**DISCLAIMER:**

This is a preliminary business case, used to inform decision-making by the Murray-Darling Basin Ministerial Council and Basin Officials' Committee on sustainable diversion limit adjustment mechanism projects.

The document represents the *Business case for modernising supply systems for effluent creeks – Murrumbidgee River* at November 2015.

The NSW Department of Industry is currently developing project summary documents that will summarise project details, and will be progressively published on the Department of Industry website.

Detailed costings and personal information has been redacted from the original business case to protect privacy and future tenders that will be undertaken to deliver these projects.

# Business case for modernising supply systems for effluent creeks – Murrumbidgee River

A Sustainable Diversion Limit Adjustment Measure

WaterNSW

Final business case

30 November 2015

**Document review and authorisation**

**Job Number: 27-A-04**

| # | Final/Draft | Date | Author | Issued to | Comment |
|---|---|---|---|---|---|
| 1.0 | Draft | 24 June 2015 | [redacted] | WaterNSW | Early draft |
| 2.0 | Draft | 26 June 2015 | [redacted] | WaterNSW | Full first draft |
| 3.0 | Draft | 28 June 2015 | [redacted] | WaterNSW | Full first draft - revised |
| 4.0 | Draft | 29 June 2015 | [redacted] | WaterNSW & Office of Water | Revised draft |
| 5.0 | Draft | 31 July 2015 | [redacted] | WaterNSW & Office of Water | Revised draft |
| 6.0 | Draft | 5 August 2015 | [redacted] | WaterNSW | Revised draft |
| 7.0 | Draft | 7 August 2015 | [redacted] | WaterNSW | Revised draft |
| 8.0 | Final | 10 August 2015 | [redacted] | WaterNSW & DPI Water | Final Business Case |
| 9.0 | Final | 14 August 2015 | [redacted] | WaterNSW & DPI Water | Final Business Case |
| 10.0 | Final | 17 August 2015 | [redacted] | WaterNSW & DPI Water | Final Business Case |
| 11.0 | Final | 24 August 2015 | [redacted] | WaterNSW & DPI Water | Final Business Case |
| 12.0 | Final | 30 September 2015 | [redacted] | WaterNSW & DPI Water | Final Business Case |
| 13.0 | Final | 21 October 2015 | [redacted] | WaterNSW | Final Business Case |
| 14.0 | Final | 30 October 2015 | [redacted] | DPI Water | Final Business Case |

Published by the NSW Department of Primary Industries, Water

*Business case for modernising supply systems for effluent creeks – Murrumbidgee River*

First published November 2015

**More information**

www.dpi.nsw.gov.au

**Acknowledgments**

This report has been prepared by R M Consulting Group.

*Front cover: Colombo Creek* [redacted] *RMCG)*

# Contents

## Figures

## Tables

# Abbreviations

| | |
|---|---|
| Baseline Conditions | The conditions that existed in June 2009, prior to the implementation of the Basin Plan. |
| Basin Plan | The Murray-Darling Basin Plan adopted by the Commonwealth Minister under section 44 of the Water Act 2007 (Cth) on 22nd November 2012. |
| Benchmark Conditions | The Baseline conditions with the Basin Plan implemented. |
| Block bank | Structure constructed across creek to create weir pool |
| CAIRO | Computer Aided Improvements to River Operations - current WaterNSW water flow monitoring tool |
| CARM | Computer Aided River Management - more developed control system being introduced by WaterNSW |
| CICL | Coleambally Irrigation Cooperative Limited |
| EPBC | Environment Protection and Biodiversity Conservation Act (1999) |
| GL | Gigalitre, i.e. 1,000 megalitres |
| Guidelines | Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases |
| IPART | Independent Pricing and Regulatory Tribunal - NSW Agency along with the ACCC involved in setting prices for WaterNSW |
| IQQM | The Integrated Quantity and Quality Model (IQQM) - the main model used by agencies in NSW for sharing and management of surface water |
| IVT | Inter Valley Transfer |
| LLS | NSW regional agency - Local Land Services |
| MDBA | Murray Darling Basin Authority |
| MIL | Murray Irrigation Limited |
| ML | Megalitre, ie 1,000,000 litres |
| NoW | NSW Office of Water - now DPI Water |
| OEH | NSW Office of Environment and Heritage |
| SCADA | Supervisory control and data acquisition - involves remote control of equipment through radio or telecommunications signals |
| SDL | Sustainable Diversion Limit - the maximum allowable sustainable limit on take |
| SDL-offset | Works and measures to allow an increased SDL with equivalent environmental outcomes |
| SDLAAC | SDL adjustment assessment committee - cross jurisdictional committee with responsibility for assessing proposals under the SDL-offset program |
| TEC | Threatened ecological communities |
| YACTAC | Yanco Creek and Tributaries Advisory Council |

# Executive summary

## ES1. Modernising supply systems from the Yanco Creek system

This business case proposes investment to modernise the supply arrangements for diversions from the Yanco Creek system. Current arrangements involve high flows down lengthy creek systems and result in significant water losses, poor levels of service and disrupted ecosystem functionality. The business case has identified a series of controls and alternative supply arrangements that will meet the same level of demand, at a higher level of service, with lower losses.

A ‘water saving’ of 14.4GL/year generated can then be converted to a 17,000 unit share General Security licence to be issued to the Commonwealth and used to deliver greater environmental outcomes than in the draft Basin Plan. It is proposed that a rules-based approach will be taken to implement arrangements to ensure that potential third party impacts are mitigated.

The project relates to irrigation supply systems located in SDL resource code SS15 “Murrumbidgee”. WaterNSW is the project proponent and has prepared this business case in consultation with DPI Water, the Office of Environmental and Heritage, DPI Fisheries, the MDBA and the Commonwealth Department of the Environment, through funding from the Australian Government as part of the SDL-offset initiative. WaterNSW is the project owner and will have responsibility for oversight of the project implementation.

## ES2. Locality

The project reviewed supply systems for irrigation diversions in five project areas supplied from the Murrumbidgee River between Narrandera and Jerilderie in New South Wales. The project areas fall within the SDL Resource Code SS15 “Murrumbidgee”.  The project will also have a smaller impact on the surface water resource SS14 “NSW Murray” as some supplementary flows will be sourced from the Murray through Murray Irrigation Limited.

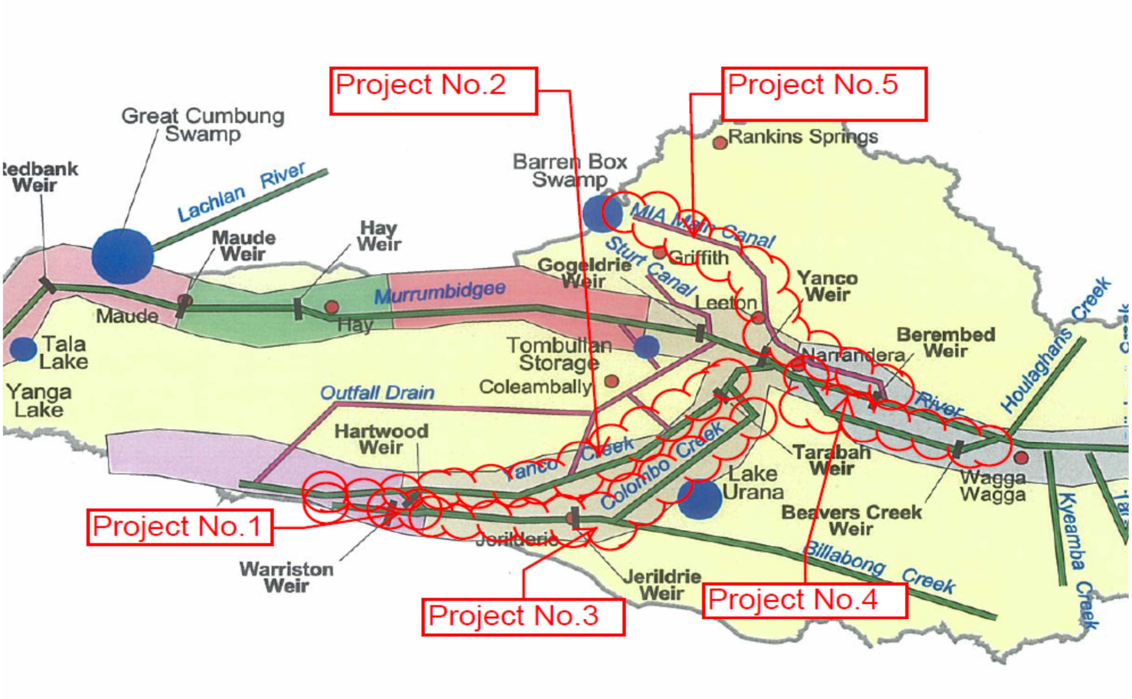



**Figure ES-1 Project area – effluent creeks of the Murrumbidgee River around Narrandera, NSW**

The five project areas are:

- Project Area 1: Forest Creek - between Billabong Creek and Warriston Weir
- Project Area 2: Yanco Creek - from the Murrumbidgee offtake to the confluence with the Billabong Creek
- Project Area 3: Colombo and Billabong Creeks - from the Yanco Creek to the confluence of the Billabong Creek with the Edward River
- Project Area 4: Old Man Creek/Beavers Creek - from the Beavers Creek Regulator to the confluence with the Murrumbidgee River
- Project Area 5: Bundidgerry Creek - from the Berembed offtake to the Murrumbidgee Irrigation supply point just upstream of Narrandera.

This business case focuses on Project Areas 1 to 3. Project Area 4, Old Man's Creek, was not progressed as it was not cost effective, while Project Area 5, Bundidgerry Creek, was identified as technically feasible but expensive to deliver and of marginal value. Further details of both of these project areas are provided in Annex 16.

## ES3. Proposed project approach

WaterNSW manages the Yanco Creek system to deliver around 110GL/year to 480 licensees along multiple creeks, listed above in Project Areas 1 to 3. The present arrangement involves the great majority of that irrigation supply being delivered the full length of the system from the Murrumbidgee at the Yanco Weir off-take. This involves high flows along 800km of sinuous creeks resulting in raised operational surplus and transmission losses. The continuous high 'unseasonal' summer flows also result in poor ecological outcomes.

### a) Operational surplus

There are few controls over flows within the 800km creek system and very long order periods, of up to 26 days between releases from the dam and final deliveries to some diverters. That makes it very difficult to implement effective order management or control. As a result, customers place a generic order and WaterNSW maintains high levels of flow in the Yanco system throughout the season to avoid risks of non-supply. The outcome is that flows within the system are greater than would be required to meet actual irrigation demand and so end of system flows at Darlot are generally higher than the target set in the *Murrumbidgee Regulated River Water Sharing Plan*.

### b) Transmission losses

Use of the lengthy sinuous creeks as a supply system results in raised losses. These are exacerbated by running the creeks at a high level, as this enhances evaporative losses from the wider creek width, spillage into flood runners and side billabong channels, and by encouraging transpiration from riparian vegetation. The construction of weirs and block banks along the length of the creek system has increased the width of the creeks and extended their length along back flood runners, further increasing the area for evaporation and seepage.

This business case proposes a four pronged approach to improve operational efficiency and generate water savings within the creek system (see Figure ES-2):

1. **Monitoring:** provision of additional monitoring capability to provide enhanced information in real-time to the system operator and water users on flows and levels throughout the creek system

2. **Controls:** provision of additional controls to allow re-regulation and tighter flow control and management along the length of the creek system
3. **Alternative supplies:** provision of alternative supply points into the creek system from the neighbouring irrigation corporations, at locations far closer to the end user, to better align demand and supply
4. **Operating rules:** codification and documentation of the revised operational protocols to optimise use of the new controls and improve diversion efficiency as well as social and environmental outcomes

This will convert the creek supply system into a highly efficient delivery system that generates water savings, which will be converted into a callable entitlement, at the same time as providing enhanced levels of service and environmental and social outcomes.

## ES4. Outcomes

IQQM modelling undertaken for the project identifies that the proposed package of measures will allow the same consumptive use to be delivered as in the Basin Plan benchmark but with reduced transmission losses and operational surplus. The modelling identified water savings of 14.4GL, equivalent to a 17,000 unit share General Security licence.[1]

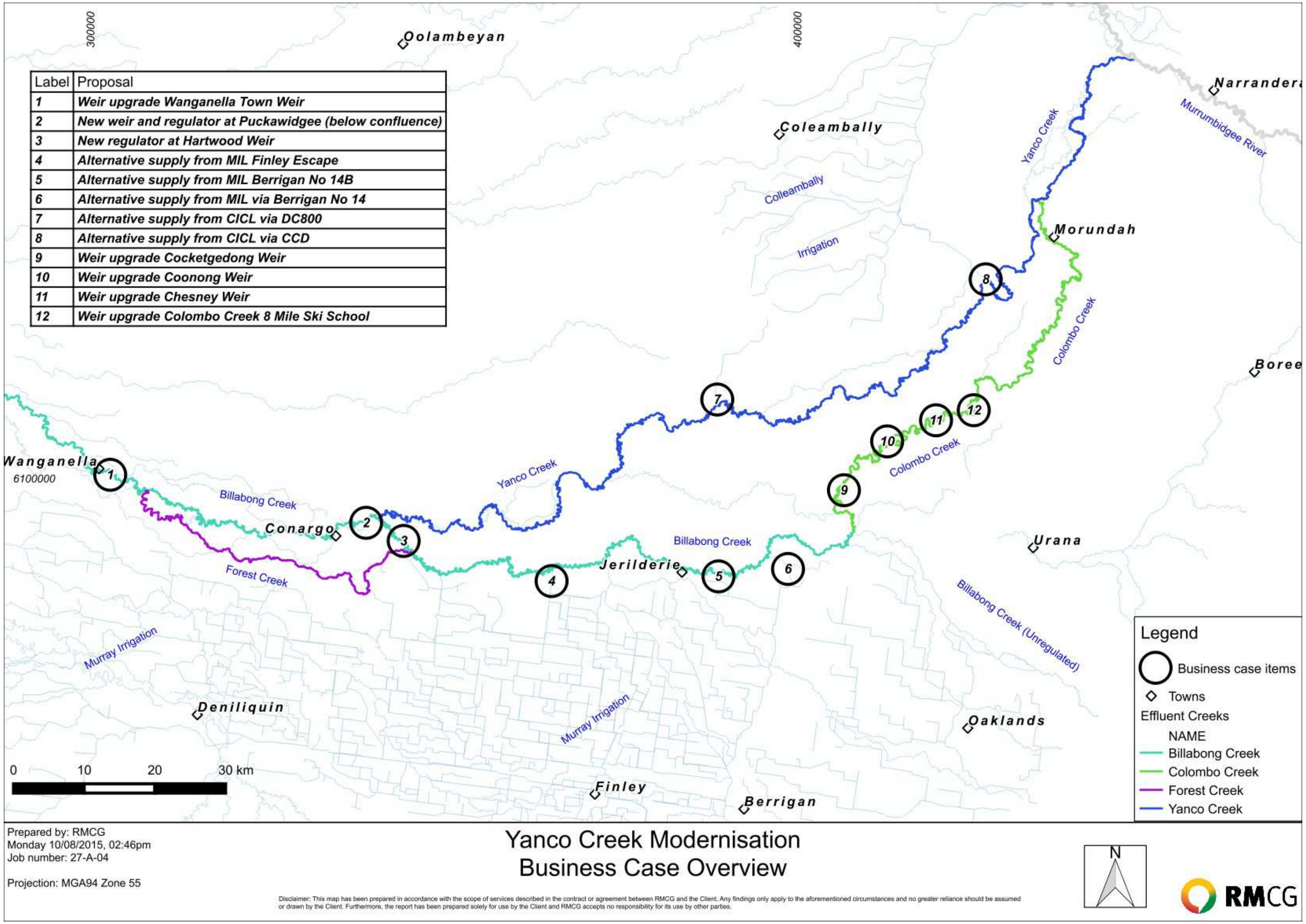
However, it is expected that more detailed simulation of river losses and representation of irrigation demand in parts of the benchmark is likely to indicate that further savings can be made. The figure of 14.4GL has been retained for this business case. However, analysis of representative year data on releases and end-of-system flows suggests that this figure is likely to be highly conservative, as the data shows current transmission losses are about 90GL and end-of-system flows are 150GL above minimum passing flows.

The proposed approach will also generate wider socio-economic and environmental benefits as it will:

- provide a robust platform for the introduction of an enhanced environmental watering regime as it will reduce the current dominance of unnaturally high diversion flows throughout the irrigation season, allowing greater variability in flows to meet eco-system outcomes,
- promote improved fish habitat and movement through the introduction of flows and fishways at weir pools and modifications to block banks on the creeks,
- enhance levels of service for diverters as they will have access to a far shorter ordering schedule allowing them to match orders more closely with demand, and
- maintain social and amenity values from the use of the creek system for urban water supply and recreation.

[1] DHI (2015), *Murrumbidgee Effluents SDL*, 5 August 2015 - see Annex 2.

## Figure ES-2: Yanco Creek system - Location of proposed works and alternative supply points




| Label | Proposal |
|---|---|
| 1 | *Weir upgrade Wanganella Town Weir* |
| 2 | *New weir and regulator at Puckawidgee (below confluence)* |
| 3 | *New regulator at Hartwood Weir* |
| 4 | *Alternative supply from MIL Finley Escape* |
| 5 | *Alternative supply from MIL Berrigan No 14B* |
| 6 | *Alternative supply from MIL via Berrigan No 14* |
| 7 | *Alternative supply from CICL via DC800* |
| 8 | *Alternative supply from CICL via CCD* |
| 9 | *Weir upgrade Cocketgedong Weir* |
| 10 | *Weir upgrade Coonong Weir* |
| 11 | *Weir upgrade Chesney Weir* |
| 12 | *Weir upgrade Colombo Creek 8 Mile Ski School* |

## ES5. Costs and risks

### a) Capital construction costs

The estimated capital construction cost for the Yanco Creeks modernisation project is $32 million. This total is comprised of a number of different categories reflecting the nature of the works proposed. The elements are specified in Table ES-1 below and their locations are shown on Figure ES-2 above.

[redacted]

The costs include a contingency of 50% on capital expenditure items where there is uncertainty. This targets the proposed works to be managed by WaterNSW, i.e. the regulators and the controls within weir pools. However, the contingency is not applied to costs incurred by the irrigation corporations (as these are subject to commercial contractual terms) nor to the costs of the proposed fishways (as these are well established).

### b) Operating costs

WaterNSW will incur on-going costs from the ownership and operation of the assets. These costs will be recovered through its annual water charges - subject to oversight from the Independent Pricing and Regulatory Tribunal (IPART).

These ongoing costs will include water charges from the irrigation corporations for the use of their infrastructure, both for existing and new alternative water supply systems, and from the operational and maintenance costs related to the new assets arising from the implementation of this proposal.

[redacted]

### c) Risks

The suite of proposed works and measures involve largely small-scale, proven approaches in locations which have already been subject to significant disturbance.

A comprehensive risk assessment was made of the proposed suite of works and a revised assessment after appropriate mitigation controls had been applied. This confirmed that all residual risks were negligible or could be adequately mitigated.

## ES6. Stakeholder engagement

A staged engagement strategy was implemented. This involved:

- Meetings with local WaterNSW staff to take advice and test proposed solutions
- A workshop with agencies to establish the policy context and identify likely issues to address
- Meetings with key regional and local stakeholders through a series of visits and meetings along the creek system. There are two main bodies through which this engagement took place:
  - The WaterNSW Murrumbidgee Customer Service Committee
  - Yanco Creek and Tributaries Advisory Council (YACTAC)
- Meetings with landholders and local councils to test the practical aspects of the proposed approach.

The broad approach and the suite of specific proposals are strongly aligned with the stated objectives of the local community and have their in-principle support.

# 1 Introduction

## 1.1 Modernising Yanco Creek supply systems

This business case proposes investment in works to modernise the supply arrangements for diversions from the Yanco Creek system, an effluent creek off the Murrumbidgee.

Current arrangements involve high flows down lengthy creek systems and result in significant water losses, poor levels of service and disrupted ecosystem functionality. The business case has identified a series of controls and alternative supply arrangements that will meet the same level of demand, at a higher level of service, with lower losses. The 'water saving' generated can then be converted to an environmental entitlement and used to deliver additional environmental outcomes than under the Basin Plan benchmark conditions.

## 1.2 Murrumbidgee business case package

This business case is one of three related SDL-offset initiatives being progressed for the Murrumbidgee River system. The three business cases are closely related and comprise:

- Computer Aided River Management (CARM) along the Murrumbidgee River.
- Yanco Creek off-take regulator at the Murrumbidgee River - to improve flow management.
- Modernising supply systems for effluent creeks – Murrumbidgee River (this business case).

The three projects are independent and each will generate an SDL offset. However, integration between the three initiatives creates significant synergies.

**CARM:** the CARM project will enhance the outcomes in this business case by providing tools for tighter operational control of the rest of the Murrumbidgee regulated river system. It will also provide greater control and modelling of flows in the Yanco creek system. That will allow environmental flows and consumptive demands to be met with greater precision so reducing 'operational surplus' from the need to supply a surplus to ensure that requirements are met. This application involves an extension of CARM beyond its current scope.

**Yanco Creek Regulator:** At present, around 10% of raised flows along the Murrumbidgee spill into the Yanco Creek system. The proposed Yanco Creek off-take regulator will allow environmental flows to the mid-Murrumbidgee to be shepherded along the river to achieve targeted environmental watering outcomes without loss of this water down the Yanco Creek. The regulator will also enable greater control of inflows to the Yanco Creek system from the Murrumbidgee River. That will allow greater precision in the matching of supply and demand in the Yanco Creek system to meet environmental and consumptive demands.

**Modernising the Yanco supply system:** (this business case) will reduce water losses in distribution while retaining environmental values. New licensed entitlement equivalent to the long term water saving of 14.4GL will be issued to the Commonwealth Environmental Water Holder. This held water can then be targeted to meet specific environmental flow requirements where required.

The proposals in this business case will have limited impact on other parallel initiatives and business cases including the Constraints Management Strategy for the Murrumbidgee or other supply measure proposals for the Murrumbidgee or the Murray.

## 1.3 Background to SDL adjustments

The Murray-Darling Basin Plan was prepared by the Murray-Darling Basin Authority (MDBA) and signed into law by the Commonwealth Minister for Water on 22 November 2012, under the Commonwealth Water Act 2007. The *Intergovernmental Agreement on Implementing Water Reform in the Murray Darling Basin* subsequently outlined the commitments and responsibilities of the participating jurisdictions and the program for putting the Basin Plan into action.

The Basin Plan sets legal limits on the amount of surface water that can be extracted from the Basin for consumptive use from 1 July 2019 onwards. The sustainable diversion limits (SDLs) for surface water are currently set at a reduction of 2,750 GL on current extraction levels. That SDL value has been modelled to create a certain level of environmental outcome. Under the provision in Chapter 7 of the Basin Plan and the *Intergovernmental Agreement on Implementing Water Reform in the Murray Darling Basin*, projects that can help achieve these environmental outcomes by improved use and management of the water would allow the SDLs to be adjusted, (the level of water recovery to be reduced), reducing impacts on regional communities.

The Basin Plan allows for up to 650 GL of the 2,750 GL of water recovery to be achieved through projects that provide improved use and management of environmental water. The Basin states and the Murray-Darling Basin Authority have established guidelines for the drafting of business cases for such proposals.[1] Five different forms of intervention are identified in the guidelines:

- **Environmental works and measures at point locations**: Infrastructure-based measures to achieve the Basin Plan's environmental outcomes at specific sites along the river using less environmental water than would otherwise be required.
- **Water efficiency projects**: Infrastructure-based measures that achieve water savings by reducing water losses through, for example, modified wetland or storage management.
- **Operating rules changes**: Changes to policies and operating rules that lead to more efficient use of water and savings and contribute to achieving equal environmental outcomes with less water.
- **Physical constraint measures**: Ease or remove physical constraints on the capacity to deliver environmental water.
- **Operational and management constraint measures**: Changes to river management practices.

