completed, the long-term average diversions under the CAP Scenario will be significantly higher than the Water Sharing Plan Scenario.

[11] Based on modelled results from 1890 to 2008.

4.2 Growth in use assessment

The Plan Limit Scenario and Current Conditions Scenario were both configured in the Macquarie Valley 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 8.

Some decisions on eligible infrastructure are still pending, or have been made after modelling has been prepared for this report. This is not expected to change the results of the growth in use assessment, but the results reported here will be updated when these decisions are finalised.

Table 8 Predicted long term (1895 to 2009) average diversions (GL/year) under the Plan Limit Scenario and Current Conditions Scenario to determine growth in use

Diversion category	Plan Limit Scenario (GL/year)	Current Conditions Scenario (GL/year)
General and high security	301.7	266.6
Supplementary access	13.7	11.24
Floodplain harvesting	41.5	51.15
Overbank flow harvesting	19.6	26.9
Exempt rainfall runoff harvesting	8.9	10.2
Non-exempt rainfall runoff harvesting	13.04	14.0
Total	**356.9**	**328.9**

With the tailwater exemption in place, these results show that floodplain harvesting has increased by 9.6 GL/year (23%) above the level in Plan Limit Scenario, there has not been any overall growth in water use. Total long-term average diversions (less exempt rainfall runoff) have decreased by 28 GL/year, a decrease of about 8%.

This growth in use assessment is based on the best available modelling of current conditions at this time. However, the modelling contains a number of key assumptions that include the continuing representation of Held Environmental Water as an irrigator, the latest infrastructure and irrigation use behaviour, and operational water management. The department is committed to updating the modelling for annual growth in use assessments to better represent these components. For the Macquarie Valley, there is a significant volume of HEW, and changes in water management and irrigator behaviour have a significant influence on the growth in use assessment.

4.3 Plan Limit compliance results

The implementation of the Valley Scale Compliance Scenario (Section 3.2.4) has demonstrated that if long-term average annual diversion volumes for the floodplain harvesting component of the Macquarie Valley regulated river system remain at the current levels, total long-term average annual diversions are still within the plan limit levels as reported in Table 9.

Table 9 Modelled long term (1895 to 2009) average annual diversions (GL/year) under the Plan Limit Compliance Scenario compared to the plan limit

Diversion category	Plan limit (GL/year)	Plan Limit Compliance Scenario (GL/year)
General and high security	301.7	268.0
Supplementary access	13.7	11.14
Floodplain harvesting	41.5	47.2
Overbank flow harvesting	19.6	23.2
Exempt rainfall runoff harvesting	8.9	10.1
Non-exempt rainfall runoff harvesting	13.0	13.9
Total	**356.9**	**326.1**

The entitlements and account management rules will be applied to avoid impacts on floodplain harvesting diversions at the current levels of overall water use. However, if there is future growth in water use, the entitlements and account management rules will provide the mechanism to ensure diversions remain within the plan limit.

There is a small reduction in long-term average diversions under the Valley Scale Compliance Scenario compared to current conditions that occurs as a result of a small number of existing floodplain harvesting works that have been determined to be ineligible, and were not included in the design of the floodplain harvesting licences.

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 policy, there has been significant investment in data and modelling to quantify floodplain harvesting more accurately. This has been incorporated into the current Macquarie Valley model. The development of the model has been described in the companion Model Build report (DPIE Water 2021a).

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 Macquarie WSP. This model will also be used to determine regulated river floodplain harvesting entitlements in the Macquarie regulated river system. Through the analyses reported 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 (DPIE Water 2021a) lists several areas of future work. Three 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
- 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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(NSW) *Water Management Act 2000* No 92. Last updated 2020. https://legislation.nsw.gov.au/~/view/act/2000/92/

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NSW Floodplain Harvesting Policy. First published May 2013, updated September 2018. http://www.water.nsw.gov.au/__data/assets/pdf_file/0012/548499/floodplain_harvesting_*Policy*.pdf. Referred to in this report as the policy

(Draft) *Floodplain Management Plan for the Macquarie Valley Floodplain 2018*. https://www.industry.nsw.gov.au/__data/assets/pdf_file/0010/146296/Draft-Floodplain-Management-Plan-for-the-Border-Rivers-Valley-Floodplain-2018.pdf

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DPI (2018a) https://www.industry.nsw.gov.au/__data/assets/pdf_file/0005/145427/floodplain-harvesting-Policy-consultation-paper.pdf

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DPIE Water (2021b). Environmental outcomes of implementing the Floodplain Harvesting policy in the Macquarie Valley. NSW Department of Planning, Industry and Environment – Water.

Tim Morrison, Cat-Tuong Chu (2018) Storage Bathymetry Model Update and Application (Macquarie Valley), report prepared by Hydrospatial Pty Ltd for Department of Industry. 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 10 illustrates how the proposed 5 yearly 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 10 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 10 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
Total	**60,197**		**54,166**	

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 3 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 11).

Table 11 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 G.4 of the companion Model Build report (DPIE Water 2021a). 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.