## 1.4 Proposed SDL-offset approach

This business case proposes measures to reduce the transmission losses and operational surplus involved in the delivery of water for consumptive use in the Yanco Creek system. This will be achieved by the provision of a combination of four broad approaches:

1. **Monitoring:** additional monitoring capability to provide enhanced information in real-time to the system operator and water users on flows and levels throughout the creek system.
2. **Controls:** additional controls to allow re-regulation and tighter flow control and management along the length of the creek system
3. **Alternative supplies:** alternative supply points into the creek system from the neighbouring irrigation corporations, at locations far closer to the end user to better align demand and supply
4. **Operating rules:** documentation of the revised operational protocols to optimise the new controls to improve diversion efficiency as well as social and environmental outcomes

[1] SDLAAC 2014. *Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases*

Taken together, these measures will generate water savings that can be used to increase the volume of held environmental water that will be available in the Murrumbidgee regulated system compared with the Basin Plan's benchmark conditions.

This Business Case has been prepared in accordance with the SDL: offset Phase 2 Assessment Guidelines[2]. The initiatives in this business case represent two categories of SDL offset supply measure:

- *Water efficiency projects*: the provision of infrastructure and controls to enhance delivery efficiency (covering items 1-3 above); and
- *Operating rules changes*: the introduction of a revised operating regime and procedures that will minimise operational surplus while enhancing levels of service (covering item 4 above).

The proposed project is not an '*environmental works and measures*' initiative, which would have the aim of achieving the Basin Plan's environmental outcomes at specific sites using less environmental water than would otherwise have been required. The business case, therefore, does not attempt to create a revised environmental watering regime or outcome for the creek system, and so does not address ecosystem targets and outcomes. However, the business case does assess the potential third party impacts from the proposed works including impacts on environmental values.

The project will provide additional environmental benefits by reducing the current dominance of irrigation supplies for creek flows during summer months. That will provide a revised watering regime that promotes enhanced ecosystem functionality in line with existing processes within the framework of the Basin Plan objects and long term environmental watering strategies.

The development of any environmental watering strategy does not form part of this business case, which focuses solely on achieving water savings from enhanced efficiency in delivery systems. These water savings will then be converted into additional environmental entitlements that will be held in the major storages in the Murrumbidgee system. It will be up to the discretion of the Environmental Water Holders as to how those entitlements are used to create priority eco-system outcomes.

## 1.5 Eligibility

The project meets the eligibility criteria for Commonwealth supply measure funding as follows:

- The project meets the definition of a 'supply measure' under the Basin Plan.
- The measure is not an 'anticipated measure' - it was not in the benchmark conditions of development.
- The measure will be designed, implemented and operational by 30 June 2024.
- The proposal is not a 'pre-existing' Commonwealth funded project, and has not been approved for funding by another organisation, either in part or in full, other than through financial support to develop this business case.
- The project was assessed under the Phase 1 Guidelines and was approved to proceed to Phase 2.

This business case demonstrates how each eligibility requirement in the Phase 2 SDLAAC Guidelines is met. Annex 1 confirms the application of the different clauses. However, the ultimate outcomes of the proposal will depend on the modelling of different combinations of SDL offset proposals to be completed in 2016 by the Murray-Darling Basin Authority.

[2] SDLAAC (2013), *Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases.*

## 1.6 Proponent and proposed implementing entity

WaterNSW is the project proponent on behalf of the New South Wales Government and has prepared this business case in consultation with the DPI Water, the Office of Environment and Heritage, DPI Fisheries, the MDBA, and the Commonwealth Department of the Environment.

WaterNSW is the project owner and will have oversight responsibility for project implementation. Further information regarding the proposed governance and project management arrangements for implementation is provided in Section 9.

# 2 Project outline

## 2.1 Locality

The project involves supply systems for irrigation demand in five project areas supplied from the Murrumbidgee River in the vicinity of Narrandera, New South (Figure 2-1). These fall within SDL Resource unit SS15 "Murrumbidgee", although the project also triggers actions regarding SS14, "the NSW Murray".

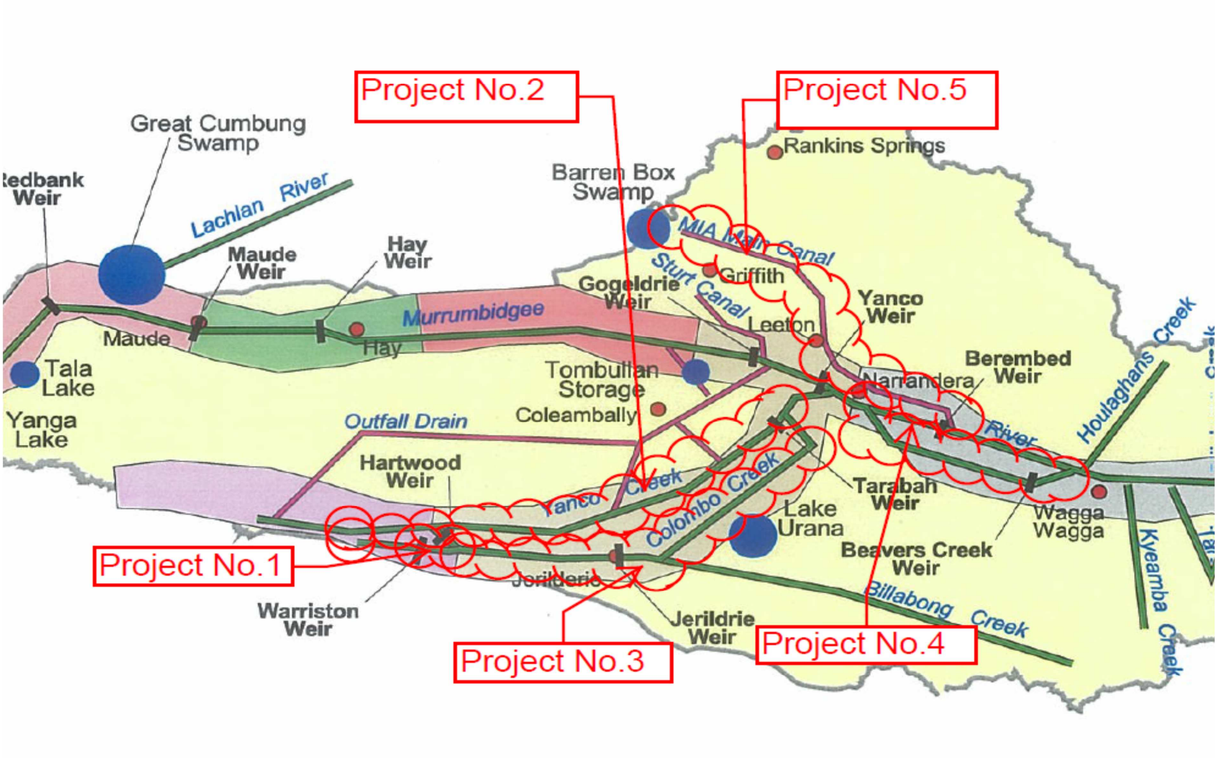



**Figure 2-1 Project area – effluent creeks of the Murrumbidgee River around Narrandera, NSW**

The five project areas reviewed were:

- Project Area 1: Forest Creek - between Billabong Creek and Warriston Weir
- Project Area 2: Yanco Creek - from the Murrumbidgee offtake to the confluence with the Billabong Creek
- Project Area 3: Colombo and Billabong Creeks - from the Yanco Creek to the confluence of the Billabong Creek with the Edward River
- Project Area 4: Old Man Creek/Beavers Creek - from the Beavers Creek Regulator to the confluence with the Murrumbidgee River
- Project Area 5: Bundidgerry Creek - from the Berembed offtake to the Murrumbidgee Irrigation supply point just upstream of Narrandera.

The project area is within the lowland reaches of the Murrumbidgee River on the Riverina Plain, between Wagga Wagga in the east and the confluence of the Billabong Creek with the Edward River at Moulamein in the west. The creeks cover a considerable length, involving some 800km of waterways and encompassing two bioregions – the Riverina and NSW South Western Slopes (Biosis 2015).

**Table 2-1: Length of creeks in project area**

| Project area | Creek | Length (km) |
|---|---|---|
| 1 | Forest Creek (regulated) | 28 |
| 2 | Yanco Creek | 203 |
| 3 | Colombo Creek | 109 |
| 3 | Billabong Creek | 273 |
| 4 | Beavers/Old Man Creek | 64 |
| 5 | Bundidgerry Creek | 41 |
| | **Total** | **746** |

There is a single hydrologic indicator site in the project area, under the Murray Darling Basin Plan, at Darlot on the lower Billabong Creek.

The majority of the floodplain surrounding the creeks is privately owned and managed for agricultural production – mixed cropping, irrigated pastures, horticulture, viticulture, rice and cotton (Beal et al. 2004). The local climate features hot summers and mild winters. Rainfall is winter dominant (June usually being the wettest month), with an average annual rainfall of 400-450mm. Dry periods and droughts are common with 29 drought years experienced between 1900 and 1986 (Beal et al. 2004). Average maximum temperatures are around 32°C in summer and 15°C in winter, with high evaporation rates throughout the year (400mm over autumn/winter and up to 1400mm over spring/summer). Therefore, rainfall does not often contribute substantially to runoff and creek flows (Beal et al. 2004).

## 2.2 Business case priorities

The Feasibility Study in Phase 1 of the SDL offset process covered all five project areas set out above. The first stage in Phase 2 was to review these five project areas to prioritise those that merited inclusion in the business case. The outcome of that review was:

- Yanco Creek system: project areas 1, 2 and 3 are closely integrated as a supply system. The prioritisation process confirmed they provided a highly prospective opportunity to generate significant water saving benefits at reasonable cost and low risk
- Old Man Creek: project area 4: proposals in this area were not progressed as they were not cost effective.
- Bundidgerry Creek: Project Area 5: proposals for Bundidgerry Creek were identified as technically feasible but expensive to deliver and of marginal value.

The Yanco Creek systems were therefore progressed as the target of this business case. Further details on the review of project areas 4 and 5 are provided in Annex 16.

## 2.3 Yanco Creek system: Project areas 1, 2 & 3

The Yanco Creek system has been operated for over 160 years as a “natural carrier” i.e. as a supply channel to deliver water for irrigators and stock and domestic users. It comprises the Yanco Creek itself, the Colombo Creek, the regulated portion of the Billabong Creek and Forest Creek.

Under natural conditions the creeks would have received flows only during high flows in the Murrumbidgee. For example, the Yanco Creek received flows when the Murrumbidgee exceeded 40,000 ML/day, which occurred only 4% of the time (White et al. 1985; Beal et al. 2004).

The creeks have been used to deliver water for stock and domestic use since 1856. Irrigation diversions expanded rapidly in the 1970s and 1980s with the deregulation of the rice industry. The creeks have been modified in a variety of ways to improve their water delivery function (Dalton & Clarke 2009):

- Construction of a cutting at the offtake point of the Yanco Creek from the Murrumbidgee River – allowing flows into the Yanco Creek at lower flows in the Murrumbidgee
- Construction of a weir on the Murrumbidgee downstream of the Yanco offtake to create a weir pool to promote flows down the Yanco Creek
- Construction of over 36 weirs and block banks along the length of the creek systems – holding the water level up so it runs into secondary flood runners, creating weir pools to provide a pump site and to store water over dry periods.

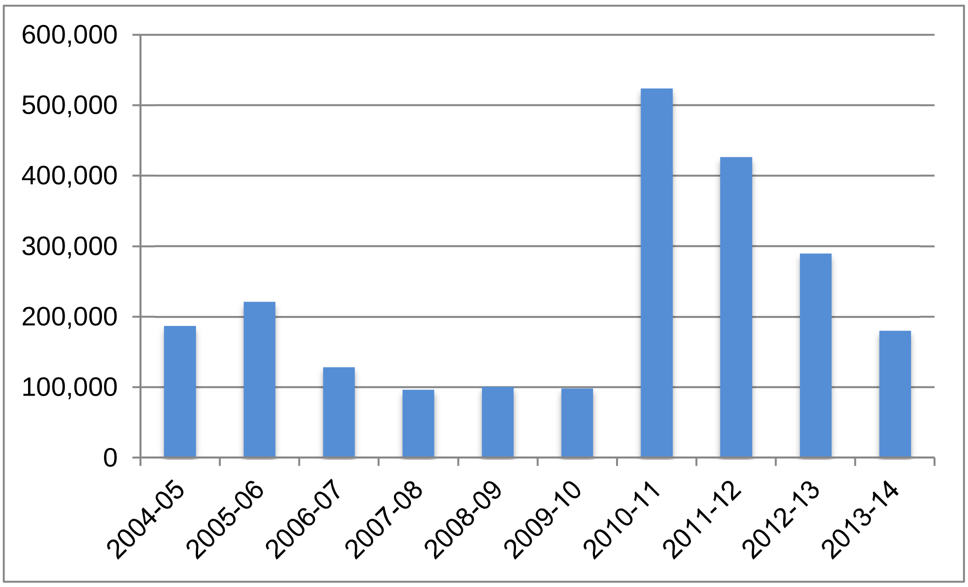
These modifications and the demand for consumptive water have resulted in the creeks' water regime being greatly modified from the natural intermittent flow regime that occurred prior to river regulation. The current water regime involves much larger annual flow volumes, and the system is operated at high levels to ensure water orders are met and the frequency of zero flow conditions (which often dominated these systems) has been largely removed (NSW Office of Water 2015; White et al. 1985).

## 2.4 Flows and demand in the Yanco Creek System

There are around 480 access licences and 230 work approvals in the Yanco creek project area. The large majority of the volume of those licences is for General Security entitlements, although smaller volumes are also allocated to stock and domestic rights and to town supplies. A total volume of 111GL was delivered in 2012/13 - the maximum diversion year between 2004/05 and 2014/15.

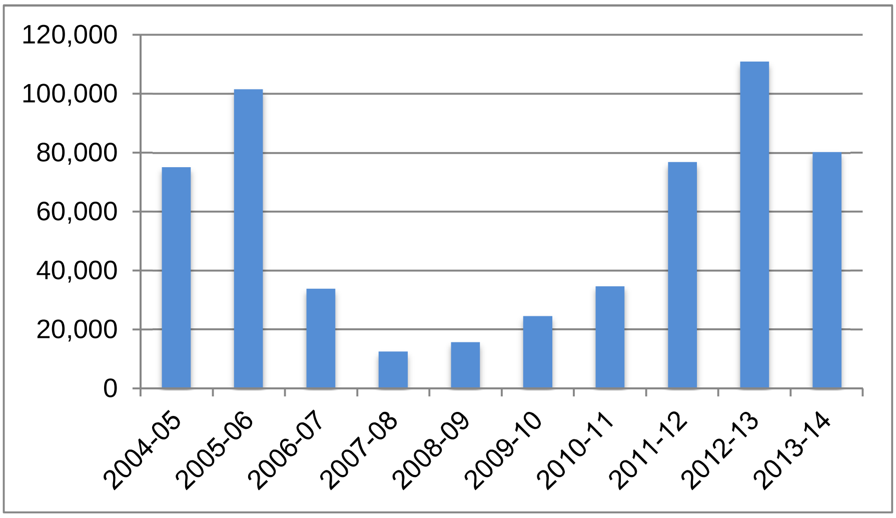
There is considerable variation in flows and deliveries between years. The following figures show flows and deliveries between 2004/05 and 2013/14.

**Figure 2: Flows at the Yanco Creek offtake (ML)**




Source: WaterNSW - see Annex 8

**Figure 3: Deliveries from Yanco Creek system (ML)**




Source: WaterNSW - see Annex 8

The key message is that there is very high variability in flows and deliveries between years.

The Yanco Creek system is effectively employed as an irrigation delivery channel during summer months and WaterNSW has the authority and discretion to manage flows to meet irrigation demand - subject to meeting the requirement for a minimum end-of-system passing flow at Darlot of 50ML/day.

The use of the creeks with large number of fixed crest weirs for irrigation supply means that flows are maintained at artificially high levels during summer months to meet irrigation demand. This largely reverses the seasonality of flows within a year.

The use of the lengthy creek system for irrigation supply results in considerable water losses. The aim of this project is to modernise the delivery system to reduce these losses. There will be two outcomes:

- To generate a water saving that can be converted into additional environmental entitlement
- To reduce the artificial high flows for irrigation supply

## 2.5 Water losses in the Yanco system

The current supply arrangements from the use of the creek for irrigation supply involve considerable transmission losses and operational surplus flows. Reducing these losses will generate water savings that can be converted into additional environmental entitlements that can be held in the dams for environmental watering programs.

### 2.5.1 Transmission losses

Use of the creeks as a supply system results in higher losses than would be incurred from delivery by means of an irrigation supply channel. These losses result from the considerable length of the sinuous creeks. These losses are exacerbated by running the creeks at a high level as this enhances evaporative losses from the wider creek width, spillage into flood runners and side billabong channels, and by encouraging transpiration from riparian vegetation.

The introduction of weirs and block banks along the length of the creek system has had the effect of increasing the surface area of the creeks and extending their length along back flood runners, further increasing the area for evaporation and seepage. These fixed crest weirs and block banks also make the system operation difficult for the operator and so lead to heightened operational surplus.

Providing controls over weir pools and making use of alternative sources of supply will reduce the physical length of the transfer path and the rate and height of the flow within the creeks. This will have a significant impact on these transmission losses and will deliver the same volume of water to end-users with a smaller aggregate volume required.

### 2.5.2 Operational surplus

There is little real-time monitoring, and few controls or re-regulation of flows within the 800km creek system and the complex back channel systems from the multiple weirs and block banks.

There are very long order periods of 26 days between releases from the dam and final deliveries. It currently takes approximately five to six weeks for regulated flows to pass from the Murrumbidgee storages (Blowering and Burrinjuck) through the Yanco Creek system to the Edward River at Moulamein (see Table 2-2).

**Table 2-2: Regulated conveyance time**

| Reach | Conveyance time Worst case |
|---|---|
| Dams to Yanco Offtake (Murrumbidgee River) | 7-8 days |
| Yanco Offtake to Tarabah Weir (Yanco Creek) | 2-3 days |
| Morundah to DC800 (Yanco Creek) | 7 days |
| Tarabah to Innes Bridge (Colombo Creek) | 8 days |
| Innes Bridge to Jerilderie (Billabong Creek) | 2 days |
| Jerilderie to Hartwood Weir (Billabong Creek) | 4 days |
| Forest Creek Offtake to Warriston Weir (Forest Creek) | 5-6 days |
| Hartwood Weir to Conargo (Billabong Creek) | 1-2 days |
| Conargo to Darlot (Billabong Creek) | 7 days |
| Darlot to Moulamein (Billabong Creek) | 7-10 days |

This long time period creates significant challenges in establishing a practical ordering regime and in managing flows to match demand. Many diverters therefore put in a generic water order for the irrigation season as a whole and effectively take water ‘on-demand’ with little direct correlation between the order details and volume taken. Rainfall rejections are therefore common place as it is impossible to predict likely demand more than three weeks in advance.

The presence of multiple block banks and weir pools along the creek system exacerbates the challenges as it creates significant blind spots for the system operator, who has limited ability to intercept, store or release water to meet demands downstream.

As a result, WaterNSW maintains high levels of supply into the Yanco Creek system at the Murrumbidgee River off-take throughout the season to avoid risks of non-supply. The outcome is that flows are held higher than required to meet demand and, as a result, end-of system flows at Darlot are generally far greater than the minimum value of 50 ML/day in the *Murrumbidgee Regulated River Water Sharing Plan*.

If there was closer physical alignment between the points of supply and demand, and greater flow-monitoring and control within the system, then WaterNSW could run the creeks with tighter controls and so reduce the operational surplus that is currently involved.

## 2.6 Proposed project approach - Yanco system

The present arrangements require the great majority of the irrigation supply in the system to be delivered the full length of the Yanco Creek system from the Murrumbidgee at the Yanco Weir off-take. This involves high flows along 800km of sinuous creeks and results in raised operational surplus and transmission losses. Section 3 below provides details of the proposed approach to reduce these losses and enhance levels of service.

This business case proposes a four pronged approach to improve system operational efficiency by:

1. **Monitoring**: providing additional monitoring capability to provide enhanced information in real-time to the system operator and water users on flows and levels throughout the creek system
2. **Controls:** constructing additional controls to allow re-regulation and tighter flow management and control along the length of the creek system
3. **Alternative supplies:** making use of alternative supply points into the creek system from the irrigation corporations, at locations far closer to the end user, to better align demand and supply
4. **Operating rules:** codifying and documenting revised operational protocols to optimise use of the new controls to improve diversion efficiency as well as social and environmental outcomes.

This approach was found to be the most feasible in terms of costs and practicability given the lengths of any new supply systems required, and likely considerable local community opposition. The revised strategy involves up-grading the creek system to meet best practice supply standards in terms of controls, monitoring and management.

## 2.7 Summary of Outcomes

As detailed in section 4.3, IQQM modelling undertaken for the project identifies that the proposed package of measures will allow the same consumptive demand to be serviced as in the Basin Plan benchmark but with reduced transmission losses and operational surplus. That modelling identified water savings of 14.4GL, equivalent to a 17,000 unit share General Security licence. This could be converted to additional environmental entitlement within the Murrumbidgee system and used to deliver greater environmental outcomes than in the draft Basin Plan.

The figure of 14.4GL has been adopted as the value of the water saving to be generated by this business case. However, analysis of historical data on releases and end-of-system flows suggests that this figure is likely to be highly conservative, as the data shows current transmission losses of 90GL and end-of-system flows, in 2012/13, 150GL above minimum passing flows.

The proposed approach will also generate wider socio-economic and environmental benefits as it will:

- Provide a robust platform for the introduction of an enhanced watering regime as it will reduce the current dominance of unnaturally high diversion flows throughout the irrigation season, allowing greater variability in flows to meet eco-system outcomes
- Promote improved fish habitat and movement through the provision of fishways at weir pools and modifications to block banks on the creeks

- Enhance levels of service for diverters as they will have access to a far shorter ordering schedule allowing them to match orders more closely with demand. An indicative order period of 7-10 days would be less than half of the current order schedule
- Retain social and amenity values from the use of the creek system for urban water supply and recreation.

# 3 Proposed works and measures - Yanco Creek System

## 3.1 Activity type - Yanco Creek system

The analysis in this section focuses on the Yanco Creek system. Four types of works and measures are proposed:

- Additional monitoring capability to provide enhanced information in real-time to the system operator on flows and levels throughout the creek system
- Additional controls to allow re-regulation and tighter flow control and management along the length of the creek system
- Alternative supply points into the creek system from the neighbouring irrigation corporations, at locations far closer to the end user to better align demand and supply
- Operating rules to codify and document system operational protocols to meet improved diversion efficiency as well as social and environmental outcomes

Figure 3-1 provides a map of the creek system with the creeks and location of the main works indicated.

## 3.2 Greater monitoring and controls

At present there are few monitoring points or controls along the creek system. This initiative will provide the tools and information that the river operator needs to run the delivery system more efficiently. These will be optimised through extending the current scope of the CARM model to incorporate the new regulating weirs, structures and input points.

## 3.3 Monitoring

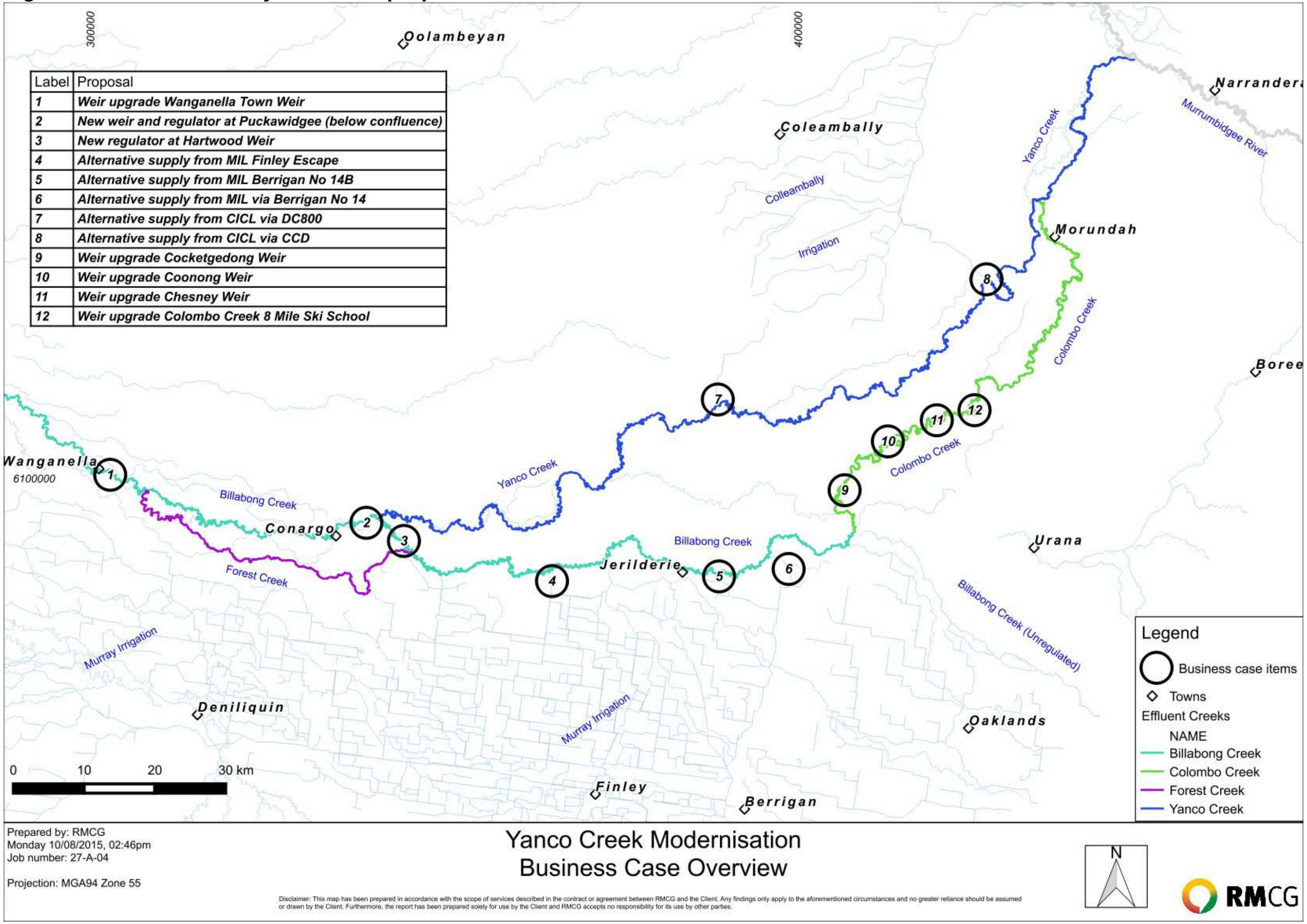
The approach will install additional monitoring points along the creek system to provide real-time reports to the system operator on current levels and flows throughout the system. This would be in-line with the CARM model and could be made available on-line to diverters to help inform irrigation decisions. The additional real time information would help eliminate operator 'blind spots' and provide visibility to customers on real-time creek flow information along with extraction data. This would promote a better understanding of the creek management, including the efficiency benefits of order compliance.

It is proposed to add to and improve existing monitoring capacity of creek level and flow rates at up to thirty strategic locations along the creek, particularly in the weir pools where the river operator currently has no way to assess stored volumes or deficits. This program can be completed in a cost effective way by adding water level monitoring at existing WaterNSW metering infrastructure and at any new re-regulation gates. Opportunities exist to improve the precision of some existing gauging stations by upgrading to new Doppler technology.

## 3.4 System regulation

It is proposed to install additional regulation within the creek system. This will enable the re-regulation, storage, movement and supply of water to be managed more tightly to match changing demand. The same controls will be available to manage flows to meet any future environmental watering regime. The installations will include best practice fish passage.

## Figure 3-1: Yanco creek systems and proposed works and measures



### 3.4.1 Location of regulators

Three sites are involved:

- Wanganella Town Weir (#1 in Fig 3-1). This regulator will re-regulate creek flows for supply to the lower reaches of the Billabong Creek. The proposed location in the mid Billabong would also capture any excess flows along Forest Creek and help improve the security of the town supply.
- Puckawidgee (#2 in Fig 3-1). The regulator will be located below the confluence of the Yanco and the Billabong. This will re-regulate flows along the two creeks and provide an offtake weir pool for diverters in the lower Yanco.
- Hartwood Weir (#3 in Fig 3-1). This regulator is needed to drive flows into Forest Creek, particularly in winter months when irrigation supplies will not be available. The weir will also re-regulate flows along the Billabong especially those from the Finley Escape.

### 3.4.2 Design criteria for regulators

A standard design has been developed for each of the three sites as the current structures are old and their structural integrity is compromised. The regulator design will meet the following design criteria:

- Allow re-regulation of flow in the waterway. This will require the capacity to deliver flows in response to downstream demand, and thus the ability to regulate flows from zero to the full gate capacity. Design discharge for consumptive flow delivery is estimated at 600 ML/d
- The structure will not be a significant barrier to unregulated flow events. There will be minimal impact on upstream water levels when the gates are fully open
- The structure will be able to establish a weir pool to just below top of bank level at the structure
- Downstream fish passage will be facilitated at the site by the design of the gate structure
- Upstream fish passage will be provided through a standard vertical slot fishway (VSF)
- The regulators will be SCADA and CARM enabled to facilitate remote operation and optimisation
- Power will be provided by a solar array dedicated to the structure.

### 3.4.3 Layout

The design employs three lay-flat gates, each 3m wide x 1.5m high. The bank adjacent to the gates will be filled in and protected against overflow events. The arrangement is illustrated in Figure 3-2, with design details provided in Annex 3.

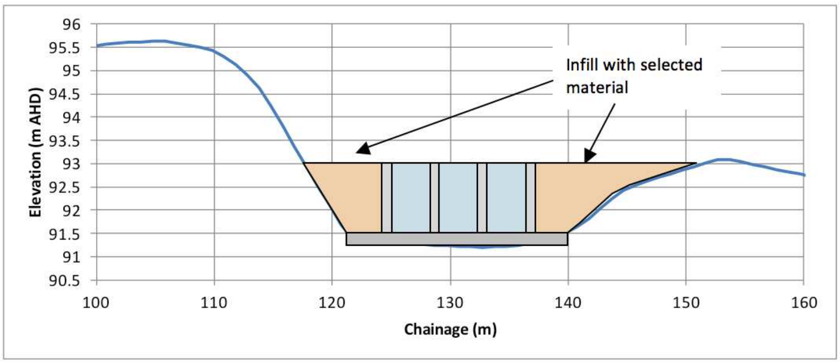



**Figure 3-2: Configuration of gates overlaid on cross-section at nominated site.**

## 3.5 Weir pool regulation

Privately owned block banks and weirs along the creeks hold the water level up and drive it into back channels, anabranches and flood runners, creating weir pools up to 15km in length. The intention was to create static weir pools for diversion points and storage for dry periods. However, the weir pools and fixed crest weirs increase transmission losses from evaporation and lead to raised risks of operational surplus as it is difficult to monitor or control flows through the system to diverters downstream.

Introducing flow control at these locations will allow re-regulation of surplus flows and active storage and release of flows from these pools to match diversion demand downstream, as well as maintaining social and environmental outcomes.

The proposed approach would involve installing new weirs on the outflow channels, with regulated gates to allow the weir pools to be managed as minor storages. New weirs are required given the age and condition of existing infrastructure. Standard vertical slot fish-ways will be provided.

### 3.5.1 Indicative design - Sheet pile weir and regulator

In each case, a sheet pile weir will be constructed that extends the full width across the channel at a suitable site approximately 100 metres downstream of the existing weir. A concrete apron will be provided on the downstream side of the sheet pile weir. An example of this type of weir is shown below.

**Figure 3-3: Sheet Pile Weir (Donnegri Creek, Narran River, South west Queensland)**

The regulator will be an overshot design, which will allow accurate measurement of downstream discharge. To achieve a discharge of 500 ML/d with 0.6 m depth will require 2 x 4 m wide gates. Solar power will be provided to allow remote operation. See Annex 4 for more details.

Where necessary, a sill will be installed below current weir pool levels as a minimum level below which the regulator cannot operate. The intention is to provide confidence to local landholders that the weir pools will be retained broadly as at present and only provide headroom to capture excess flows and provide for peak demand downstream. This sill will also prevent outflow of retained sediment that could otherwise smother downstream benthic ecosystems.

### 3.5.2 Fish passage

The design of the overshot regulator will facilitate downstream passage of fish, including eggs and larvae, with minimal impact. Two options were considered for up-stream fish passage, a bypass fishway or a vertical slot fish-passage (see Annex 5).

**A bypass fishway** involves a narrow channel that circumvents the weir. It is constructed with a series of natural features, including meandering waterways with a low gradient, pools, riffles, and vegetation. Fish are attracted to the entrance by the flow conditions in the bypass and make their way up through the waterway into the upstream weir pool. The fishway would have an average grade of approximately 1:150, meaning that it will be approximately 150m in length to facilitate a 1 metre headwater difference.

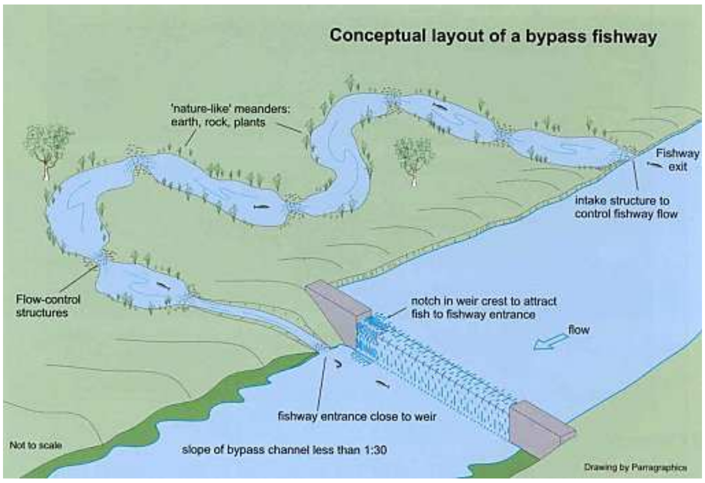



**Figure 3-4: Conceptual layout of a bypass fishway**

The design has the advantage of price. However, in river systems with a heavy load of detritus, these systems can quickly become blocked and ineffective. They therefore require high levels of maintenance, which can be unrealistic in isolated locations. They can also lead to high passing flows as they are in essence a side channel around the weir. This can result in significant uncontrolled losses.

**A vertical slot fish-passage** involves constructing a narrow artificial pathway at the side of the weir to provide a stepped passage through a series of bays. The number of cells and the size of the installation depend on the headwater difference.

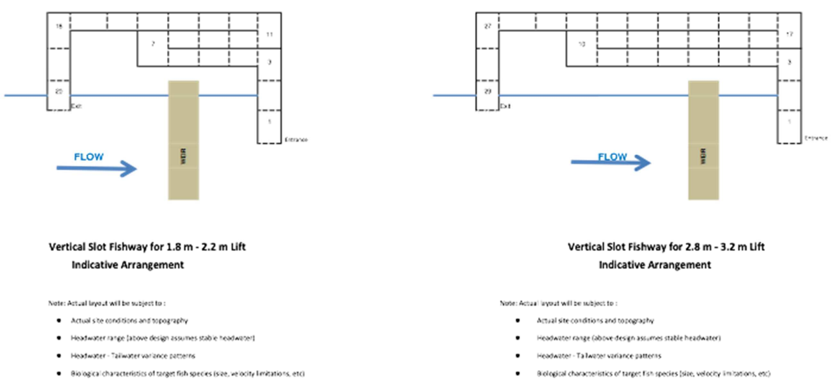



**Figure 3-5: Standard vertical slot fishway**

This second approach has the advantage of being a standard accepted design with lower maintenance requirements due to its enclosed design. However, it is considerably more expensive to construct.

Given the isolated location of the weirs it was decided to choose the vertical slot fish-passage as the preferred approach.

### 3.5.3 Priority locations

Four such weir pools along the Colombo Creek have been identified as priorities, at:

- Cocketgedong Weir,
- Chesney Weir,
- Coonong Weir (lower Sheepwash Weir) and
- Eight Mile Weir (Ski-club).

Local landowners were engaged in the project development phase and gave in-principle support for this approach as it would improve creek efficiency, fish passage and long term sustainability of the creek system.

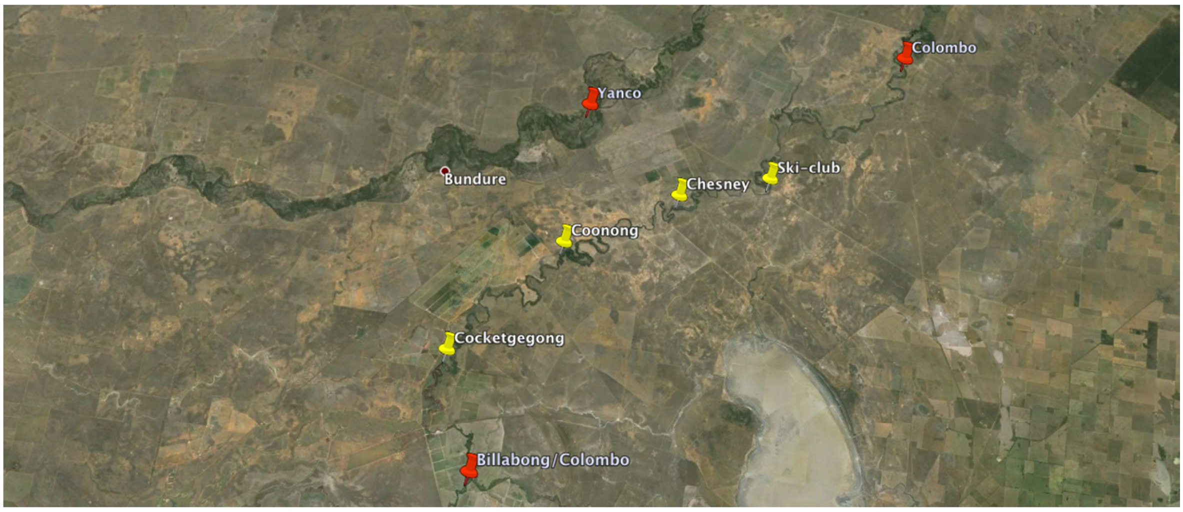



**Figure 3-6 Location of weir pool regulators on the Colombo Creek**

The modelling assumes active pools of 200ML, each with a surface area of 50ha. This would provide 70km of interconnected flow path along the Colombo Creek with benefits for both regulation and fish-passage without impacting the commercial and social value of the weir pools.

The project identified a number of other locations where a similar approach could be adopted, particularly in the Yanco Creek where improved management of block banks would lead to more effective flow control and improved ecosystem outcomes. Discussions with YACTAC identified a number of priority locations for improved management to exclude breakouts of regulated flows into anabranches and billabongs, e.g. at Six Mile, McCrabb's, 9 Mile (Mundoora Pastoral Co), 18 Mile (Mundoora Pastoral Co), and McCaughey block-banks. This could be achieved by installing regulators through the block bank or the fixed crest weir to provide the capacity to water the relevant anabranch and/or provide controlled flows within the main creek.

The business case includes two such initiatives, with design and cost parameters equivalent to the design developed for the Colombo Creek weir pools.

### 3.5.4 Capturing excess flows in Forest Creek

Excess flows down Forest Creek currently spill over Warriston Weir as an operational surplus. The business case proposes to re-establish a flow path down Piccaninny Creek to re-direct these excess flows back to the Billabong Creek. A remotely controlled gate on the Warriston Weir pool will be required. The design of the gate will match the outline design above for the Colombo Creek weir pools. The flows in the Billabong from Piccaninny Creek will then be re-regulated at the Wanganella regulator for diversion further downstream.

## 3.6 Alternative supplies

Much of the creek system borders two irrigation supply corporations. It is proposed to supplement current flows in the creeks that are sourced from the Murrumbidgee with additional supplies from these irrigation corporations. This would use both existing and enhanced escape channels building on current arrangements. The attached schematic (Fig 3-7) identifies the creek system and proposed supply points.

The proposed supply points are:

- **Coleambally Irrigation** along the north west length of the Yanco Creek:
  - CCD - 300ML/day into the mid Yanco downstream of the Colombo junction.
  - DC800 - 100ML/day into the lower Yanco.
- **Murray Irrigation** along the southern face of the Billabong and Forest Creeks. MIL has confirmed that it is practical to deliver the following flows into the creek system through their irrigation infrastructure:
  - Berrigan 14 and 14B: guaranteed 50ML/day from these escapes into the upper Billabong above Jerilderie with up to 80ML available during much of the season
  - Finley Escape: 300ML/day into the mid Billabong Creek to supply the mid and lower Billabong Creek, Forest Creek and the lower Yanco from the new Puckawidgee regulator.

There are a number of advantages to this approach:

- A shorter length of supply channel can be used to supply water to a diversion point on the creek in place of a far longer length of creek. That reduces transmission losses from the shorter length of the channel and the lower seepage and evaporation rate per unit length.
- The supply point can be located far closer to the point of diversion. This permits a tighter alignment between supply and demand, and so allows the implementation of a stricter water ordering policy. This reduces the operational surplus that occurs where 'excess supply' is introduced at the head of the system to reduce risks of under supply downstream due to the lengthy ordering period
- The approach implements the obligation on WaterNSW to increase the efficiency of its supply arrangements but does so in a way that minimises impacts on existing diverters
- The alignment between supply and demand also delivers better levels of service for diverters and the environment. A 7-10 day ordering period should be feasible and more than halves the current order time.

The *'operating rules'* change involves WaterNSW amending its water order management protocols so that, in future, it will take these alternative supply sources and regulated weir pools as the standard baseflow for delivery to diverters rather than its current approach which is to see these as back-up sources of supply to supplement the flows from the Yanco off-take on the Murrumbidgee.

**Figure 3-7: Schematic of creeks and supply points**

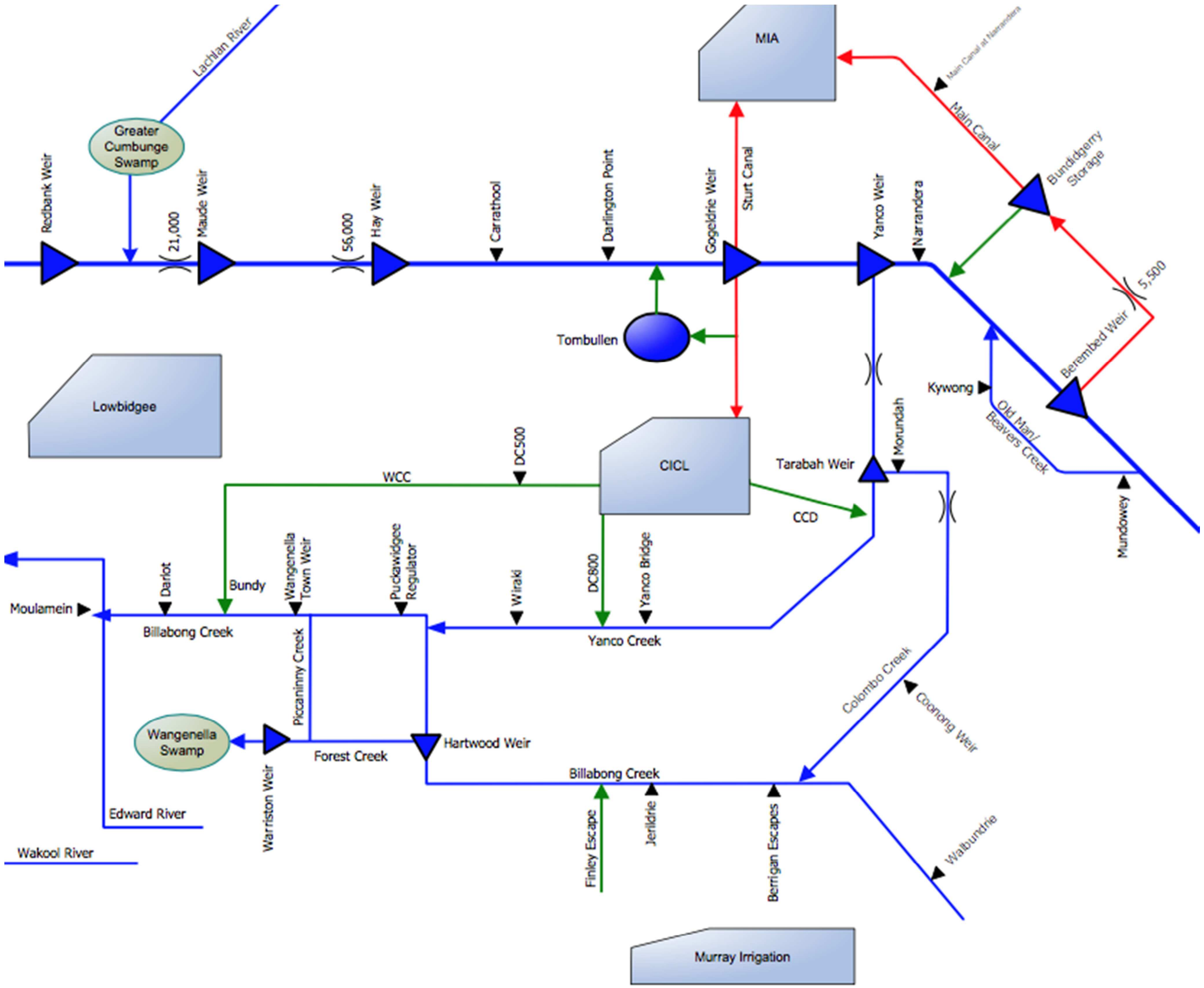


**Table 3-1: New supply arrangements**

| Supply | Reach | Current (ML/day) | Proposed (ML/day) | Annual (ML) |
|---|---|---|---|---|
| CCD - CICL | Mid Yanco Creek | 300 | 300 | 60,000 |
| DC800 - CICL | Lower Yanco Creek | 50 | 100 | 20,000 |
| Finley escape - MIL | Billabong Creek | 250 | 300 | 60,000 |
| Berrigan escapes - MIL | Billabong Creek | 0 | 50 | 10,000 |
| **Totals** | | 600 | 750 | 150,000 |

Recent total annual demand within the Yanco Creek system for irrigation diversions has been around 110,000ML. The new supply options can deliver 150,000ML/yr. This section confirms that the location of those new supply points aligns with projected demand by river reach:

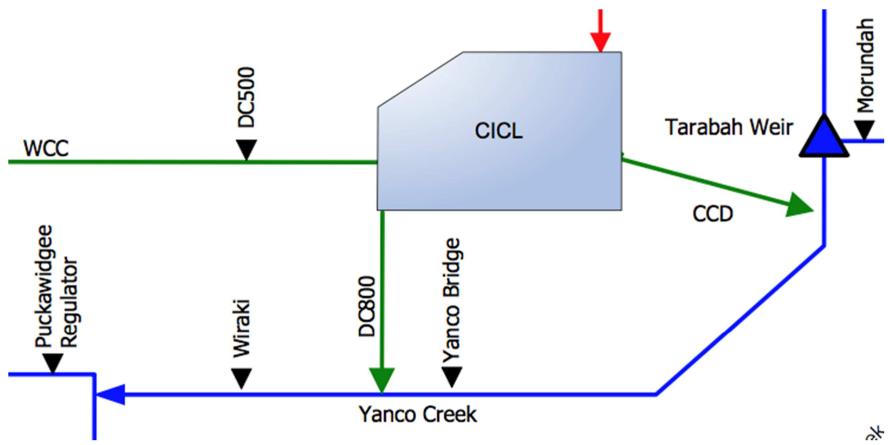
- The mid/lower Yanco Creek can be supplied by the CCD and DC800 out of Coleambally Irrigation
- The upper Billabong can be supplied by the Berrigan Escapes from Murray Irrigation
- The mid Billabong can be supplied by the Finley Escape from Murray Irrigation
- The Forest Creek can be supplied by the Finley Escape from Hartwood Weir
- The lower Billabong can be supplied by the Finley Escape from Hartwood Weir, from surplus captured in the Puckawidgee regulator and via the Piccaninny Creek return flow from Forest Creek.

The only reach not serviced by this approach will be the Colombo Creek. This will continue to be supplied from the main Yanco Creek off-take, through the new regulated weir pools. This will allow significant sections of the creeks to be operated at lower flows for irrigation supply during the summer.

### 3.6.1 CCD to Yanco Creek

Coleambally Irrigation Cooperative Limited (CICL) has an existing catchment drain known as the Coleambally Catchment Drain (CCD). This drains into the Yanco Creek out of the eastern edge of the irrigation district. The CCD has recently been upgraded to allow supply of 300ML/day into the Yanco creek on a consistent basis, bypassing the top sections of the creek system. This was funded as part of the CARM initiative.