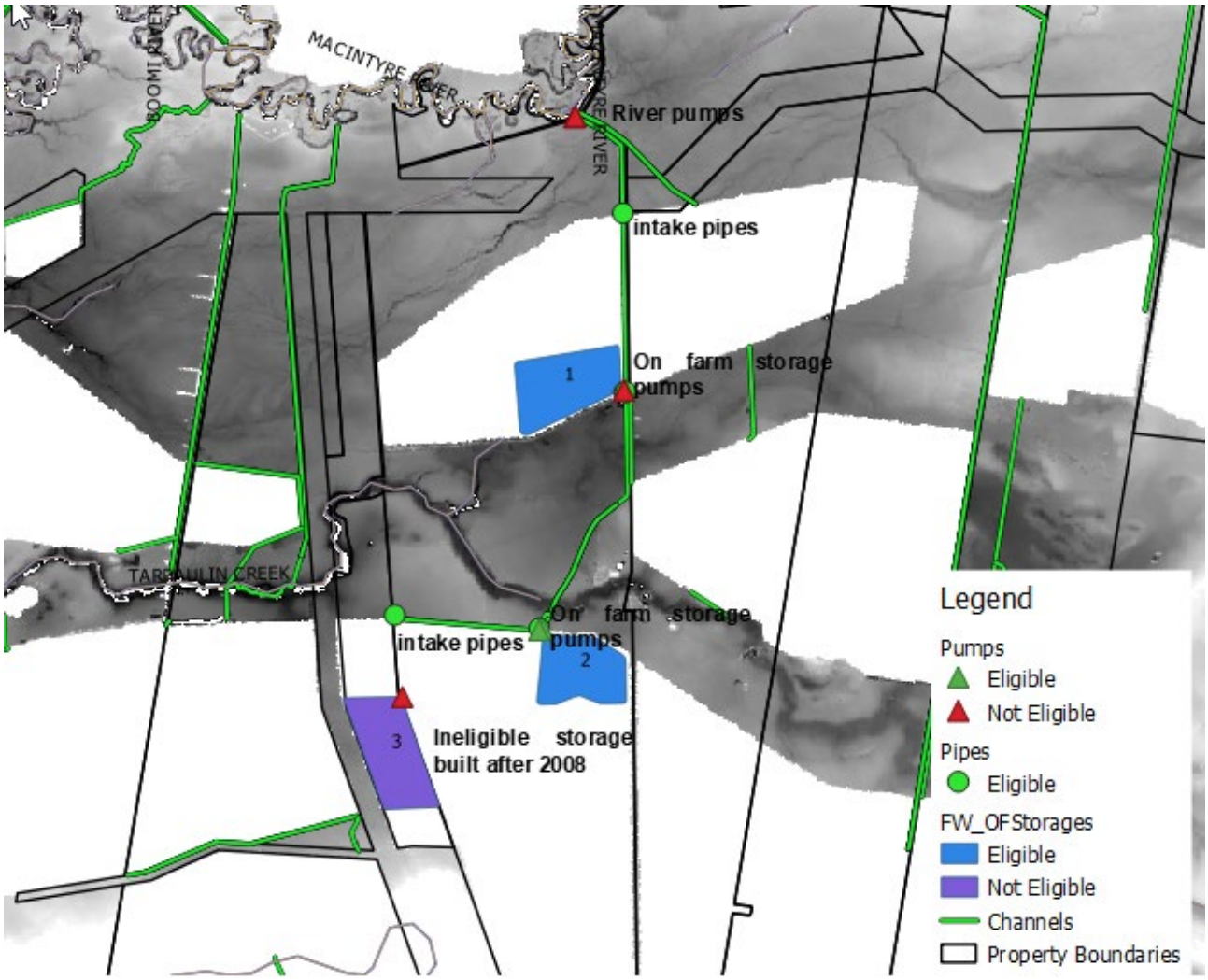

Figure 3 Example property with multiple storages and intakes

Appendix C Model version

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

- File Name MACQ_EW_20210308.sqq
- IQQM Version iqmgui_v7_101_0_rc1

Each Scenario is implemented by selecting a different scenario input set contained within this file.

Table 12 Model scenarios and their filenames

Scenario	Filename
Plan limit	MACQ_BDL_20220908.sqq
Current infrastructure	MACQ_CC_preFPH_20220908.sqq
Eligible Development	MACQ_EW_20220908.sqq
08/09 Scenario	MACQ_IEW_20220908.sqq
Current infrastructure with floodplain harvesting rules	MACQ_CC_wExempt_20220908.sqq
Cap Scenario	MACQ_CAP_20220908.sqq

Appendix D Glossary and abbreviations

Table 13 Abbreviations and acronyms

Acronym	Expansion
BDL	Baseline diversion limit
LTAAEL	Long term average annual extraction limit
NRAR	NSW Natural Resources Access Regulator
OFS	On-farm storage
SDL	Sustainable diversion limit
WSP	Water Sharing Plan

Table 14 Terms

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 **Error! Reference source not found.**)
Current Conditions Scenario	Model scenario that uses the best available information on most recent known levels of irrigation infrastructure and entitlements (details in Section **Error! Reference source not found.**)
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 (LTAAEL)	The upper limit on 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)
On-farm storage (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.

Term	Description
Plan Limit	The authorised long-term average annual extraction limit as defined in the Water Sharing Plan
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 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 *NSW Floodplain Harvesting Policy*
Water Sharing Plan (WSP) Scenario	Model scenario that reflects the level of development specified in the Water Sharing Plan. For the Macquarie regulated river system, this is the level of development at June 2000 and management arrangements set out in the Macquarie WSP. Candidate for the Plan Limit Scenario (details in Section 3.2.1)