**Figure 3-8: CCD Supply to Yanco Creek**



### 3.6.2 DC800 to Yanco Creek

The DC800 is a smaller escape from CICL that discharges from the south western quadrant of CICL into the lower Yanco (see Figure 3-8 above). Current flows come from multiple, small-scale intermittent drainage escapes with manual controls. So, at present this is not a practical supplementary source of supply as it cannot be adjusted to meet demand downstream.

It is proposed to expand this discharge to provide a regular supply into the Yanco Creek, with a flow of 100ML/day. This would require investment in two sets of works within CICL's delivery system:

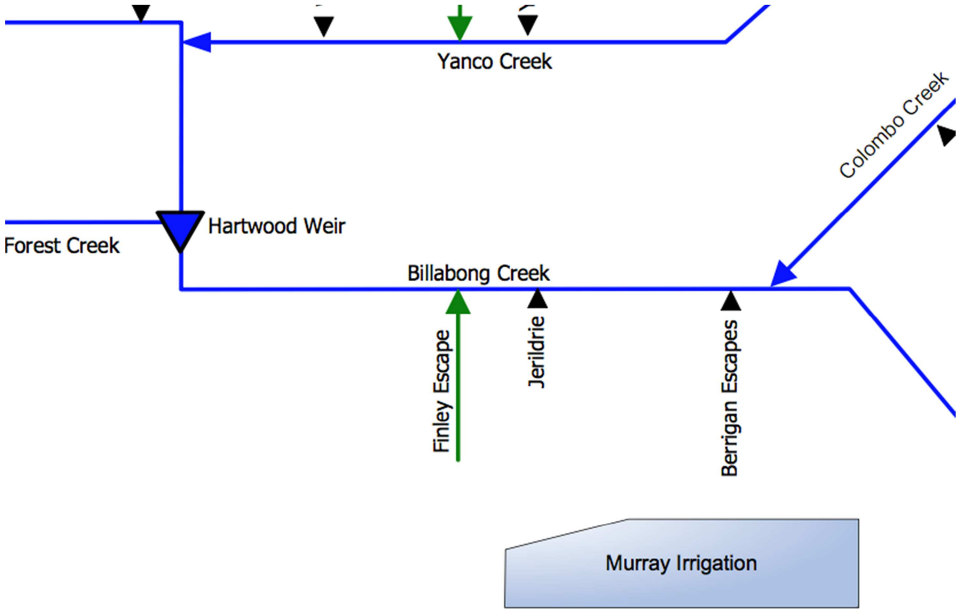
- Automation of seven manual escapes at a unit cost of [redacted]
- Connection of DC800 to the Yamma 4 main supply channel at a total cost of [redacted]

This is a relatively cheap and feasible supply option, and discharges into the Yanco Creek far closer to end diverters thus reducing transmission losses (see Annex 6 for more details).

### 3.6.3 Finley Escape to Billabong Creek

Murray Irrigation supplies properties along the length of the southern side of the Billabong Creek. There is a major discharge point known as the Finley Escape just downstream of Jerilderie that drains excess irrigation flows and rainfall off properties and into the creek system. This escape is already the subject of an *Accredited Escape Agreement* with WaterNSW to deliver bulk supplies into the Billabong Creek.

**Figure 3-9: Finley Escape to Billabong Creek**




The existing agreement gives WaterNSW access to 250ML/day as a second priority supply. The proposal is to upgrade this agreement to deliver up to 300ML/day into the Billabong Creek, with the same rights as a standard customer. This would provide the major source of supply for diverters in the lower half of the system on the mid Billabong Creek, Forest Creek and lower Billabong Creek, past the junction with Yanco Creek.

This is a large and relatively cheap supply option and is easy to progress as it is already subject to a supply agreement. The works include capacity augmentation to the channel system and upgrades to regulators to automate the drainage flows, at a total capital cost of [redacted] (see Annex 7 for more details).

### 3.6.4 Berrigan 14 & 14B Channels to Billabong Creek

The Berrigan 14 and 14B Escapes are smaller channels operated by Murray Irrigation, upstream of Jerilderie and below the confluence with the Colombo Creek. They are currently used as escape channels to provide relief from excess drainage flows.

The proposal is to use these escapes to feed water into the Billabong Creek. This would provide a flow of up to 80ML/day to service diverters upstream of Jerilderie and also the township itself, with a guaranteed flow of 50ML/day. Murray Irrigation has indicated that augmentation of these channels and their automation would involve capital costs of [redacted] (Annex 7).

## 3.7 Operating regime

The proposal involves modernising the Yanco Creek supply system. The proposed approach transforms the supply system into an efficient modern delivery system with best practice controls, hydro-dynamic modelling, forecasting and optimisation all integrated through extension of CARM.

### 3.7.1 Optimised integration

The provision of the new hardware and alternative supply options outlined above is only part of the package. The full benefit relies on the integration of that new infrastructure into the existing CARM operating system.

The modernised Yanco Creek system aims to mimic a modern day irrigation channel operated under a 'demand management' system. The modernised system will generate good quality, real time information on flows and levels. It will have controls in place to capture, store and release flows to match demands. It will have access to a suite of supply sources at strategic locations along the system.

The modernised operating system will employ best-practice SCADA, hydrodynamic modelling, irrigation demand forecasting and optimisation software to automate gate controls and inputs and outputs to meet irrigation demand. In addition to reducing losses and operational surplus, the modernisation will result in improved levels of service and efficiency benefits as well as broader environmental and social outcomes. The operating system will employ best-practice integration and predictive software to automate controls.

### 3.7.2 Operating rule change for multiple enduring benefits

A modernised Yanco Creek system will require changes to the existing operating protocols. The extended CARM model will be calibrated to include the new additional infrastructure and storage, supply and control nodes. This will enable the operation to optimise alternative supply sources in preference to the traditional offtake at the Murrumbidgee. The optimised regime will need to be documented and implemented in a staged implementation program. This represents an '*operating rule change'*.

The proposed package of measures has been developed in partnership between WaterNSW, local diverters through YACTAC, the regional irrigation corporations and environmental agencies such as DPI Fisheries. The proposed approach is designed to deliver far greater efficiency of supply of diversion orders and improved service to customers, at the same time as maintaining and enhancing social and environmental values.

The proposed approach continues to use the creek as the supply system. At present irrigation flows dominate creek flows during the irrigation season. The proposed approach would reduce the scale of these flows, allowing the introduction of a better managed and more targeted environmental watering regime that can include appropriate seasonal fluctuations to meet ecosystem outcomes. The new controls will need to be operated to meet these shared outcomes. The optimised operating regime will set out protocols for the timing and extent of use of the different component elements to deliver irrigation diversions as well as supporting these agreed wider objectives.

## 3.8 Works and measures by creek/location

The following sections confirm the above proposals by reference to their location/creek.

### 3.8.1 Yanco Creek

The proposed works comprise:

- CCD: use of the current supply agreement into the mid Yanco Creek at up to 300ML/day
- DC800: enhanced capacity to deliver 100ML/day supply into the lower Yanco
- Modification of block banks in the mid Yanco to control flows

### 3.8.2 Colombo Creek

The proposed works comprise four locations where regulators will be installed at existing weir pools and block banks to provide re-regulation and control of flows to meet demand downstream, at:

- 8 Mile Weir (Ski School)
- Coonong Creek weir
- Chesney weir
- Cocketgegong weir

### 3.8.3 Billabong Creek

The proposed works comprise:

- New escape flows of 50ML/day at Berrigan 14/14B to supplement flows in the upper Billabong
- Augmented supply from the Finley escape below Jerilderie to 300ML/day for the mid Billabong
- Re-furbished regulator at Hartwood Weir to enhance controls and regulation capacity
- New regulator at Puckawidgee below the confluence with the Yanco to re-regulate excess flows and provide a weir-pool to facilitate diversions in the lower reaches of the Yanco Creek
- Refurbished regulator at Wanganella to re-regulate flows in the lower Billabong Creek

### 3.8.4 Forest Creek

The proposed works comprise:

- Restoration of the Piccaninny Creek to direct excess flows from Forest Creek to the lower reaches of the Billabong Creek by means of a control gate at Warriston Weir and re-regulation at Wanganella.

# 4 Outcomes

## 4.1 Methodology

The primary objective of the proposal is to promote greater efficiency in the operation of the creek system for delivering water for consumptive use. The current arrangements involve high values for transmission losses and operational surplus.

The proposed measures will generate water savings from the current arrangements through two main mechanisms, in line with the SDL offset Guidelines:

- *Water efficiency projects:* investment in infrastructure to enhance delivery efficiency
- *Operating rules changes:* documentation of changes to operating protocols to implement the new arrangements within an integrated regime.

## 4.2 Implementation

### 4.2.1 Transmission losses

The creek system is currently run at a high level during much of the irrigation season. The presence of block-banks throughout the system also creates weir pools and increases surface area and the wetted perimeter. These factors increase transmission losses through a number of mechanisms:

- A higher creek level leads to a greater creek width. That greater width and the weir pools create a greater surface area that promotes higher levels of evaporation
- A higher creek level encourages spillage into secondary wetlands, flood runners and anabranches. Much of that spillage is then lost to supply
- A higher creek level throughout the summer promotes increased rates of growth of riparian vegetation and so heightened transpiration

The current ordering scheme also means that the large majority of diversion supply is sourced from the main stem of the Murrumbidgee. This means that water will travel hundreds of kilometres between the dam and the ultimate point of diversion. Each kilometre travelled increases the transmission loss.

The proposals in this business case will help reduce these transmission losses through a number of routes:

- Introducing alternative supply sources close to the end user will reduce the overall distance travelled between the point of supply and the point of diversion. That reduces opportunities for losses
- Provision of greater controls on flow management will allow closer alignment between supply and demand. This will allow the creeks to be run at lower flow rates and heights. That will contain flows within the main creek bed and so reduce risks of spillage into side channels, and excessive evaporation or transpiration
- Installing regulating gates will reduce weir-pool levels and sizes, so reducing the surface area for evaporation and the risks of spillage into secondary flood runners etc.

### 4.2.2 Operational surplus

Operational surplus relates to the volume of regulated flows out of the end of the system that are in excess of ordered demand and minimum flow targets.

Supply levels and flows in the creeks are currently maintained at a high level in order to ensure that water is available when needed to meet diverters' demands. The level provided is generally in excess of the actual aggregate demand because of the very long lead times between release from the dam and diversions from the creek. This excess is also driven by the limited controls available within the creek system to re-regulate or release supplies at a local scale.

As a result, end-of-system flows are often well above the agreed target of 50ML/day at Darlot as specified at Clause 64 of the *Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2003*.

This business case will help reduce this operational surplus through two major routes:

- Provision of enhanced controls and re-regulation of flows within the creek system will allow greater precision in the management and supply of water to meet specific requirements at nominated locations, rather than reliance on excess flows from the Murrumbidgee off-take.
- Creation of alternative supply sources far closer to the end user will enable a tighter ordering regime to be implemented. That will allow bulk releases into the creeks to be far more closely aligned with orders, so reducing the need to provide excess supply to cater for unforeseen events.

## 4.3 Modelling

Modelling was undertaken for this project by DHI in line with best practice impact assessment for SDL offset proposals (Annex 2).[1]

### 4.3.1 New Baseline

The version of the Murrumbidgee IQQM used to represent baseline and benchmark conditions does not closely represent all of the individual river sections, with the initial model calibrated to a coarser level within the Yanco Creek system. The model also does not include a number of projects that were implemented as part of the *Water for Rivers* program to provide water savings for the Snowy Initiative. Some of these projects were actually completed after 2009, but are part of the Snowy Initiative, which is intended to be fully represented in the baseline (and hence benchmark) conditions.

It is proposed that the current baseline/benchmark model is updated for comparison with the proposed package of measures. The following modifications were made to the MDBA Benchmark model to provide increased detail in the model to more accurately model the incremental effect of the proposed measures.

- The Finley escape from Murray Irrigation was added, as per the *Water for Rivers* project (2012).
- Yanco Offtake: order smoothing and irrigation spring - summer season scaling (20%) were added to reflect actual operational practice (a similar approach was used in 2012 by DPI Water in the Water for Rivers modelling).
- Order capacities of the Coleambally Irrigation escape channels were modified from MDBA Benchmark to supply more water to the Yanco Creek, as per the *Water for Rivers* project (2012):

[1] DHI (2015), *Murrumbidgee Effluents SDL,* 5 August

  - CCD: 300 ML/day
  - DC800: 50ML/day

### 4.3.2 Scenario - Combined weirs and escapes

The following modifications were made to the new Baseline “model 3”, to model the effect of the following proposed measures:

- Additional regulation structures were added at the following locations:
  - Hartwood Weir on the mid Billabong Creek
  - Wanganella Weir, on the lower Billabong creek
  - Puckawidgee Weir below the confluence between the Yanco and Billabong Creeks
- Weir pool regulation was added.
  - A “lumped weir” was inserted to represent 4 regulated installations on the Colombo Creek at 8 Mile (ski-club) weir, Chesney weir, Cocketgedong weir and Coonong weir.
  - A “lumped weir” was inserted to represent 2 regulated block banks on the Yanco Creek at 18 Mile, and McCaughey weirs
- Piccaninny Creek was added as a flow path from Forest Creek to Billabong Creek - upstream of the proposed Wanganella Weir regulator
- Escapes to the Billabong Creek were modified as an alternative sources:
  - Berrigan Escape as a new source at 50 Ml/d combined capacity
  - Finley Escape augmented from 250/day to 300ML/day
- Order capacities of the Coleambally Irrigation DC800 escape drain was modified to supply more water to downstream in the Yanco.
  - DC800: 100ML/day

### 4.3.3 Results

The modelling identified that the addition of the proposed projects led to an increase in water availability in the system. This increase was generated by a number of factors including:

- The presence of additional re-regulation in the system allowed for supply from those locations instead of the previous reliance on flows from the Murrumbidgee off-take, reducing operational surplus
- The shorter distance between supply from irrigation corporations and re-regulation weir pools and the final point of diversion demand reduced transmission losses

A General Security water savings node was added to the model on the river near Narrandera, and the model was iterated until the General Security allocation and irrigation diversions returned to their pre-project long-term average values. In addition, as the projects involve increased diversion through escapes from Murray Irrigation, there is an effect on inter-valley trade accounts (less than 5,000 ML/year on average) and it is proposed that a rules-based approach will be taken to ensure that potential third party impacts are mitigated.

It was found that a 17,000 General Security water savings licence (equivalent to an LTCE volume of 14.4 GL/yr) was provided by the various measures identified above.

That is, the proposed project generates effective water saving of 14.4GL from a reduction in both transmission losses and operational surplus. The likely reduction in operational surplus is similar to that from CARM, and the integrated modelling of the Murrumbidgee package of measures will guide how the savings entitlement will be used between the Murrumbidgee and Murray valleys.

### 4.3.4 Risks and Issues

A review of the Murrumbidgee IQQM by DPI Water identified that the current model may not fully capture the full water savings available from proposed investments. The review showed that there were a number of enhancements that would better represent and improve the calibration of the Yanco sections of the model. These related, in particular, to modelled loss nodes and system inflows from the Irrigation Corporation drains. It is possible, therefore, that the modelled results for these proposals would change if these model upgrades were implemented. It was not possible to complete these upgrades in the time allowed for this business case.

The level of irrigation development assumed in the model also impacts on the level of savings recorded. The benchmark model has significantly lower levels of development than the current position. This reduces the impact of these water efficiency proposals. Therefore these model results are sensitive to the amount of irrigation development remaining in the Yanco system under the basin plan, with the benefits of these proposals likely to increase if the irrigation development remains above the levels in the benchmark model run.

The business case retains the conservative figure for the projected water savings of 14.4GL as this minimises potential implications for other licensees in NSW.

## 4.4 Comparison with observed flows

In order to demonstrate the potential for savings, and test the likely conservatism of this modelling assessment (ie that the savings might be higher), the results from the IQQM modelling were compared with historic data on recorded values for flows and diversions within the creek system. Observed data was analysed for 2012/13 as a recent representative year (Annex 8).

### 4.4.1 Flow input

There are three current sources of input to the creek system:

- Flows into the head of the creek system from the Murrumbidgee/Yanco offtake
- Un-regulated flow from the upper Billabong Creek - as measured at the Cocketgedong gauge
- Supplementary flows from the two irrigation corporations

The values for these inflows in 2012/13 are presented in the following table.

**Table 4-1: Inflows to Yanco Creek system 2012/13**

| Source | Volume (ML) |
|---|---:|
| Yanco offtake | 289,939 |
| Billabong unregulated | 44,663 |
| Irrigation Corporations | 37,648 |
| **Total** | **372,250** |

### 4.4.2 Outflows from System

There are three primary points at which outflows are recorded from the creek system:

- Recorded use by diverters as metered by WaterNSW
- End of system outflows for the Billabong Creek measured at Darlot
- Flows over Warriston Weir at the end of the regulated Forest Creek

These three values for 2012/13 are presented in the following table:

**Table 4-2: Outflows from Yanco Creek system 2012/13**

| Outflow | Volume (ML) |
|---|---:|
| Recorded use | 110,937 |
| Darlot end-of-system flows | 162,610 |
| Warriston Weir flows | 6,945 |
| **Total** | **280,492** |

### 4.4.3 Losses

Total 'losses' in the creek system can then be estimated, at an aggregate level, as the difference between total inflows and total outflows. This is a figure of 90,000ML. A reduction in current transmission losses of 15% would be equivalent to a saving of 13,000ML.

### 4.4.4 Operational surplus

Operational surplus occurs where the system operator releases a larger volume into the system than is eventually taken for consumptive use. This can occur where there is a long travel time and so risks of rainfall rejection after orders have been placed, or where there are few controls in the system and a desire to minimise the risk of not being able to deliver the demand required.

The WaterNSW data identifies two figures that could represent values for the current operational surplus:

- **End-of-system flows at Darlot:** Under the *Murrumbidgee Regulated River Water Sharing Plan* the system operator is required to maintain a minimum passing flow of 50ML/day at Darlot. This equates to an annual flow of 18,250ML.
- **Flows at Warriston Weir:** this fixed crest weir is at the end of the regulated section of Forest Creek. The objective is that there should be no flows over the weir. However, the current controls make this outcome difficult to achieve.

The 'operational surplus' then represents the volume of recorded outflows above these targets. The values for these variables in 2012/13 are set out in Table 4-4. This shows a 'gross' surplus of 150GL.

The table identifies potential reductions in this surplus from the proposed package of measures, ie.

- A 15% reduction in the current surplus at Darlot from the additional controls in the system
- Capture of all surplus flows in the Forest Creek through the reintroduction of Piccaninny Creek as a flow path back to Billabong Creek.

**Table 4-3: Operational surplus estimates 2012/13**

| | Min passing flow | Actuals | Surplus | Saving |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Darlot | 18,250 | 162,610 | 144,360 | 15% = 21,654 |
| Warriston Weir | 0 | 6,945 | 6,945 | 100% = 6,945 |
| **Total** | | | **151,305** | **28,599** |

The above calculations suggest that the potential saving from the project could be at least 40GL (13GL from a reduction in transmission losses, plus a 28GL reduction in operational surplus). The value of 14.4GL adopted from the IQQM modelling is therefore a conservative estimate.

## 4.5 Wider benefits

This approach will also:

- Provide a robust platform for the introduction of an enhanced watering regime as it will reduce the current dominance of unnaturally high diversion flows throughout the irrigation season, allowing greater variability in flows to provide eco-system outcomes
- Promote improved fish habitat and movement through the introduction of fishways at weir pools and modifications to block banks on the creeks
- Enhance levels of service for diverters as they will have access to a far shorter ordering schedule allowing them to match orders more closely with demand. This will provide a more productive and resilient irrigation community
- Retain social and amenity values from the use of the creek system for urban water supply and recreation.

## 4.6 Interdependencies and complementary actions

### 4.6.1 Interdependencies

This business case forms part of a suite of three proposals related to the modernisation of flow management within the Murrumbidgee system:

- Computer Aided River Management (CARM) along the Murrumbidgee River.
- Yanco Creek off-take regulator at the Murrumbidgee River - to improve flow management.
- Modernising supply systems for effluent creeks – Murrumbidgee River (this business case).

Each of the proposals is effective as a standalone initiative. However, the three business cases are closely integrated and would generate synergies from joint implementation:

**CARM:** the CARM system, which is already operational will be extended beyond its current scope to provide greater control and modelling of flows through the river and creek systems. This will optimise the effectiveness of the investment in monitoring and controls and so allow environmental flows and consumptive demands to be met with greater precision reducing 'operational surplus'.

**Yanco Creek Regulator:** At present, around 10% of raised flows along the Murrumbidgee are diverted into the Yanco Creek system. The proposed Yanco Creek off-take regulator will allow environmental flows to be shepherded along the river to achieve targeted environmental watering outcomes in the mid-Murrumbidgee without loss of a proportion of this water down the Yanco Creek. The regulator will also enable control of inflows to the Yanco Creek system from the Murrumbidgee River. That will allow greater precision in the matching of supply and demand in the Yanco Creek system to meet environmental and consumptive demands.

The proposed investment in modernising the Yanco Creek delivery system should have limited or no effects on other supply proposals in the Murrumbidgee and Murray. The proposal should provide benefits to the proposed business case for the Murrumbidgee Constraints Management project as it will reduce the high flow levels required along the Murrumbidgee to meet irrigation demand in the Yanco Creek system.

### 4.6.2 Complementary actions

As noted above, the proposals will reduce the current dominance of high diversion flows throughout the irrigation season. This will allow the development and implementation of an enhanced environmental watering regime, with the introduction of greater variability in flows to meet eco-system outcomes.

That enhanced environmental watering regime does not form part of this proposal and represents the major complementary program that will be rolled-out to optimise the benefits from this proposal.

There are also a number of other complementary actions focused on rehabilitation of the waterways and their riparian environment. Many of these align with existing natural resource management plans such as *The Yanco Creek System Natural Resource Management Plan* (Beal et al. 2004) and the *Yanco Creek System Environmental Flows Study* (Alluvium 2013).

Suggested complementary actions include:

- Improving the environmental value of weir pools where required through installation of fish passage.
- Large woody debris retention, potential reinstatement and supply through maintenance/regeneration of riparian trees.
- Creation of a minimum 20m buffer between the top of the bank and any cultivation.
- Fencing off the riparian zone and providing off line watering points for stock grazing.
- Pest plant management e.g. ongoing willow control.
- Maintenance of vegetation covers in drainage depressions that drain water from cultivated fields to the creeks.
- Carp management e.g. physical controls where possible to exclude adult carp from floodplain wetlands during watering events.

These projects are outside the scope of this business case. Outcomes will be delivered through local stakeholders including YACTAC and the Local Land Services, subject to available funding.

# 5 Summary of costs and proposed schedule

## 5.1 Capital construction costs

The estimated capital construction cost for the Yanco Creeks modernisation project is $32 million. This total is comprised of a number of different categories reflecting the nature of the works proposed (see Annex 9 for further details of the cost components). Section 9.2 confirms future asset ownership.

[redacted]

The first category involves the provision of additional monitoring equipment and the development of the operating system needed to make best use of that data.

[redacted]

The next category represents the additional structures introduced to provide the controls required to re-regulate, hold and deliver flows as required throughout the system.

[redacted]

The third category (Table 5.4) identifies the costs of obtaining alternative sources of supply from irrigation corporations that will provide inputs into the system far closer to the end user.

[redacted]

Finally, there are the costs incurred in developing and implementing the final projects themselves. This covers a range of activities from Flora and Fauna surveys, through detailed design and project management to stakeholder engagement.

[redacted]

## 5.2 Costing methodology

### 5.2.1 Approach

All project proposals are costed as conceptual designs not as fully developed proposals. Overall costs were calculated from unit costs, based on the professional experience of the relevant parties. Site visits were undertaken to assess the on-ground issues involved and Digital Elevation Models considered in identifying alignments and flow velocities.

The cost elements assessed included:

- Earthworks
- Site establishment
- Access
- Structures - the major engineering works
- SCADA/automation controls
- Establishment costs

- Land valuation and acquisition
- OH&S Compliance Costs
- Make good and commissioning

The costs for the project elements were derived from a number of different sources:

- Price Merrett and Associates: additional supply options
- Alluvium: regulators and other control structures
- Murray Irrigation & Coleambally Irrigation: augmentation costs for escapes and associated works.

### 5.2.2 Contingency

A contingency was applied to the costs of the individual items in the construction program to reflect the early, conceptual basis for the designs and the recognised uncertainties. This approach meets standard engineering practice.

A contingency of 50% was applied to the major construction items under WaterNSW's control:

- The regulators
- Weir-pool and block bank controls

This % uplift was appropriate given the uncertainty around the precise locations of the assets, the geotechnical conditions or the potential impacts on sites of high value for flora, fauna or cultural heritage.

However, no such contingency was applied to costs incurred in purchasing the monitoring equipment or in obtaining alternative supplies from the two irrigation corporations as these costs were set on informed commercial contractual terms. Equally, no contingency was applied to the cost of the fishways as the costing is broad brush, set at $1M/metre of lift. This average value should be achieved over the multiple sites proposed.

## 5.3 Project development and implementation costs

The project will face a range of costs to fully develop and implement the proposed works and measures. Those costs will fall on WaterNSW as the project proponent. The construction budget recognises and includes those costs:

- Tendering and contract letting
- Detailed design of the individual projects, with requisite survey and modelling
- Planning applications and permits from state agencies
- Comprehensive surveys to establish cultural heritage and flora and fauna values
- Project management and works over-sight
- Stakeholder engagement

The project costing includes a value of [redacted] for these costs as detail in Table 5-5 above. This includes [redacted] for detailed flora and fauna surveys and assessment of cultural heritage impacts. The costs were derived from a combination of:

- Unit costs for standard activities such as flora and fauna surveys provided by specialist firm Biosis

- Stakeholder engagement costs from parallel work elsewhere
- Standard industry approaches for calculating project management costs calculated as a percentage of the capital costs involved. These costs excluded the capital costs to be incurred by the irrigation corporations as outside the costs incurred by WaterNSW:
  - 10% for survey, geotechnical investigations, detailed design and modelling
  - 5% for tendering, contract administration and commissioning
  - 5% for project management and owners costs

## 5.4 Operating costs

The proposed works and measures will generate on-going operational costs. These will include:

- Bulk water charges from the Irrigation Corporations for the use of their infrastructure in providing the alternative supplies
- Operational costs from the additional staffing required to implement the new systems
- Maintenance costs for routine and breakdown response

These costs will be borne by WaterNSW and recovered through their annual water charges - subject to oversight from the Independent Pricing and Regulatory Tribunal (IPART). The details are outlined below.

### 5.4.1 Water Charges

WaterNSW will be liable for charges from the irrigation corporations for the use of their assets to transfer bulk water deliveries from the rivers through to irrigation escapes to the creeks.

Murray Irrigation charges WaterNSW [redacted] for delivery of ordered water from its escapes. It also adds an additional 10% to the volume delivered to cover transmission losses.[2] On that basis the projected annual operating costs of water sourced from Murray Irrigation would be [redacted] over 25 years (at a 6% discount rate).

[redacted]

WaterNSW's contractual arrangements with Coleambally Irrigation include future annual charges for use of the relevant assets so there are no ongoing costs related to this project.

[2] Murray Irrigation (2015), 2015/16 FEES AND PRICES SCHEDULE - Annexure A to the Fees and Prices Policy

### 5.4.2 Operating and maintenance costs

The proposed package of measures will involve WaterNSW acquiring a suite of assets including:

- New and refurbished creek regulators
- Control capacity at six weir-pool block banks
- Vertical slot fishways
- Additional monitoring equipment

The following section identifies the projected costs that will be incurred in operating and maintaining these assets:[3]

#### a) Monitoring, Weir-pool controls and Regulators

Operating costs would be relatively low and comprise mostly labour and transport to access the site. There would also be routine maintenance and replacement costs. These annual costs are estimated at 1.5% of the capital construction costs.

Given a capital cost of [redacted] this would generate an annual cost of [redacted] over ten years.

#### b) Fishways

The time and costs associated with operation of the fishway depend on the operational tasks required and the facilities provided for remote operation. For the purposes of the business case it is presumed that operation of fishway components will be via SCADA, allowing remote operation. Given this the following program of works is projected

- **Initial 12 Months: f**ollowing commissioning the fishway operation will be closely monitored for approximately 12 months. These visits will identify any issues that may be associated with entrance and exit conditions, with debris and/or sediment, with gate operation, water quality, and any observable fish behaviour. It will also involve inspection of the fish monitoring system and any observable defects or damage with the structure.
- **Subsequent period:** Subsequent inspections / operational visits can be co-ordinated to coincide with the weir inspections. They will add approximately 2 hours to each weir visit. There may be a need for site visits specifically for the fishway where operational issues or alarms are triggered.
- **Maintenance activities:** These include clearing debris from the entrance or exit, removing accumulated sediment or debris in the fishway, etc. The business case costing has assumed debris clearing at exit / entrance will occur approximately 4 times per year and the fishway will be cleaned out on an annual basis.
- **Monitoring:** Where provided, a fish tag reader will monitor the performance of the fishway. However, it will itself require regular inspection and performance assessment. In the absence of intermittent failures or problems, an annual assessment would be satisfactory.

The annual operation and maintenance costs of the VSF are estimated to be 3% of the capital cost in the first year and 1% of the capital construction costs for subsequent years. This generates an annual cost of [redacted] in year 1 and [redacted] in succeeding years.

[3] *pers comm.* Michael Bain, Alluvium - based on experience of similar assets at other locations.

[redacted]

The table above confirms a projected budget for O&M of [redacted] over ten years with a discount rate of 6%.

### 5.4.3 Regulatory pricing

WaterNSW would normally seek a return on the capital value of its operational assets and a charge against the depreciation incurred in the use of those assets. However, these charges are not levied where the assets have been constructed from external funding grants.

## 5.5 Cost benefit analysis

### 5.5.1 Water savings - value for money

The primary outcome of the project will be to generate savings from the current losses in the diversion delivery system and regime. The modelling identified a conservative value of 14.4GL. This is the figure adopted for this business case. At this value, the proposed investment of $32M will generate water savings at a unit cost of $2,200/ML.

That represents good value in comparison with other investment opportunities where, for example, investment in irrigation modernisation often involves cost of $4,000/ML and environmental program initiatives which may cost $5,000/ML. The cost is also in-line with the current market value of high security entitlements in the Murray at $1,950/ML[4].

Analysis of representative year (2012/13) releases and end-of-system flows suggests that a higher value for the water savings of up to 40GL is not unrealistic. Monitoring after project completion will allow these values to be re-validated. If these alternative higher values are achieved in practice, they would generate savings at lower unit costs as follows:

**Table 5-8: Value for money in water savings**

| | Conservative | Medium | High |
|---|---|---|---|
| Cost | $31,923,000 | $31,923,000 | $31,923,000 |
| Saving (ML) | 14,400 | 20,000 | 40,000 |
| $/ML | $2,217 | $1,596 | $798 |

### 5.5.2 Wider benefits

The proposed investment will also generate a suite of wider triple-bottom line environmental, social and economic benefits. These are identified in section 4.5 as:

- Provide a robust platform for the introduction of an enhanced watering regime as it will reduce the current dominance of unnaturally high diversion flows throughout the irrigation season, allowing greater variability in flows to meet eco-system outcomes.

[4] Victorian Water Register: report 14 August 2015, Victorian Murray - Barmah to SA border

- Promote improved fish habitat and movement through the introduction of fishways at weir pools and modifications to block banks on the creeks
- Enhance levels of service for diverters as they will have access to a far shorter ordering schedule allowing them to match orders more closely with demand. This will provide a more productive and resilient irrigation community
- Maintain social and amenity values from the use of the creek system for urban water supply and recreation.

These are qualitative, non-monetary benefits. However, they will enhance the value for money assessment that merely considers the cost of generating water savings.

## 5.6 Project schedule

Table 5-9 provides a high-level program schedule for the project. Provided investment decisions are taken before 2019, the works will be fully operational prior to 2024.

**Table 5-9: Project schedule**

| Stage | Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|---|
| Planning and concept designs | | | | |
| New entitlement creation | | | | |
| Detailed design phase | | | | |
| Approvals | | | | |
| Procurement | | | | |
| Construction works | | | | |
| Commissioning | | | | |

## 5.7 Project cash flow requirement

The section below provides an indication of the cash flow requirements for the delivery of the project.

This adjusts the capital costs from earlier sections to take account of expected inflation. The adjustment is based on advice from the Department of the Environment (Cth) and involves two components, with an assumed annual average escalation factor of 2.68%:

- Costs are adjusted to reflect the four year implementation program as set out in Table 5-9 above
- Costs are adjusted from the 2014/15 price base to the assumed start of the project in 2017/18

The exercise involves four stages:

- Attribution of the project costs for the different project elements across the four year implementation schedule, in line with the indicative program in Table 5-9
- Escalation of those costs over the four year timeline from the original 2014/15 price base
- Aggregation of those total costs into an adjusted total project budget over the four year period
- Escalation of that aggregate budget over three years to take account of the delay in the start of the project to 2017/18

### 5.7.1 Projected cash flow

The following table takes the individual elements of the projected budget and attributes them to each of the four years of the project schedule.

[redacted]

The next table then projects forward that expenditure from the current 2014/15 price base by a factor of 2.68%/yr. to take account of projected inflation.

[redacted]

The final table then projects forward that total aggregate expenditure of $33.884 million to take account of the three year delay in the likely start date for the project.

[redacted]

This identifies a total nominal budget of $36.682 million. This involves an escalation of $4.76 million over the 2014/15 price base of $31,923. Adoption of this budget should ensure that the project has sufficient cash flow to fund the necessary works in the years in which they are projected to occur.

# 6 Potential adverse impacts

## 6.1 Risk assessment overview

The Phase 2 Assessment Guidelines cover three risk categories:

- **Adverse ecological effects** (clause 4.4.2: *business cases need to include an assessment of potential adverse ecological impacts resulting from the operation of the proposed measure*)
- **Impacts from the operation of the measure** (clause 4.7: *All business cases need to include a risk assessment and risk management strategy for the proposed operating regimes or proposed operating rules changes*)
- **Project development and delivery risks** (clause 4.11.4: *The business case needs to include a risk assessment and risk management strategy for risks to project development and delivery*)

The guidelines confirm that the business case will be assessed on the basis that:

- All significant project development and delivery risks and impacts have been identified, adequately described and analysed and robust treatments and mitigations proposed;
- The risk management strategy complies with the AS/NZS ISO 31000:2009 Risk management—Principles and Guidelines; and
- All residual risks are negligible or can be adequately mitigated.

This business case implements these requirements. This section of the business case sets out a risk management framework that has been applied across all impacts. The section covers the issues related to:

- Project development and delivery risks
- Adverse ecological effects
- Impacts from the operation of the measure

## 6.2 Risk management framework

A comprehensive risk assessment of the impacts of the proposed changes was completed in line with AS/NZS ISO 31000:2009. This assessed both the likelihood of an event occurring and the severity of the outcome if that event occurred. This methodology generates a risk matrix in line with the AS/NZS standard. Table 6-1 shows the risk matrix and definitions used in this risk assessment.

**Table 6-1: AS/NZS ISO 31000:2009 Risk prioritisation matrix**

| | Consequence | | | | |
|---|---|---|---|---|---|
| Likelihood | Negligible | Minor | Moderate | Major | Extreme |
| Rare | Low | Low | Low | Moderate | High |
| Unlikely | Low | Low | Moderate | High | High |
| Possible | Low | Moderate | Moderate | High | Very High |
| Likely | Low | Moderate | High | Very High | Very High |
| Almost Certain | Moderate | Moderate | High | Very High | Very High |

In each case, an initial risk assessment was made of the activity and then a revised assessment after appropriate mitigation controls had been applied. The assessment confirms that all residual risks are negligible or can be adequately mitigated (see Annex 10 for the full risk register).

## 6.3 Scope

The scope of the risk assessment is focused on the potential impacts arising from the design, construction and operation of the proposed works.

The project involves small-scale works or measures that have limited potential to create adverse third party impacts. The proposals involve:

- Modification of existing weirs and regulators
- Construction of one new in-stream regulator on the Billabong Creek at Puckawidgee
- Increased use of existing outfalls/escapes from irrigation corporations, with minor works within the delivery systems to increase flows

**Table 6-2: outline of proposed works on the creeks**

| Works | Activity |
|---|---|
| Warriston Weir | Remotely controlled gate to Piccaninny Creek |
| Hartwood Weir | Re-build and upgrade |
| Wanganella Weir | Re-build and upgrade |
| Puckawidgee regulator | New regulator below confluence of Yanco and Billabong Creeks |
| Colombo Creek | Installation of new controls on 4 existing weirs/block banks |
| Yanco Creek | Installation of new controls on 2 existing weirs/block banks |

Most of the works required relate to existing infrastructure in locations on creeks which are already highly disturbed. Wherever regulators are amended or constructed then provision has been made for best practice fish-passage.

## 6.4 Impacts assessment

The risk assessment was informed by a desktop analysis of Aboriginal and historical heritage values (See Annex 11), and a separate ecological desktop assessment of the project areas to identify terrestrial and aquatic ecological risks (see Annex 12). Both reviews were conducted by Biosis Pty Ltd.

The impact assessment focused on the risks that the proposed works might have on heritage or natural values. The general advice was that the construction impacts would be confined to a small area in each location within areas that had previously been heavily disturbed.

The risk assessment did not include potential impacts from changed flow regimes on aquatic ecosystems as:

- There is already considerable variability in flows within and between seasons depending on rainfall, allocations and irrigation demand
- The investment in water savings is an enabling initiative, reducing artificially high summer flows and providing the opportunity to develop and implement a revised watering regime.

## 6.5 Priority risks and mitigation strategies

The following section reports on risks under three broad categories:

- Planning and Design: risks in project development
- Construction: risks in the construction of the works
- Operational: risks from the operation of the new works and measures

In each case the high priority risks are reviewed and the relevant mitigation strategies confirmed.

### 6.5.1 Planning and design

There are a series of potential risks to the success of the proposals during the project planning and developments stage:

- **Stakeholder support**: there is a long history of partnership in water and resource management in the region. There are, therefore, well informed and active water-users and stakeholders within the creek systems and along the Murrumbidgee. The project has engaged with many of these stakeholders (see Section 8.2). Stakeholder opposition would undermine the viability of the project. An active stakeholder engagement program will be maintained to retain and build community understanding and support.
- **Inter-valley transfers (IVTs)**: the effectiveness of the alternative supply arrangements depend on accessing flows from Murray Irrigation. This will require an inter-valley transfer from the Murrumbidgee to the Murray to account for the changed source of supply. (Section 9.3). Failure to negotiate an IVT would reduce access to supplementary flows. It is proposed that a rules-based approach will be taken to ensure that potential third party impacts are mitigated. DPI Water will negotiate with MDBA over the implementation.
- **Water savings and environmental flows**: the investment will generate water saving that will be converted into a new environmental entitlement held by the CEWH. Various agencies and the regional community will be responsible for developing an agreed environmental watering strategy and regime for the Creeks. Failure to agree this revised regime could impact on ecosystem values. WaterNSW and DPI Water will lead discussions with other agencies to agree a consensus outcome.

**Table 6-3: Project development risks**

| | Risk | | | With mitigation | | |
|---|---|---|---|---|---|---|
| Issue | Likelihood | Consequence | Rating | Likelihood | Consequence | Rating |
| Stakeholders | Possible | Major Harm | B | Unlikely | Moderate Harm | C |
| IVTs | Unlikely | Major Harm | B | Unlikely | Moderate Harm | C |
| Watering regime | Possible | Major Harm | B | Unlikely | Moderate Harm | C |

### 6.5.2 Project construction risks

The works proposed are mostly small scale and mainly involve up-grades of existing infrastructure. However, construction projects of any size can create a suite of standard risks. Priority risks are listed below. In each case the core mitigation strategy is the employment of a credible professional construction company and letting of contracts that include requirements for standard controls.

- **Fire risks**: at times of high ambient temperatures there are risks that construction activities will trigger fires in native vegetation or neighbouring crops. This is a risk that will be managed by properly established safety procedures
- **Injury risks**: the construction sector routinely tops the sector with the highest workplace injuries. Equally there are potential risks to members of the public if construction sites are not properly fenced. Once again this risk will be managed through the enforcement of standard OH&S procedures
- **Cultural heritage impacts**: the survey by Biosis identified that there were few sites of cultural significance in the proposed areas and that much of the area was already heavily disturbed and cultivated. However, there is a risk that the construction works, particularly along the creek line, may disturb sensitive artefacts. A Cultural Heritage Management Plan will be developed to include protocols for the recognition of sites and for the engagement of trained staff to notify and engage with representatives of appropriate communities
- **Impacts on flora and fauna**: any construction activity is likely to impact to some extent on local flora and fauna, particularly in regard to works within creeks. The Biosis report recommended that a survey be completed at a local level once detailed designs have been drawn up to identify and avoid high risk areas and/or to acquire offsets to mitigate the impact
- **Poor quality**: there is a risk that the assets constructed are of sub-standard quality and so do not deliver the design outputs sought. This risk is dealt with through standard procurement practice and retention of a bond or insurance to rectify any shortcomings identified in practice.

**Table 6-4: Project construction risks**

| | Risk | | | With mitigation | | |
|---|---|---|---|---|---|---|
| Issue | Likelihood | Consequence | Rating | Likelihood | Consequence | Rating |
| Fire risks | Possible | Major Harm | B | Unlikely | Major Harm | B |
| Injury risks | Unlikely | Major Harm | B | Rare | Major Harm | C |
| Cultural heritage | Possible | Major Harm | B | Unlikely | Moderate Harm | C |
| Flora and fauna risks | Likely | Moderate Harm | B | Possible | Moderate Harm | C |
| Poor quality | Possible | Major Harm | B | Unlikely | Moderate Harm | C |

### 6.5.3 Operational risks

The third category of risks relates to the operation of the new assets and systems. There are three priority risks:

- **Flow regime:** the revised creek operating regime will result in changes to the flows within individual creeks and reaches. A parallel project will be needed to establish an optimal environmental watering regime to manage the flows into and within the creek system. The development of this revised regime was not within the scope of this water saving project. DPI Water and OEH will liaise over the development of the revised regime. One priority concern raised by DPI Fisheries related to the upper Yanco where the current high flows sustain a valuable population of Trout Cod. The proposed flows in this location will remain within the bounds of historic annual variability. The proposed watering regime can then augment these flows as required.
- **Fish passage:** The multiple block banks and weirs effectively block fish-passage along many creeks. The one new regulator proposed on the Billabong Creek could increase this risk. The project will therefore provide vertical slot fishways to promote enhanced fish passage at all locations where works are undertaken - in line with the requirements of Section 218 of the *Fisheries Management Act 1994*. This will enhance fish habitat across the creek system, by increasing flow diversity and fish-passage along the full length of the Colombo Creek and much of the Yanco Creek. OEH expressed concern at the potential for fishways to become ineffective over time due to inadequate maintenance. The business case has included costs for the routine maintenance and operation of the fishways.
- **Water quality:** New supplementary supply sources are routed through the two irrigation corporations. There are risks that the water quality of these sources may adversely impact the health of the creeks. WaterNSW, the MDBA and OEH already use the irrigation corporations to route water between catchments. The evidence from routine sampling is that the outflows meet required standards for water quality. An emergency system will be implemented to shut-off any escape when there is any risk say from spillage of pesticides.

**Table 6-5: Operational risks**

| | Risk | | | With mitigation | | |
|---|---|---|---|---|---|---|
| Issue | Likelihood | Consequence | Rating | Likelihood | Consequence | Rating |
| Flow regime | Likely | Moderate Harm | B | Unlikely | Minor Harm | D |
| Fish passage | Likely | Moderate Harm | B | Unlikely | Minor Harm | D |
| Water quality | Possible | Moderate Harm | C | Unlikely | Minor Harm | D |

# 7 Technical feasibility and fitness for purpose

## 7.1 Overview

### 7.1.1 Scale and complexity

The proposed package of works involves a suite of standard, small-scale, engineering activities:

- Increased use of existing outfalls/escapes from irrigation corporations. Any augmentation works will be completed by the relevant water corporation through their existing works approvals and delivery arrangements.
- Up-grade of existing weirs and regulators. The technology is proven and accepted.
- Construction of one new in-stream regulator on the Billabong Creek. The design is a standard package and will include features to ensure fish-passage and minimise disruption to flows and ecosystem functionality.

The scale and scope of the works is limited and the proposed approaches comprise standard, proven technologies.

### 7.1.2 Scope and definition

Proposals were identified from previous work and discussions with informed stakeholders. Conceptual analysis and costing of the proposals was completed by experienced practitioners, based on a proven track-record of designing and implementing parallel projects elsewhere. Limited field trips were undertaken to inform the analysis. However, the proposals are still essentially conceptual propositions. Final designs, alignments and impact assessments will be completed as part of the project roll-out.

- Summary details of the proposed works are provided in Section 3
- Annexes 3 - 6 provide concept design specifications for the key components
- Reliance on other measures is covered in Section 4.6
- Cost estimates are provided in Section 5
- Asset ownership, governance and funding arrangements are confirmed in Section 9

## 7.2 Options analysis

Clause 4.8 of the Phase 2 Guidelines requires information on the options analysis carried out to demonstrate that the preferred solution was the optimal approach. The clause also requires evidence on the other alternative designs and specifications that were considered.

This section provides evidence in-line with this requirement. A structured process was followed in selecting and developing the recommended package of measures.

### 7.2.1 Multi-criteria assessment

An initial multi-criteria assessment was carried out to limit the resources expended on developing conceptual designs and costings for options that were unlikely to merit consideration. For example, this exercise excluded any further work on the Old Man Creek as being of high cost with little opportunity to generate further water savings.

### 7.2.2 Prioritisation of alternative water supplies

A full prioritisation exercise was then completed on the alternative supplementary water supply sources, informed by the design and costing of the priority options from the multi-criteria assessment. This prioritisation review assessed each option against four key criteria:

- **Value for money**: in terms of the cost of works per ML additional supply. The review considered both the relativity between schemes and their absolute values against a number of benchmarks
- **Water saving**: the volume of projected water savings from the option.
- **Feasibility**: the technical, regulatory and practical issues involved. Each of the proposals was tested against a range of measures to judge the likely complexity of the approach:
  - Technical: did it involve tried and tested simple infrastructure or required state of the art innovative arrangements?
  - Timescale: was the project easy and quick to implement or would it involve longer timescales?
  - Regulatory: could it be implemented simply with minimal licensing or was it likely to trigger significant regulatory approvals?
  - Environmental impact: would it create significant potential impacts or minimal changes?
- **Community response**: what was likely to be the community response to the approach?

The following table summarises the quantitative value against each score to reflect the relative weighting of each attribute. This allowed the alternative options to be ranked. Value for money and water savings were both given equivalent weightings. Feasibility was accorded a slightly more limited variance, as a second order criterion. While 'Community response' was accorded a higher weighting given the importance of community support at Clause 4.11.1 of the Phase 2 Guidelines.

**Table 7-1: Multi-criteria scoring for prioritisation**

| Criterion | High | Medium | Low |
|---|---|---|---|
| Value for money | 5 | 3 | 1 |
| Water saving | 5 | 3 | 1 |
| Feasibility | 4 | 2 | -1 |
| Community response | 6 | 3 | -2 |

The results of the prioritisation exercise are summarised in Table 7-2 below and then expanded in the following sections. The outcomes and choices were then further refined as a result of later modelling of water savings and final costing of selected options.

**Table 7-2: Prioritisation ranking of alternative water supply options**

| Option | Commentary | VFM | Saving | Feasibility | Community | TOTAL |
|---|---|---|---|---|---|---|
| Finley storage & escape to Billabong Creek | Good value, a large volume, established regime & strong support | 3 | 5 | 4 | 6 | **18** |
| Wollamai escape into Forest Creek | Good value and easy to complete | 5 | 3 | 4 | 3 | **15** |
| Berrigan escape into Billabong Creek | Cheap and useful upstream of Jerilderie | 5 | 1 | 4 | 3 | **13** |
| CCD: channel to Colombo Creek | Large volume into the Colombo, relatively simple technology | 3 | 5 | 2 | 3 | **13** |
| DC800: storage for supply to Yanco | Provides for downstream users on Yanco | 3 | 5 | 2 | 3 | **13** |
| Blighty 17 direct supply to Forest Creek | Assumes low costs for on-farm works | 3 | 3 | 4 | 3 | **13** |
| Hartwood weir channel to lower Yanco Creek | Provides good use for Finley Escape but superseded by regulator in lower Yanco | 3 | 3 | 2 | 3 | **11** |
| Yanco direct to Colombo customers | Contrary to CCD strategy | 3 | 3 | 2 | 3 | **11** |
| West Corurgan escapes | Unrealistic as discharge into unreg creek & costs of pumping | 5 | 1 | -1 | 3 | **8** |
| DC800: augment supply from CICL | Involves extensive works and disruption to CICL | 3 | 3 | -1 | 3 | **8** |
| DC800: direct supply to diverters | Expensive and requires conversion | 1 | 1 | 2 | 3 | **7** |
| Finley Escape direct to diverters | High cost, conversion risk and internal farm costs and charges | 1 | 1 | 2 | 3 | **7** |
| Bundidgerry project channel | High cost, low water saving, marginally feasible | 1 | 1 | 2 | 3 | 7 |
| Bundidgerry project storage | High cost, marginally feasible given elevations | 1 | 1 | -1 | 3 | 4 |

**Table 7-3: Prioritisation ranking of control options**

| Option | Commentary | VFM | Effect | Feasibility | Community | Total |
|---|---|---|---|---|---|---|
| Hartwood Weir | Existing structure, important controls, community support | 5 | 5 | 5 | 6 | 21 |
| Gauging stations | Critical, low cost supporting controls | 5 | 5 | 5 | 6 | 21 |
| Coonong | Agreed priority works - small scale | 5 | 3 | 5 | 6 | 19 |
| 8 Mile regulator | Agreed priority works - small scale | 5 | 3 | 5 | 6 | 19 |
| Block banks | Important for control - mixed community response | 5 | 3 | 5 | 3 | 16 |
| Lower Yanco | New control & higher cost but important control structure | 3 | 3 | 5 | 3 | 14 |
| Billabong | High cost and high impact | 1 | 3 | 2 | 3 | 9 |

### 7.2.3 High priority outcomes - Support: scores from 13-18

- **Finley** storage & escape to Billabong Creek: this option provides a large volume alternative source based on an established agreement and infrastructure with Murray Irrigation. Support from Murray Irrigation as the system augmentation will also provide benefits for local irrigators. The scale of this option was reduced following modelling and further demand assessment. The outcome was to obviate the need for the storage. This led to a significant reduction in cost. *Included at smaller scale*
- **Wollamai** escape into Forest Creek: this option is based on existing infrastructure, it is easy to implement, matches area of high demand, and has support from Murray Irrigation. However, the modelling showed little benefit in terms of water savings at a cost of $1M. This did not generate value for money. *Excluded*
- **Berrigan** escape into Billabong Creek: this involves existing infrastructure, it is easy to implement in a good location to supply diverters upstream of Jerilderie, and has support from Murray Irrigation. Retained as good value for money. *Included*
- **CCD**: 12km channel to Colombo Creek: this option involves relatively large-scale if simple works, to transfer the alternative supplies across to the Colombo Creek, it makes use of the resource and can also provide direct connection to diverters. *However, the scheme was only marginal in terms of feasibility, high risk in terms of impacts on landholders and the environment and very high cost (Annex 13). Excluded*
- **DC800**: storage for supply to Yanco: this utilises an existing escape from Coleambally Irrigation. The escape is constrained so a new storage will allow higher flows to match peak demand over a shorter time-frame. It makes an important contribution to the mid and lower Yanco. *Further examination identified opportunities to augment flows from within CICL. The amended scheme was retained as an important alternative source at a reasonable price. Included.*
- **Blighty 17 direct supply**: this option involves conversion of properties on the Forest Creek to direct supply from Murray Irrigation. It is relatively easy to establish, and increases flexibility in supply options. *However, this was high cost and generated low benefits in terms of system modelling. Excluded.*

### 7.2.4 Medium priority outcomes - Borderline: scores of 11

- **Hartwood weir channel** to lower Yanco Creek: this option involves an 8km channel across from Hartwood weir to supply diverters on the lower Yanco. This would make good use of the new supply out of the Finley Escape. However, it would require pumping to lift the supply from Billabong Creek and land acquisition. The option has been superseded by the proposal for a regulator to provide a weir pool on the Lower Yanco. Retain as a second order option depending on effectiveness of the new regulator and flows down the Yanco. *Excluded.*
- **Yanco channel direct to Colombo customers:** this option retained CCD flows in the Yanco rather than the Colombo and then provided a direct connection to diverters currently supplied off the Colombo Creek. This option runs counter to the CCD option which transfers flows from the CCD to the Colombo. *Excluded*

### 7.2.5 Low priority outcomes - Not support: scores of 4-8

- **West Corurgan escapes:** these were potential sources of supply in the upper reach of the Billabong Creek for diverters at the top end of the Creek. However, the option would involve making regulated releases into an unregulated stretch of the Creek, which would run counter to streamflow policy. The option was also superseded by the CCD option that has capacity to meet demand in this location
- **DC800 - augment supply from CICL**: this option sought to augment potential supplies for the DC800 escape by investing in augmentation works within Coleambally Irrigation. However, this

would involve considerable costs and disruption to existing supply systems and did not have the support of the irrigation corporation. *Later investigation identified mutually advantageous augmentation options (Annex 6). Included*

- **DC800 - direct to diverters:** this option sought to convert diverters in the vicinity of the DC800 escape into direct customers of Coleambally Irrigation. However, the costs of supply were high and had little support from the relevant properties to take the supply and pay the higher charges
- **Finley Escape - direct to diverters:** this option sought to supply diverters directly from the Finley Escape. Once again, the costs were high and had little support from local diverters.
- **Bundidgerry project channel:** This option is reviewed and reported on above at section 2.3.2
- **Bundidgerry project storage:** This option is reviewed and reported on above at section 2.3.2**Error! Reference source not found.**.

### 7.2.6 Flow controls

The other major suite of measures proposed involves interventions to provide WaterNSW with greater management over flows within the creeks in order to implement effective controls. The development of the recommended suite of works involved assessment of a number of options:

- **Block banks and weirs:** there are many small-scale constructions along the length of the creeks that were installed at some time over the last 150 years to supplement supplies at the local scale but which now interrupt and frustrate flow management of the creeks. Previous studies have identified a program of works to remove and modify these installations. These scored 16 on the assessment.

  This business case has selected a prioritised program of works that will deliver the best return for the investment.

- **Regulators:** WaterNSW needs greater controls on flows within the creek system to be able to manage the delivery of diversions demands efficiently and with least loss. This project reviewed a range of options for additional re-regulation controls on existing fixed crest weirs (some have manually removable 'drop boards') to identify a cost effective package that also minimised interventions in the creek to retain 'natural flows'. That review included:
  - **Puckawidgee:** A regulator on the Billabong Creek downstream of the junction with the Yanco Creek. The advantage of this location is that it can re-regulate flows from the enhanced Finley Escape and from down the Yanco. The resultant weir-pool could also service an important group of diverters in the lower Yanco.
  - **Hartwood regulator:** the Harwood Weir provides a weir-pool to supply water down the Forest Creek. At present the controls on the weir are relatively simple with manual drop boards etc. In future Hartwood Weir will play a larger role in re-regulating flows from the Finley Escape to service diverters down the Billabong Creek. That will require the provision of additional control capacity through the installation of automated gates and fish-passage.
  - **Wanganella:** A regulator on the lower Billabong helps to re-regulate flows down the Creek and also provides a weir-pool for Wanganella Township. It can also re-regulate flows from Forest Creek down the Piccaninny Creek. This weir will greatly assist in meeting D/S demands and the Darlot end of system target.
  - **Gauging stations:** The system operator has few monitoring stations to record levels and flows along the creeks. The standard practice within the Murrumbidgee system is for a gauging station every three days of travel. On that basis, this project proposes the introduction of a further four such stations across the system.

# 8 Stakeholder engagement

## 8.1 Engagement

An engagement strategy was implemented commensurate with the scope of the business case. This involved a number of elements and stages:

- Meetings with local WaterNSW staff to take advice and test proposed solutions
- A workshop with agencies to establish the policy context and identify priority issues to address. This included NSW Fisheries, OEH, MDBA, CEWO and the Department of Environment (Cth)
- Meetings with key regional and local stakeholders through a series of visits and meetings along the creek system. There are two main bodies through which this engagement takes place:
  - The WaterNSW Murrumbidgee Customer Service Committee (CSC)
  - The Yanco Creek and Tributaries Advisory Council (YACTAC)
- Three further rounds of meetings with local stakeholders to explore the practical aspects of alternative options and approaches
- Briefing and engagement of Fisheries NSW to ensure adequate appreciation of their requirements

The Murrumbidgee Customer Service Committee (CSC) is the peak body representing the interests of the range of water users and agencies along the Murrumbidgee as listed in Table 9-1. The individual members represent not only their own local individual interests but also the concerns of peak bodies.

**Table 8-1: Murrumbidgee CSC membership**

| Name | Interests |
|---|---|
| [redacted] * | Operations General Manager - Coleambally Irrigation |
| [redacted] | General Manager - ChemCert |
| [redacted] * | Operations Executive - Murrumbidgee Irrigation |
| [redacted] | Ricegrowers Association of Australia |
| [redacted] * | Office of Environment and Heritage |
| [redacted] | Hay Water Users Association |
| [redacted] * | Murrumbidgee Private Irrigators Inc |
| [redacted] | Chair - NSW Irrigators Council |
| [redacted] * | Yanco Creek & Tributaries Advisory Council (YACTAC) |
| [redacted] | Commonwealth Environmental Water Holder |
| [redacted] * | Riverina Regional Organisation of Councils |

WaterNSW briefed this group at its formal meetings on the aims of the project, both prior to the project commencing and mid-way through the exercise. In addition, several members of the CSC were also included in the face-to-face community engagement (indicated by * above).

The CSC supported WaterNSW's objective to reduce water losses in the Yanco Creek system by increasing the efficiency of water deliveries, provided this also improved levels of service for irrigators.

## 8.2 Stakeholder engagement program

This section reports on the community consultation completed in May 2015 to engage local stakeholders in the exercise. The primary focus was on the modernisation program, although the discussion with YACTAC also covered the proposed Yanco Creek Regulator. The objective was to seek input into the development of realistic options for the modernisation program and to identify the range of issues and concerns that those stakeholders had about the alternative approaches.

### 8.2.1 Program - May 2015

The exercise was conducted at a relatively high level as the proposals were still at a conceptual stage. The program covered the following stakeholders.

**Table 8-2: Community engagement program May 2015**

| Date | Entity | Coverage |
|---|---|---|
| 20 May | Murrumbidgee Irrigation | Modernisation of Bundidgerry Creek supply |
| 20 May | Narrandera Shire Council | Modernisation of Bundidgerry Creek supply |
| 20 May | Uarah Fishery | Modernisation of Bundidgerry Creek supply |
| 20 May | Rel Heckendorf | Old Man Creek & Beavers Creek |
| 21 May | Coleambally Irrigation (CICL) | Possible supply to Yanco system through CICL |
| 21 May | Jerilderie Shire Council / RAMROC | Modernisation proposals for Yanco Creek |
| 21 May | Jim Hermiston | Alternative supplies to Forest Creek |
| 21 May | Local Land Services (LLS) | Modernisation proposals for creek system |
| 21 May | YACTAC | Modernisation proposals for Yanco Creek |
| 22 May | Murray Irrigation (MIL) | Possible supply to Yanco system through MIL |

The consultation involved a combined team from WaterNSW and the consultant team:

- [redacted], Manager Basin Planning, WaterNSW
- [redacted], Basin Planning Unit, WaterNSW
- [redacted], RMCG
- [redacted] RMCG
- [redacted] Alluvium

### 8.2.2 Feedback on consultation outcomes

The following sections report briefly on key responses to each of the meetings. A fuller record is provided in Annex 15.

- **Coleambally Irrigation (CICL):** Coleambally Irrigation are strong supporters of the proposed project and offered the use of their assets to help provide additional supplies to the Creek system.
- **Jerilderie Shire Council and RAMROC:** [redacted] supported improvements in the delivery arrangements for water usage across the creek system to promote more productive and profitable agriculture provided the new arrangements properly took account of the needs of the local councils.
- [ s.22 ] [redacted]**:** [ s.22 ] [redacted] spoke for diverters along the Forest Creek on the practical issues around amending supply arrangements.
- **Local Land Services:** LLS supported engagement of local community representatives in the development of any proposed changes and emphasised the values of any future environmental flow regime.

- **YACTAC:** YACTAC expressed concern about the potential impacts if the business case sought to close down the Yanco Creek as a delivery system and transfer all licensees on to direct supplies from the irrigation corporations. YACTAC's proposals for future developments are closely aligned with the proposals in this Business Case
- **Murray Irrigation:** Murray Irrigation is a supporter of the initiative and was interested in exploring the opportunities to support WaterNSW. It was concerned to ensure that any proposals:
  - Provided appropriate commercial outcomes for Murray Irrigation that reflected costs incurred and assets employed.
  - Did not adversely affect existing customers - as there is considerable growth in this area
  - Included recognition of their cooperation that would minimise future impacts from any final adjustment required to meet the targets of the Basin Plan.

## 8.3 Further consultation

Three further rounds of meetings were held to explore and refine the practical implications of the proposed measures.

### 8.3.1 June 2015

A round of meetings was held in June to look further at specific sites and issues. The meetings were led by [redacted] and [redacted] from WaterNSW and [redacted] from RMCG and were supported by [redacted], Rural & Environmental Services, who also provides advice to YACTAC.

Meetings were held with a number of landholders along the Forest and Billabong Creeks, in particular with [redacted] (ex Chair of YACTAC). This helped confirm the practical issues around establishing alternative supplies and identified priority locations for modifications to in-stream block banks and weirs.

### 8.3.2 July 2015

A later round of meetings was held in July to look in more detail at a number of proposed options:

- Operational staff in WaterNSW to validate the proposed approach
- CICL to explore opportunities to expand flows through DC800
- MIL to test and validate costs and designs for use of alternative escapes
- Colombo Creek weir pools: visits to four locations along the Colombo Creek to meet with landholders and test the practical issues around providing controls on weirs to allow re-regulation and release of flows.
- The meetings involved:
  - [redacted] from RMCG
  - [redacted] from WaterNSW
  - [redacted] representing YACTAC
  - [redacted] from Fisheries NSW
  - Landholders from relevant block banks and weir pools
  - Local Council representatives

### 8.3.3 August 2015

[redacted] from WaterNSW then met with a number of local landholders and councils in the area to brief them on the revised proposals and take their advice on practical issues and priorities. This included:

- Meetings with landholders around the proposed Puckawidgee Regulator below the confluence of the Yanco and the Billabong Creeks. There was strong in principle support for the proposal and agreement to co-operate in terms of access across private land to the optimal location on the creek. This will facilitate construction and maintenance and reduce the security risks that arise where assets are located on public land.
- Meeting with Conargo Shire Council - Councillors and Officers. Many of the Councillors are local diverters from the creeks. They endorsed the broad approach and supported the proposals for re-regulation and control of flows within the creek system and the benefits this would generate for growers, the environment and the town supply. They offered use of their shire newsletter as a mechanism to keep the local community informed on progress.

## 8.4 YACTAC

There is a long history of active participation by the local community in the management of water resources in the Yanco Creeks area. This leadership dates back into the nineteenth century but has been most active since the setting up of the *Riverina Creeks Committee* in 1900 and the *Yanco, Colombo and Billabong Water Trust* in 1921, which was converted into the *Yanco Creek & Tributaries Advisory Council* in 1980.[1]

In 2004 YACTAC launched its *Yanco Creek System Natural Resource Management Plan*, which addressed a wide range of issues including environmental flows and delivery constraints (*Beale et al 2004)*. There was significant overlap in the aims and objectives of this Management Plan with the water efficiency and water savings charter of *Water for Rivers.* As a result

> *it was agreed to form a Steering Committee of key stakeholders to guide the development and implementation of the Yanco Creek Water Efficiency Project.*[2]

YACTAC has continued to pay an active role in this area. Including:

- Community established Landholder Levy to fund NRMP works
- Balancing the protection of the Yanco-Colombo & Billabong Creek
- Riparian needs with the Community - LLS (2010)
- Environmental Flows Study
- Baseline Fish Monitoring Study
- Collaborative LLS projects – Box Thorn, Community,

The stakeholder engagement strategy for this business case reflected this partnership approach and the leadership role of YACTAC in the southern half of the study area. YACTAC made a presentation to the Murrumbidgee CSC in June setting out its proposals for *The Yanco Creek System - Project*.[3]

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1 [redacted] (2002), *Song of Running Water.*
2 [redacted] *Yanco Creek System Water Efficiency Project*
3 [redacted] (June 2015), *Opportunities for SDLA Proposals,* YACTAC presentation to Murrumbidgee CSC

*The project seeks to reduce evaporation losses, rehabilitate some anabranches and wetlands to replicate more naturally occurring wet and dry cycles, provide alternate and more efficient water supply pathways into the creek, and improve gauging, metering and monitoring of water use. Project benefits:*

- *Water savings achieved by the reduction of losses and more efficient delivery strategies*
- *Ecological rehabilitation of identified anabranches and wetlands in Yanco Creek system by returning to a more natural wetting and drying regime*
- *Improved system gauging, improved metering and monitoring of water use.*
- *Environmental Flows Study that can be used to help procure environmental water for the Yanco Creek System.*

There is close alignment between these objectives and the proposals in this Business Case. The following table reproduces the future priorities for YACTAC listed in that presentation and confirms where they are addressed in this proposal.

**Table 8-3: Reconciliation OF YACTAC priorities and this business case**

| Possibilities and Benefits | This project |
|---|---|
| End of System Flows identified in MDB accounting | Outside this project |
| Re-reg Opportunities – Hartwood Weir, Ski Weir, Algudgerie, Coonong, Nine mile | Strong support - Sections 3.5 |
| Weirs – McRabbs, Six Mile | Strong support - Sections 3.5 |
| Fish Passage | Strong support - Section 3.5.2 |
| Improved delivery times | A key proposal: Sections 3.7.1 & 4.5 |
| Real Time Monitoring for all users | A key proposal: Sections 3.7.1 |
| Less water required for conveyance | The major proposal: Section 4 |

Engagement with Jim Parrett as a representative from YACTAC in the consultation built dialogue and confidence. This established a strong basis for a continuing regional partnership between WaterNSW and YACTAC in developing and implementing this program.

## 8.5 Consultation conclusion

This section gives confidence to SDLAAC that this business case meets the requirements of clause 4.11.1 of the Phase 2 Guidelines that:

- Key stakeholders have been identified;
- Those materially affected have been consulted;
- The consultation strategy will meet stakeholder expectations and respond to their concerns; and
- There is evidence of broad community support for the project.

# 9 Project delivery

## 9.1 Governance and project management

WaterNSW is the project owner and will have oversight responsibility for project implementation. It has a well-established track-record in the delivery of water reform programs. DPI Water will play a key role in managing the creation of the new entitlements for the environment and any variations to IVT management and for wider water reform and regulatory issues.

WaterNSW will be responsible for managing the creek system to deliver services that meet the needs of the licensed diverters and the holders of environmental entitlements. That responsibility will include ensuring operation of regulators and other controls to meet minimum passing flow requirements.

## 9.2 Ongoing asset ownership, operation, maintenance and management

The new in-creek assets will belong to WaterNSW who will have responsibility for their operation and maintenance. WaterNSW will contract with Murray Irrigation and Coleambally Irrigation for the supply of supplementary supplies, subject to payment of the capital costs of ensuring system adequacy to deliver those services, as well as an annual sum to reflect on-going costs. The regional irrigation corporations will retain responsibility for any new assets created within their systems.

This provides a robust basis for the project implementation and gives confidence to funding agencies that there are well established competent authorities in place to ensure effective use of the funds.

## 9.3 Inter Valley Transfers (IVT) & Water Sharing Plans

Obtaining additional flows from the escapes operated by Murray Irrigation will convert flows that are currently sourced from the Murrumbidgee into flows that are delivered out of the Murray. It will be necessary to account for this transfer through the inter-valley trade accounting system.

The Murray-Darling Basin Agreement (Schedule D – Adjusting Valley Accounts and State Transfer Accounts) Protocol 2010 sets out the rules for maintaining accounts to record the volume of water allocations and entitlements transferred / traded between trading zones. As well as setting out accounting rules, the Protocol sets out rules for delivering the water necessary to supply transfers of allocations and entitlements.

The volume and timing of call-outs is managed through operating plans agreed between New South Wales and the Murray Darling Basin Authority. These plans consider the likely impact of deliveries from Murray Irrigation on the IVT account balance and the need for IVT call-outs to maintain the target range of IVT account balances.

This measure will increase the draw on supplies from the Murray valley, which is estimated to have a modest impact on IVT accounting. It is proposed that a rules-based approach will be taken to ensure that potential third party impacts are mitigated

## 9.4 Legal and regulatory requirements

The project involves a limited number of works within a small footprint:

- Upgrades to existing in-stream structures and works to establish controls to restore flow connectivity

- One new in-stream regulator to regulated excess flows and control flows downstream
- Small scale works on assets owned and controlled by irrigation corporations.

Enhanced fish passage and connectivity have been provided for in line with S218 of the Fisheries Management Act 1994.

The risk assessment in Section 6 above confirms that the scale of the works and footprint of the proposed works is small. The Biosis review of Cultural Heritage impacts concluded that:

> *The proposed works do not impact on any of the known heritage sites (Aboriginal and historical) which are present within the project areas and generally cross areas that have been cleared and disturbed previously.*

The same over-arching analysis applies to potential flora and fauna impacts.

The following sections review and confirm the applicability of relevant legislative frameworks at a State and Commonwealth level.

### 9.4.1 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* establishes a system of environmental assessment and approval by the Commonwealth for actions that significantly affect Matters of National Environmental Significance (MNES).

In particular, the Act provides protection for nationally listed threatened species, migratory species and ecological communities. If a proposal is likely to have an impact upon any MNES under the Act, such as:

- Commonwealth-listed threatened species and ecological communities,

then the proponent has an obligation under the Act to refer the proposal to the Commonwealth Environment Minister for a decision as to whether the action is a 'controlled action' and therefore requires assessment and approval (via a Bilateral Agreement between NSW and the Commonwealth).

A final decision on the implications of the proposals for the relevant MNES will be completed as part of the final detailed project planning. However, the initial assessment by Biosis suggests it unlikely that any such matters will be triggered by the construction works themselves. Equally, the revised watering regime will provide a mechanism to determine flows that optimise ecosystem outcomes in-stream, where the current multiple block banks and weirs current obstruct flows and connectivity.

### 9.4.2 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) requires the consideration and management of impacts of proposed development or land-use changes on the environment (both natural and built) and the community. The Act is administered by the NSW Department of Planning and Infrastructure.

WaterNSW is deemed a determining authority under Section 110 of the Act and the proposal would be assessed under Part 5 of the Act. Under Section 111 of the Act, a determining authority has the duty to consider the environmental impacts of an activity and is required to "take into account to the fullest extent possible all matters affecting or likely to affect the environment" arising from the proposal.

WaterNSW would be required to prepare a Review of Environmental Factors (REF) if impacts to the environment are not considered significant.

**Assessment of Significance (Section 5A)**

Section 5A of the EP&A Act requires proponents and consent authorities to consider if a development will have a significant effect on threatened biota listed under the *Threatened Species Conservation Act* and *Fisheries Management Act*. Section 5A outlines seven factors that must be taken into account in an Assessment of Significance. Where any Assessment of Significance determines that a development will result in a significant effect to a threatened biota, a Species Impact Statement (SIS) is required.

The proposed works may alter the hydrological regime of the creeks, which may result in changes to the composition and structure of ecological communities. The optimal flows patterns will be confirmed as part of the enhanced watering regime that will need to follow this project. The need for assessments of significance will be confirmed during the comprehensive impact assessment that forms part of the detailed project planning if the proposal is supported for funding.

### 9.4.3 Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act* provides for the protection and conservation of biodiversity in NSW through the listing of threatened biota; key threatening processes; and critical habitat for threatened biota.

Once again the initial assessment suggest a low risk of adverse impacts but the detail will be confirmed in the comprehensive impact assessment that will form the first stage of the project implementation program if the initiative is funded.

### 9.4.4 State Environmental Planning Policies (Part 3 Division 2)

State Environmental Planning Policies (SEPPs) outline policy objectives relevant to state wide issues. A number of SEPPs are likely to be relevant to the current project and would be identified once the final design is determined.

### 9.4.5 Fisheries Management Act 1994

This section outlines the requirements regarding potential impacts on fisheries.

**<u>Part 7 – Protection of Aquatic Habitats</u>**

s.199 – Under s199 of the FM Act, the Minister for Primary Industries is required to be consulted over any <u>dredging or reclamation works</u> carried out, or proposed to be authorised, by a public authority (other than a local government authority) (i.e. any excavation within, or filling or draining of, water land or the removal of woody debris, snags, rocks or freshwater native aquatic vegetation or the removal of any other material from water land that disturbs, moves or harms these in-stream habitats).

s.219 – permit/approval to <u>obstruct the free passage of fish</u>.

**<u>Part 7A – Threatened Species Conservation</u>**

In NSW, legislative responsibility for the conservation of threatened species, populations and ecological communities rests with two agencies: the NSW Office of Environment and Heritage (OEH) through administration of the Threatened Species Conservation Act 1995 (TSC Act), and NSW DPI through administration of Part 7A of the FM Act.

OEH has responsibility for the conservation of mammals, birds, reptiles, amphibians, terrestrial invertebrates and terrestrial and freshwater plants. NSW DPI has responsibility for the conservation of all 'fish', which by definition also includes freshwater, estuarine and marine aquatic invertebrates (such as crustaceans, molluscs and polychaetes), as well as marine vegetation, including saltmarshes, mangroves, seagrasses and macroalgae.

The FM Act contains schedules of species, populations and ecological communities that have been listed as 'threatened'. Threatened species and ecological communities are listed under four categories: species presumed extinct, critically endangered, endangered and vulnerable. Populations are listed under the category 'endangered'. The FM Act also includes a list of 'key threatening processes'.

Part 7A (s220ZW) of the FM Act provides for the licensing of actions that are likely to result in:

- harm to a threatened species, population or ecological community; or
- damage to a habitat of a threatened species, population or ecological community.

<u>Threatened species test of significance – Section 5A (known as the '7 part test')</u>

Section 5A of the EP&A Act lists factors which must be taken into account to determine whether there is likely to be a significant effect on threatened species, populations, and ecological communities or their habitats. Also termed the '7 part test', this consideration assists with the assessment of applications (under Ss 78A, 79B and 79C, EP&A Act), or environmental assessment (ss111 – 112 EP&A Act).

Where a proposed development is in the potential range of a listed threatened species, population or ecological community under the FM Act and/or the EPBC Act, and the area has not been declared a critical habitat, the following applies:

- A '7 part test' is completed. If the determining/consent authority determines that the project will not have a significant impact after considering the '7 part test', then the proposal may be accepted, subject to compliance with relevant government policy including DPI Fisheries Policy & Guidelines.
- If the determining/consent authority determines that the proposed project will have a significant impact via the '7 part test', then a Species Impact Statement (SIS) is required to be prepared, or the proposal may require modification where possible (e.g. changes to construction designs or relocation of the project to another site).
- Modifications to the original proposal require re-application of the '7 part test'. If the modified project still may cause a significant impact, then a SIS must be prepared for the project.

<u>Species Impact Statement (SIS)</u>

A finding of significance under s5A of the EP&A Act will require that the applicant prepare a SIS, if they still wish to proceed with their application. The required content of a SIS is listed in s221K of the FM Act. The information from the SIS will be used to make an assessment of the application and determine whether the impacts are acceptable or not.

Prior to the preparation of a SIS, the applicant must obtain the requirements of the Director-General of NSW DPI. These requests should be accompanied by the s5A assessment, a copy of the development application and any Statement of Environmental Effects (SEE), Review of Environmental Factors (REF) or Environmental Impact Statement (EIS) that may have been prepared. The Director-General's requirements will outline all matters to be included in the SIS so that a more detailed assessment can be undertaken.

## 9.5 Monitoring and evaluation

WaterNSW provides annual reports to record and report on key attributes of its business performance. That will include volumes supplied and services delivered as well as the performance of control structures such as fishways.

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# Appendix 1: Summary of response to the Phase 2 Assessment Guidelines

This section confirms how this business case delivers against each of the relevant requirements of the SDLAAC Stage 2 Guidelines. The following table lists the requirements and then records where the issue is dealt with in this business case.

**Table 9-1: Compliance with Phase 2 Guidelines**

| Guidelines section | Heading | Requirement | Business case section |
|---|---|---|---|
| 3.1.1 | Supply measure definition | Defines the requirements for supply measures | 1.4 & 4.2 |
| 3.1.2 | Measures not included in the benchmark conditions of development | Confirm that the measure was not in the benchmark conditions of development | 1.5 |
| 3.2 | Constraint measure requirements | Defines application of guidelines to constraint measure initiatives | Not applicable |
| 3.3 | Operational by June 2024 | The measure must be capable of entering into operation by 30 June 2024 | 1.5 |
| 3.4.1 | The measure is a 'new measure' | Confirm the measure has not received funding or have funding approved | 1.5 |
| 3.4.2 | Compliance with the purposes of the Water for the Environment Special Account | Defines funding eligibility for constraint measure initiatives | Not applicable |
| 4.1 | Project details | Key project details and overview | 2 |
| 4.2 | Ecological values of the site | Description of the ecological values of the site | Not applicable |
| 4.3 | Ecological objectives and targets | Confirm objectives and targets | Not applicable |
| 4.4.1 | Anticipated ecological benefits | Proposed outcomes from the investment | Not applicable |
| 4.4.2 | Potential adverse ecological impacts | Assessment of potential adverse impacts | 6.5 |
| 4.5.1 | Current hydrology and proposed changes | Clear articulation of current and proposed hydrology | Not applicable |
| 4.5.2 | Environmental water requirements | Water requirements of new inundated areas | Not applicable |
| 4.6 | Operating regime | Explanation of the role of each operating scenario | 3 & 7 |
| 4.7 | Assessment of risks and impacts of the operation of | Assessment of risks and mitigation | 6.6.3 |

| Guidelines section | Heading | Requirement | Business case section |
|---|---|---|---|
| | the measure | options | |
| 4.8 | Technical feasibility and fitness for purpose | Evidence that the project infrastructure is technically feasible | 7 |
| 4.9 | Complementary actions and interdependencies | Confirm interaction with other initiatives | 4.6 |
| 4.10 | Costs, Benefits and Funding Arrangements | Detailed costing and listing of benefits | 5 |
| 4.11.1 | Stakeholder management strategy | Confirm stakeholder list and stakeholder management strategy | 8 |
| 4.11.2 | Legal and regulatory requirements | Legal and regulatory requirements | 9.4 |
| 4.11.3 | Governance and project management | Governance and project management | 9.1 & 9.2 |
| 4.11.4 | Risk assessment of Project Development and Delivery | Risks from project development and delivery | 6.6 |

# Appendix 2: Annexes

This Appendix lists the annexes attached to this business case to provide further evidence and supporting material.

| # | Author | Title | Coverage |
|---|---|---|---|
| 1. | RMCG | Bundidgerry analysis | Options assessment |
| 2. | DHI | Modelling | Assessment of water savings |
| 3. | Alluvium | Regulators | Design and costing |
| 4. | Alluvium | Weir pools | Design and costing |
| 5. | Alluvium | Fishways | Design and costing |
| 6. | CICL | DC800 escape | Design and costing |
| 7. | MIL | Escape flow analysis | Capacity availability assessment |
| 8. | WaterNSW | Yanco Creek system flows | Data on historic flows |
| 9. | RMCG | Cost data | Cost data analysis |
| 10. | RMCG | Risk register | Comprehensive risk assessment |
| 11. | Biosis | Cultural Heritage | Report on impacts |
| 12. | Biosis | Flora & Fauna report | Report on impacts |
| 13. | RMCG | Supply channels | Assessment of supply options |
| 14. | RMCG | Finley escape invert | Assessment of supply options |
| 15. | RMCG | Stakeholder engagement | Meeting reports |
| 16. | RMCG | Other areas reviewed | Reports |

# Murrumbidgee SDLA – Update of Benchmark model

## 1 Benchmark model revisions

This report describes:

- additional work to update the Benchmark model to include more detailed representation of hydrological and operational processes for the Yanco Creek system that are necessary to assess the Yanco modernisation proposal, and
- a final summary of the model enhancements to represent all of the Water for Rivers projects in the Murrumbidgee Valley previously described in *Murrumbidgee CARM Sustainable Diversion Limit Adjustment Modelling – Business Case* (DHI 2015) report prepared during development of the business case.

This work includes some minor additional enhancements to the representation of the Water for Rivers projects.

Some amendments to the MDBA Benchmark model are necessary to allow detailed assessment of proposed Murrumbidgee supply measure proposals. The MDBA Benchmark model took account of Water for Rivers pre-2009 projects by post-processing results, and it is proposed to adapt the Benchmark model to represent these projects directly. Furthermore, some hydrological and operational processes have been updated or extended in the Murrumbidgee IQQM to provide a robust assessment of the post-2009 Water for Rivers projects, and it is proposed that these model enhancements be included in the Benchmark model, together with representation of these later projects.. This work is described in more detail in “Murrumbidgee CARM Sustainable Diversion Limit Adjustment Modelling – Business Case” report prepared during development of the business case.

The changes to the models are summarised in the sections below. They are also show in flowchart form in Figure 1. This figure shows the relationship between the various models, and what information or alterations are used to produce each model.



## 2 Water for Rivers projects prior to 2009

The Water for Rivers projects carried out prior to 2009 not included in the MDBA Benchmark IQQM model include:

- Purchase of general security licence from the valley of 40,400 unit shares (prior to 2009)
- On-farm reconfiguration projects yielding 21,500 general security unit shares
- Coleambally Irrigation Area works, yielding 3,500 unit shares of Coleambally Irrigation Area conveyance licence
- Barren Box Swamp works, yielding 20,000 unit shares of Murrumbidgee Irrigation Area conveyance licence
- Hay PID works, yielding 1,000 ML/yr of conveyance licence
- Forest Creek removal of Warriston Weir minimum flow requirement of 100 ML/d, yielding 34,700 general security unit shares

The licences associated with these projects were redistributed in the model, from the irrigation corporation bulk offtake or the reach scale irrigation nodes to a water savings node (dummy irrigator) just downstream of Blowering Dam.

*General Security licences*
Of the total 61,900 general security unit shares (40,400 unit shares purchase and 21,500 unit shares on-farm reconfiguration), 32,000 unit shares was taken from the Coleambally Irrigation Area bulk licence, 7,500 unit shares from Forest Creek irrigators, and the remainder of 22,400 unit shares was taken uniformly from all other river pumpers (excluding the Murrumbidgee Irrigation bulk licence). The total of 61,900 unit share general security licence was then added as a dummy irrigator node immediately downstream of Blowering Dam, to avoid re-allocation of this water.

*Murrumbidgee Irrigation and Coleambally Irrigation conveyance*
This was removed from the allocation – additional volume table in the bulk irrigator (3.4) node. The volume provided by the conveyance licence to be removed was calculated for each row in the table, and the table volume decreased accordingly. A new dummy irrigator node with equivalent allocation – volume was then added immediately downstream of Blowering Dam to avoid re-allocation of this water.

*Hay PID conveyance*
This conveyance of 1,000 ML/yr was removed from the bulk irrigator node allocation – volume table, across all entries (i.e. constant allocation). This water was added to the dummy re-allocation node downstream of Blowering Dam used for the MI and CI conveyance licences.

*Forest Creek – Warriston Weir*
The MDBA Benchmark model has the 100 ML/d Warriston Weir minimum flow requirement already removed. For this reason the 34,700 general security unit shares produced by this measure are not included in the revised Benchmark model.

The redistribution of licences is outlined fully in Appendix A. The tables in Appendix A include:

- The calculation of the licence to be removed from the irrigation or bulk supply nodes, for general security and conveyance licence types
- The revised licences after the WFR licence is removed
- The revised irrigation areas (reduced using a similar approach used by the MDBA when decreasing licensed entitlement to represent water recovery from the Water Sharing Plan scenario to the Benchmark scenario)

# 3 Adjustments to support representation of Murrumbidgee supply measure proposals

This section outlines the changes required to the Benchmark model to allow a robust evaluation of the effect of the Murrumbidgee supply measure proposals.

## 3.1 Water for Rivers projects post 2009 (tripartite projects)

The post 2009 WFR projects are referred to here as the tripartite projects, as they were developed under an agreement between the NSW Office of Water, State Water and Water for Rivers.

Modelling the changes due to the tripartite projects requires improving the model's representation of some physical processes that have previously been lumped together, such as transmission losses across several smaller river reaches. For example, the Wilson Anabranch project involves construction of a regulator on the Wilson Anabranch on lower Yanco Creek, in order to reduce losses during regulated flow periods. In the

MDBA Benchmark model (and the Water Sharing Plan model), the losses caused by the pre-project Wilson Anabranch are not separately represented in the model. If this unadjusted model was used as the benchmark, the post-project model would show no reduction in losses compared to this benchmark. To more accurately calculate the change from the project, losses in the anabranch first have to be represented.

The tripartite projects requiring adjustments to the MDBA Benchmark to allow more accurate representation of their impact are:

- Wilson Anabranch and associated losses
- Beavers Creek existing offtake structure, and losses and return flows on the Beavers / Old Man Creek system
- Augmented supply via Irrigation Corporations:
    - Coleambally Irrigation Area escape drain operation and historical loss provision, and
    - Murray Irrigation Finley Escape drain operation,
- Oak and Gras Innes Wetland losses on Bundidgerry Creek
- Tributary utilisation for regulated orders (for CARM)
- Yanco Offtake operation (for CARM)
- Rainfall rejection from Murrumbidgee Irrigation (for CARM)

The changes to the Benchmark model are summarised in Table 1. These changes are described in more detail in DHI 2015.

Some further work has also been undertaken to implement associated changes to key parameters (relating to irrigated crop areas) at irrigation nodes where entitlement has been recovered through (pre and post 2009) Water for Rivers projects. An approach similar to that used to "recover" entitlement from irrigation nodes in the Benchmark model (representing implementation of the Basin Plan) has been adopted.

## 3.2 Yanco Colombo Billabong modernisation project

Projects that produce water savings due to reduced transmission losses are sensitive to the loss functions in IQQM. They are sensitive to both the magnitude of the loss, but also the change in loss resulting from a change in flow.

The calibration in the 2005 and 2007 versions of the Water Sharing Plan models uses very flat flow – loss curves to simulate transmission losses in Yanco Colombo Billabong Creeks (i.e. the loss is the same even if the flow doubles). This means any long term reduction in flow through the creek system through efficiency or using irrigation corporation escapes produces little simulated benefit.

DPI Water have recalibrated the loss functions in the Yanco Colombo Billabong system to produce updated functions and new residual catchment inflow time series. The updated loss functions provide a better representation of observed behaviour and are more sensitive to change in flow. This, in turn, produces a more realistic transmission loss assessment.

## 3.3 Yanco Offtake

No changes to the Benchmark model are understood to be required for the Yanco Regulator supply measure proposal.

## 3.4 Nimmie Caira and Yanga National Park projects

No changes to the Benchmark model are understood to be required for the Nimmie Caira and Yanga National Park supply measure proposals.

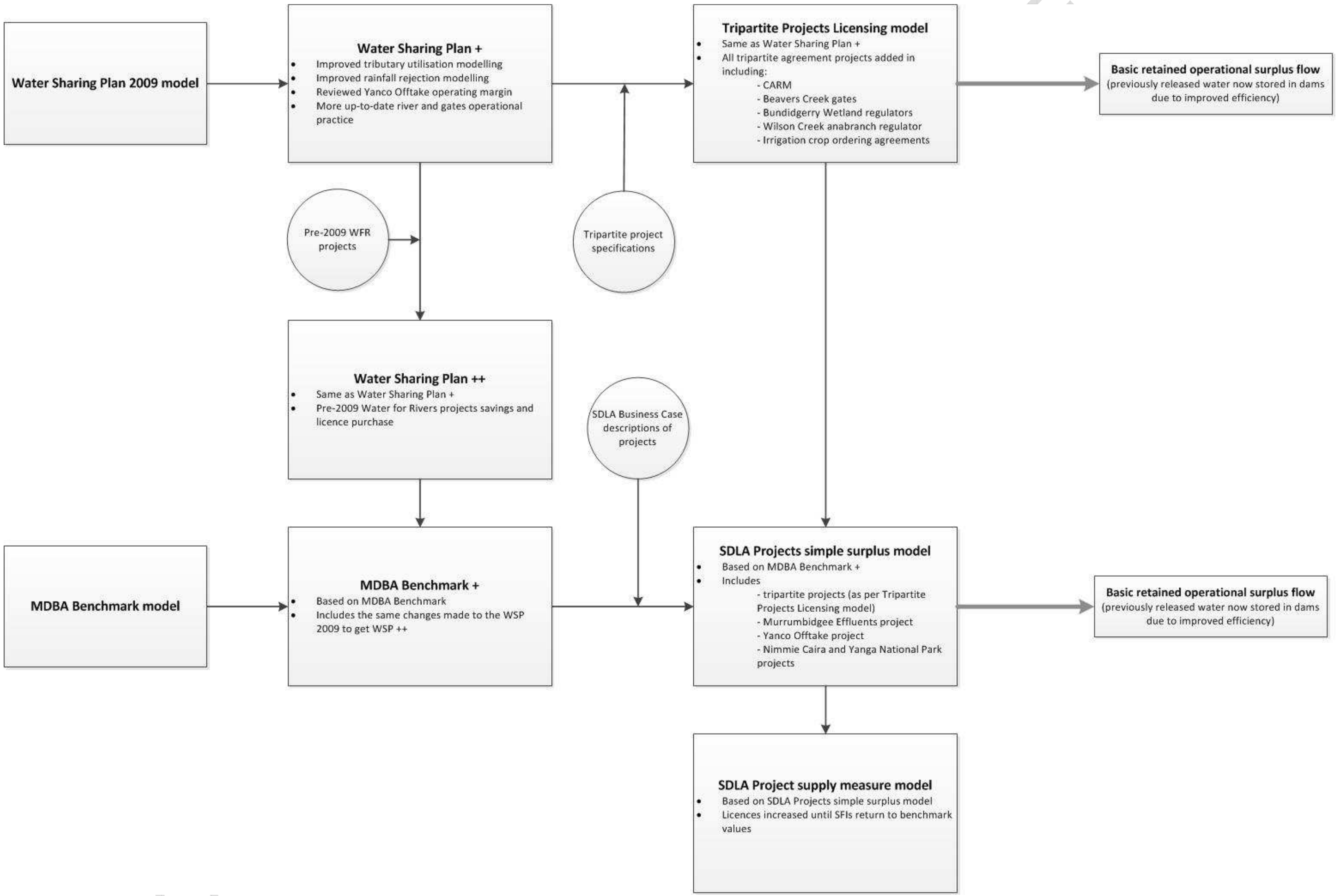
Table 1 Summary of Benchmark model changes to support SDLA project assessment

| Project | Key changes |
|---|---|
| Beavers Creek regulator and high-river anabranch control structures | • Prevent model ordering extra water just to supply head at offtake if river is too low<br>• New spill from river into “Old” Old Man Creek anabranch<br>• New spill from Old Man Creek through Dog Fall Creek anabranch back to river<br>• Split loss function Berembed to Yanco into Berembed – OMC return, OMC return to Yanco<br>• Removal of variable Beavers offtake relationship (low level culvert was jammed)<br>• Add Berry Jerry Forest floodplains<br>• Update Old Man Creek transmission loss function<br>• Add flow-dependent evaporation loss |
| Coleambally Irrigation Escape Drains | • Refinement of modelling prior to new agreement between State Water and CI that puts more orders through CI drains<br>• Redistribution of orders to drains done on Yanco Creek near Morundah, rather than up at Offtake (avoids redistribution based on Colombo orders)<br>• Added 10% loss provision through CI (State Water working agreement)<br>• Review of historical redistribution patterns<br>• Addition of CI winter shutdown into redistribution calculation |
| Wilson Anabranch | • Placement of regulator to prevent anabranch inflows during regulated flow periods<br>• Opened during winter<br>• Addition of:<br>• Existing anabranch offtake relationship based on pipe rating<br>• Anabranch pond into model:<br>    • Existing composite outflow based on spillway and outlet pipe capacity |

| Project | Key changes |
|---|---|
| | • Applied combined evaporation and seepage (1mm/day) |
| Bundidgerry Creek wetlands | • New regulators on small wetlands to exclude regulated flows during supply periods<br>• Gras Innes wetland (just north of storage) and Oak Creek (south of Bundidgerry Creek, several km upstream of storage)<br>• Open water evaporation loss modelling<br>    • Based on Bundidgerry Storage level for Gras Innes<br>    • Based on water level and creek flow rate for Oak Creek |
| Finley Escape | • Refinement of modelling prior to new agreement between State Water and MIL<br>• WSP model – average of 25GL/yr, repeating annual pattern<br>• WFR project increases utilisation to an average 37GL/yr, depending on orders in lower Billabong (saving is ~2.6GL/yr)<br>• Benchmark model updated with MSM-Bigmod flows from MI – average of ~50GL/yr<br>• *Not adjusted from MDBA Benchmark model* |
| CARM | • Benchmark adjusted to allow modelling of the impact of three processes (see Appendix 2 for more information on these changes):<br>    • Tributary utilisation<br>    • Rainfall rejection<br>    • Yanco Offtake order margin<br>• Potential other changes such as improved monitoring and hydraulic routing too difficult to include directly |
| Yanco Colombo Billabong transmission losses | • Update of loss functions<br>• Addition of residual catchment inflow series |

| Project | Key changes |
|---|---|
| Yanco Offtake | • No changes required |
| Nimmie Caira and Yanga National Park | • No changes required |

Figure 1 Flowchart showing model versions for Benchmark and Project models



# 4 Effect of Benchmark changes

After the changes to the benchmark model were made, long-term average diversions were calculated for each licence category. These are summarised in Table 2 for the Benchmark (BIDG) and the Adjusted Benchmark (GNX7).

The table gives the average annual volume diverted under each licence type, the total number of unit shares of that licence type, and the proportion of the 1 ML/unit share diverted.

Table 2 Average annual diversions for water years 1895 – 2008

| **Licence category** | **Benchmark (BIDG)** | **Adjusted Benchmark (GNX7)** |
|---|---|---|
| | **Volume (ML)** | **Volume (ML)** |
| General security (**total**) | 599910<br><br>(57.1% of 1051100 us) | 602291<br><br>(57.4% of 1051100 us) |
| High security (irrigation) | 349916<br><br>(98.0% of 356846 us) | 349646<br><br>(98.0% of 356846 us) |
| Hay PID to be transferred to WFR | 983<br><br>(98.3% of 1000 ML) | 984<br><br>(98.4% of 1000 ML) |
| MI and CI Conveyance (irrigation) | 367223<br><br>(98.5% of 373000 us) | 342677<br><br>(98.0% of 349500) |
| MI and CI Conveyance (WFR projects) | - | 23121<br><br>(98.4% of 23500) |
| MI and CI Conveyance (**total**) | 367223<br><br>(98.5% of 373000) | 365799<br><br>(98.1% of 373000) |
| Supplementary | 72463<br><br>(36.5% of 198780) | 72516<br><br>(36.5% of 198780 us) |

Announced allocations on the 1st October (summer crop planting decision date) and 1st June (effectively end of water year allocation) are shown in Figure 2 and Figure 3 for the Benchmark and Adjusted Benchmark models. Effective allocations, which include carryover, are shown in Figure 4 and 5 for these dates.

The changes to the Adjusted Benchmark model have the apparent impact of reducing annual licence allocations, as shown in Figure 2 – Figure 5 below. This is despite average annual irrigation diversions staying the same. The primary reason for the change in allocation is the change in how tributary utilisations are modelled.

In the Benchmark model, utilisations are modelled using a fixed tributary recession factor – i.e. when working out how much tributary water will be available in 1-4 days to use to supply orders, the model takes todays flow and multiplies it by the factor to get the potential future reduction in order. In the Benchmark model a factor of 1.0 is applied in the tributary catchments between the dams and Gundagai, and value of 0.85 – 0.90 are applied between Gundagai and Wagga Wagga.

In the Benchmark this factor is applied irrespective of the tributary discharge magnitude or whether the tributary is rising or falling. As part of the evaluation of CARM for the Water for Rivers tripartite licence evaluation, past river operations worksheets were reviewed to understand what the level of utilisation had been in the past. This found that operators utilised a higher proportion of the tributary inflow at lower discharges and on the falling limb of the hydrograph. They used less of the inflow on the rising limb of the hydrograph, particularly for larger discharges. This information was used to derive relationships between potential tributary utilisation, discharge magnitude and whether the tributary was rising or falling (see Appendix A for these relationships).

These utilisation relationships are applied in the Adapted Benchmark model, instead of the constant tributary utilisation factors in the Benchmark model. As previous fixed utilisations were very high (1.0 upstream of Gundagai, 0.85-0.90 between Gundagai and Wagga Wagga), running the model with the new variable utilisations has reduced the use of tributaries to fill orders in the Adapted Benchmark model. This has led to the reduction in the apparent reduction in reliability in the model, as shown in Figure 2 – Figure 5.

Table 3 Average allocations on 1st October and 1st June

| | | **Benchmark (BIDG)** | **Adjusted Benchmark (GNX7)** |
|---|---|---|---|
| **Announced allocation** | 1 October | 56.8 | 54.9 |
| | 1 June | 86.9 | 84.0 |
| **Effective allocation** | 1 October | 79.1 | 74.5 |
| | 1 June | 94.6 | 90.4 |

Figure 2 Announced allocation exceedance – 1st October

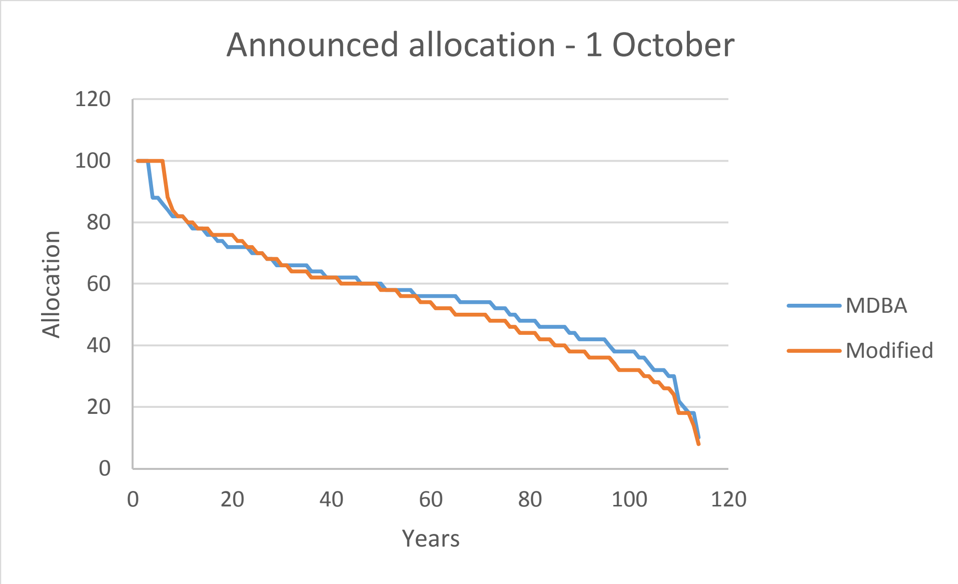



Figure 3 Announced allocation exceedance – 1st June

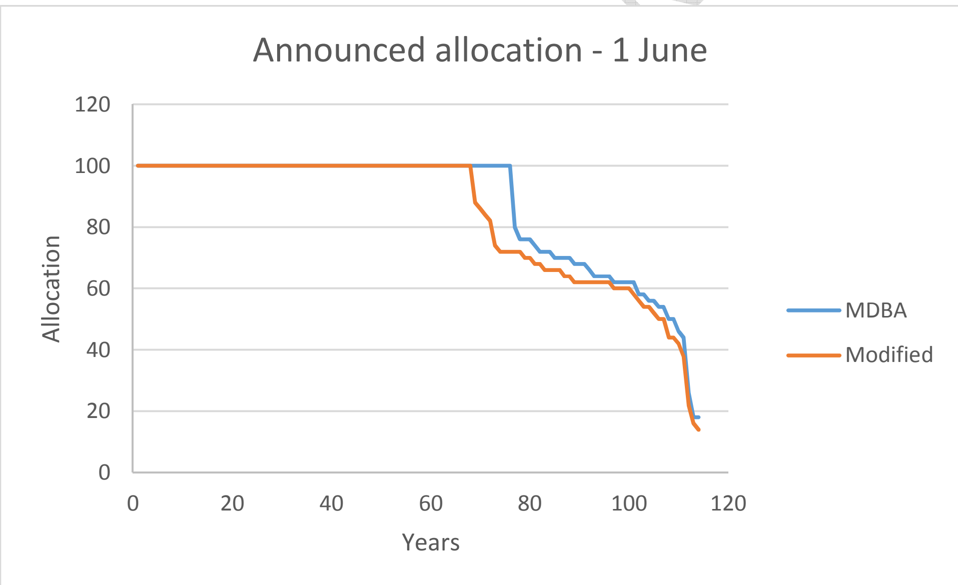


Figure 4 Effective allocation exceedance – 1st October

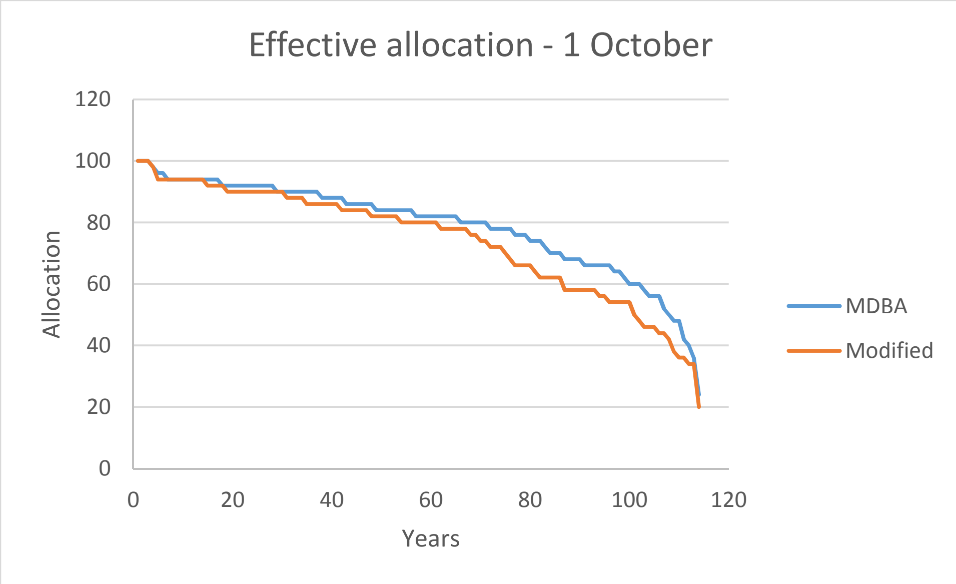
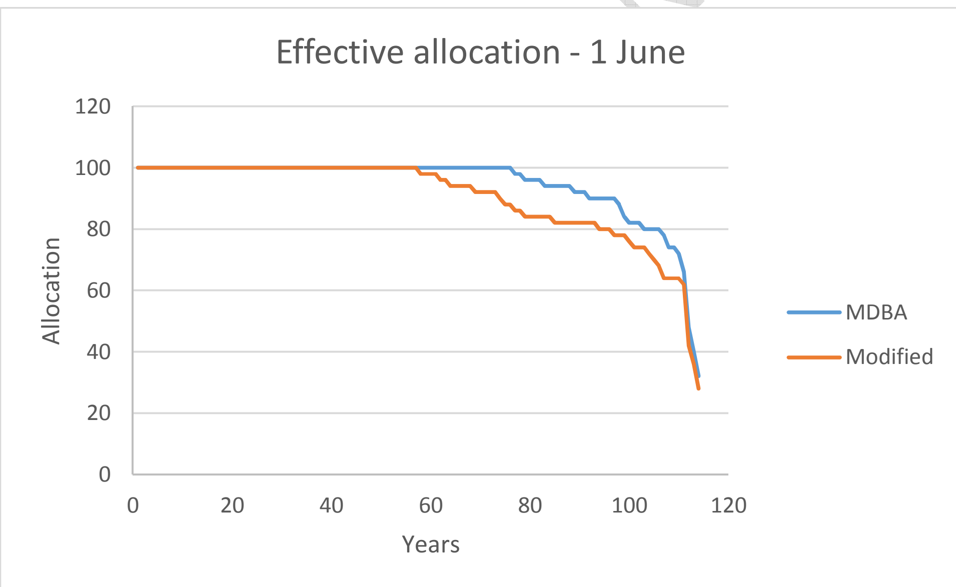
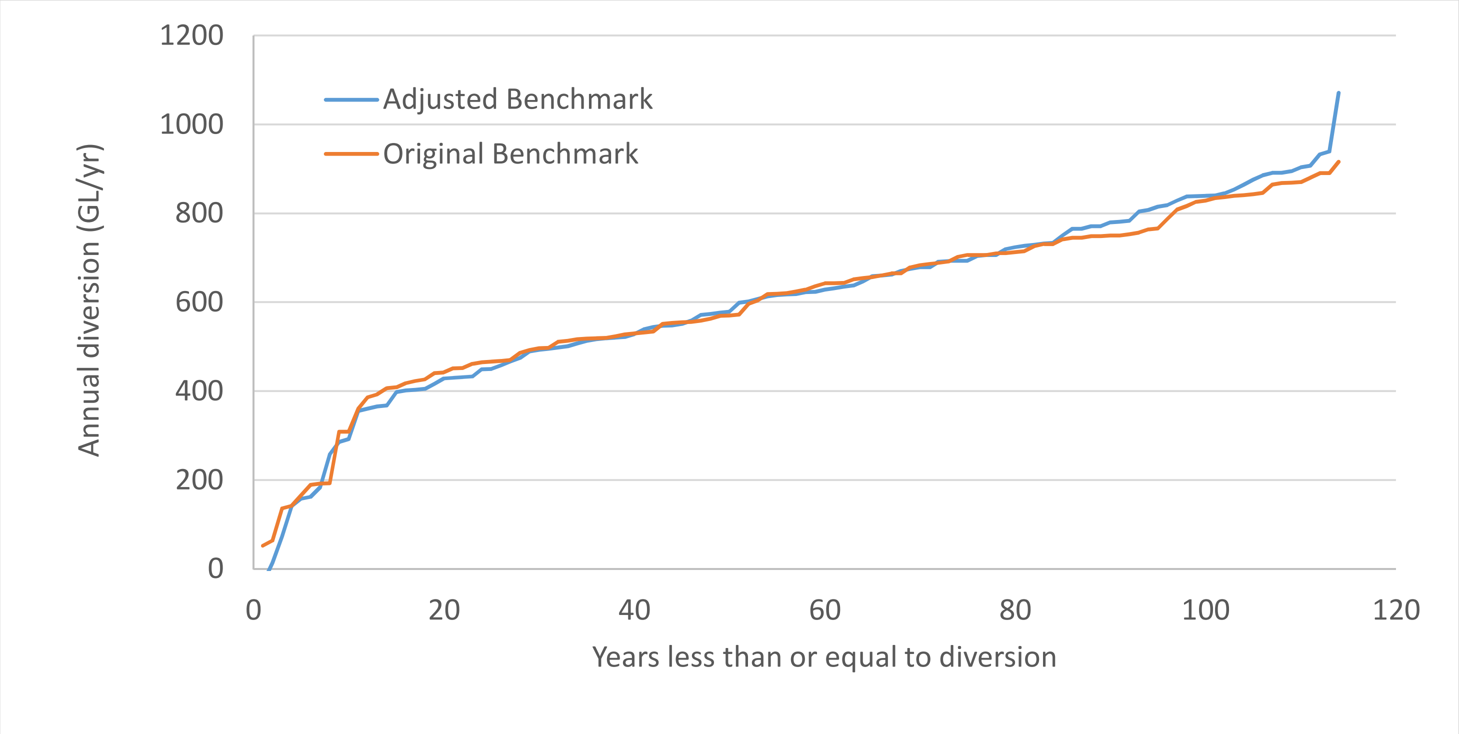



Figure 5 Effective allocation exceedance – 1st June




The effect on annual total diversions of general security diversions is shown in Figure 6. This plots the Benchmark annual GS for each year against its corresponding Adjusted Benchmark value.

Figure 6 Comparison of annual general security diversion volume in Benchmark and Adjusted Benchmark models



# Appendix A – Pre-2009 licence redistribution

Table A1 Summary of pre-2009 Water for Rivers licence purchases (General Security)

**GENERAL SECURITY**

| | | |
|---|---|---|
| **Licences to WFR pre-2009** | | |
| River Pumpers - purchase | 40400 | GS unit shares |
| On-farm reconfiguration | 21500 | GS unit shares |
| **TOTAL GS CHANGE** | 61900 | GS unit shares |
| | | |
| **Distribution of GS licence purchased / from reconfig** | | |
| Coleambally | 32000 | GS unit shares |
| Yanco Billabong and Forest Creek | 7500 | GS unit shares |
| Remainder to distribute to river pumpers (excl. MI) | 22400 | GS unit shares |
| | | |
| **Murrumbidgee River redistribution** | | |
| Licence to be removed across river pumpers | 22400 | GS unit shares |
| Total river pumpers excl YCB, Forest, CI and MI | 411588.6 | GS unit shares |
| Licence to be removed per unit share | 0.054423 | Per existing GS unit share |
| | | |
| **Yanco Billabong redistribution** | | |
| Licence to be removed across YCB | 7500 | GS unit shares |
| Total YCB licence | 116052.2 | GS unit shares |
| Licence to be removed per unit share | 0.064626 | Per existing GS unit share |

Table A2 Summary of change to IQQM node licences for Water for Rivers pre-2009 licence redistribution (General Security)

| Node (bulk 3.4 or non-bulk 8.0) | Upstream extent | Downstream extent | Original GS licence on bulk or non-bulk node | Updated GS licence on bulk or non-bulk node | Change in GS licence | Original area | Change in area | Updated area |
|---|---|---|---|---|---|---|---|---|
| 328 | Dams | Gundagai | 14970.4 | 14155.7 | -814.7 | 1261 | -77.2 | 1183.8 |
| 525 | Gundagai | Wagga | 21626 | 20449.0 | -1177.0 | 722 | -111.5 | 610.5 |
| 340 | Wagga | Beavers Off | 8049 | 7610.9 | -438.1 | 635 | -41.5 | 593.5 |
| 344 | MI Main Canal | | 341259.4656 | 341259.5 | 0.0 | | | |
| 342 | Beavers Offtake | Berembed | 12490 | 11810.3 | -679.7 | 1063 | -64.4 | 998.6 |
| 347 | Berembed | OMC return | 1419 | 1341.8 | -77.2 | 416 | -7.3 | 408.7 |
| 351 | Beavers OMC | | 27161 | 25682.8 | -1478.2 | 5093 | -140.0 | 4953.0 |
| 356 | OMC | Narrandera | 6502 | 6148.1 | -353.9 | 1072 | -33.5 | 1038.5 |
| 359 | Narrandera | Yanco Weir | 6372.6 | 6025.8 | -346.8 | 81 | | 81.0 |
| 365 | CI Main Canal | | 182199.8311 | 150199.8 | -32000.0 | 38964 | -3030.3 | 35933.7 |
| 366 | MI Sturt Canal | | | | | | | |
| 367 | Yanco Weir | Gogeldrie | 4367.5 | 4129.8 | -237.7 | 242 | -22.5 | 219.5 |
| 513 | Gogeldrie | Darlington Point | 30040 | 28405.1 | -1634.9 | 3256 | -154.8 | 3101.2 |
| 501 | Darlington Point | Carrathool | 75050 | 70965.5 | -4084.5 | 12243 | -386.8 | 11856.2 |
| 290 | Carrathool | Hay | 147420 | 139396.9 | -8023.1 | 19357 | -759.8 | 18597.2 |
| 294 | Hay | Maude | 25144.901 | 23776.4 | -1368.5 | 13155.784 | -129.6 | 13026.2 |
| 517 | Maude | Redbank | 15260 | 14429.5 | -830.5 | 1002 | -78.6 | 923.4 |
| 521 | Redbank | Balranald | 6398.225 | 6050.0 | -348.2 | 1041.78 | -33.0 | 1008.8 |
| 505 | Balranald | Murray | 9318 | 8810.9 | -507.1 | 1270 | -48.0 | 1222.0 |
| 154 | Yanco Offtake | Morundah | 8672 | 8111.6 | -560.4 | 2163.036 | -53.1 | 2110.0 |
| 529 | Morundah | DC800 | 7705.997 | 7208.0 | -498.0 | 2043.464 | -47.2 | 1996.3 |
| 533 | DC800 | Billabong Confluence | 11144.693 | 10424.5 | -720.2 | 3105.292 | -68.2 | 3037.1 |
| 509 | Colombo Creek | | 5686.489 | 5319.0 | -367.5 | 1633.196 | -34.8 | 1598.4 |
| 179 | Cocketdegong | Jerilderie | 13866.9 | 12970.7 | -896.2 | 1535.82 | -84.9 | 1451.0 |
| 183 | Jerilderie | Warriston | 34059.1 | 31858.0 | -2201.1 | 3089.54 | -208.4 | 2881.1 |
| 436 | Puckawidgee | Darlot | 30028 | 28087.4 | -1940.6 | 1823.652 | -183.8 | 1639.9 |

| Node (bulk 3.4 or non-bulk 8.0) | Upstream extent | Downstream extent | Original GS licence on bulk or non-bulk node | Updated GS licence on bulk or non-bulk node | Change in GS licence | Original area | Change in area | Updated area |
|---|---|---|---|---|---|---|---|---|
| 438 | Darlot | Moulamein | 4889 | 4573.0 | -316.0 | 1911.72 | -29.9 | 1881.8 |

Table 3 Summary of pre-2009 Water for Rivers licence redistribution (Coleambally Irrigation Conveyance)

| 3.4 node allocation table (Node 365) | | | | |
|---|---|---|---|---|
| | MDBA BIDG model | | Updated WFR Benchmark model | |
| GS allocation | CI extra allocation | Conveyance part | Conveyance part | CI extra allocation |
| 0 | 123400 | 111600 | 108595 | 120395 |
| 0.35 | 123400 | 111600 | 108595 | 120395 |
| 0.36 | *123813* | 112360 | 109335 | 120788 |
| 0.4 | *125467* | 115400 | 112293 | 122360 |
| 0.5 | 129600 | 117833 | 114661 | 126428 |
| 0.75 | 135700 | 123916 | 120580 | 132364 |
| 1 | 141800 | 130000 | 126500 | 138300 |

Table 4 Summary of pre-2009 Water for Rivers licence purchase (Murrumbidgee Irrigation Conveyance)

| 3.4 node allocation table (Node 344) | | | | |
|---|---|---|---|---|
| | MDBA BIDG model | | Updated WFR Benchmark model | |
| GS allocation | MI extra allocation | Conveyance part | Conveyance part | MI extra allocation |
| 0 | 380000 | 150250 | 137884 | 367634 |
| 0.1 | 435077 | 155750 | 142931 | 422258 |
| 0.2 | 435648 | 161250 | 147978 | 422376 |
| 0.25 | 435933 | 169500 | 155549 | 421982 |
| 0.3 | 436219 | 177750 | 163120 | 421589 |
| 0.4 | 443210 | 194250 | 178262 | 427222 |
| 0.5 | 437361 | 210750 | 193404 | 420015 |

| 3.4 node allocation table (Node 344) | | | | |
|---|---|---|---|---|
| | MDBA BIDG model | | Updated WFR Benchmark model | |
| GS allocation | MI extra allocation | Conveyance part | Conveyance part | MI extra allocation |
| 0.5999 | 437946 | 242750 | 222771 | 417967 |
| 0.6 | 490932 | 243000 | 223021 | 470953 |
| 0.7 | 476503 | 243000 | 223000 | 456503 |
| 0.8 | 462074 | 243000 | 223000 | 442074 |
| 0.9 | 447645 | 243000 | 223000 | 427645 |
| 1 | 433216 | 243000 | 223000 | 413216 |

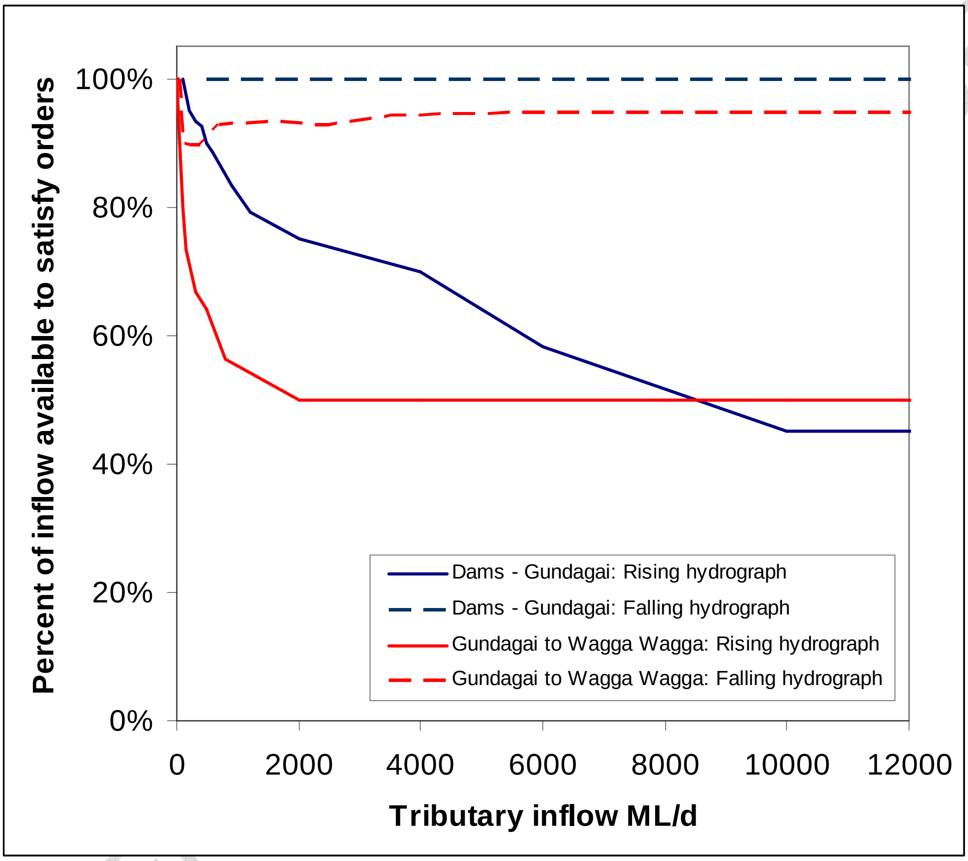
Table 5 Summary of pre-2009 Water for Rivers licence purchase (Hay PID Conveyance)

| 3.4 node allocation table (Node 290) | | | | |
|---|---|---|---|---|
| | MDBA BIDG model | | Updated WFR Benchmark model | |
| GS allocation | Hay extra allocation | Conveyance part | Conveyance part | Hay extra allocation |
| 0 | 6142 | 1000 | 0 | 5142 |
| 0.1 | -6143.1 | 1000 | 0 | -7143 |
| 0.2 | -1672.2 | 1000 | 0 | -2672 |
| 0.3 | 2798.7 | 1000 | 0 | 1799 |
| 0.4 | 7269.6 | 1000 | 0 | 6270 |
| 0.5 | 11740.5 | 1000 | 0 | 10741 |
| 0.6 | 16211.4 | 1000 | 0 | 15211 |
| 0.7 | 20682.3 | 1000 | 0 | 19682 |
| 0.8 | 25153.2 | 1000 | 0 | 24153 |
| 0.9 | 29624.1 | 1000 | 0 | 28624 |
| 1 | 34095 | 1000 | 0 | 33095 |

# Appendix B – CARM measure background

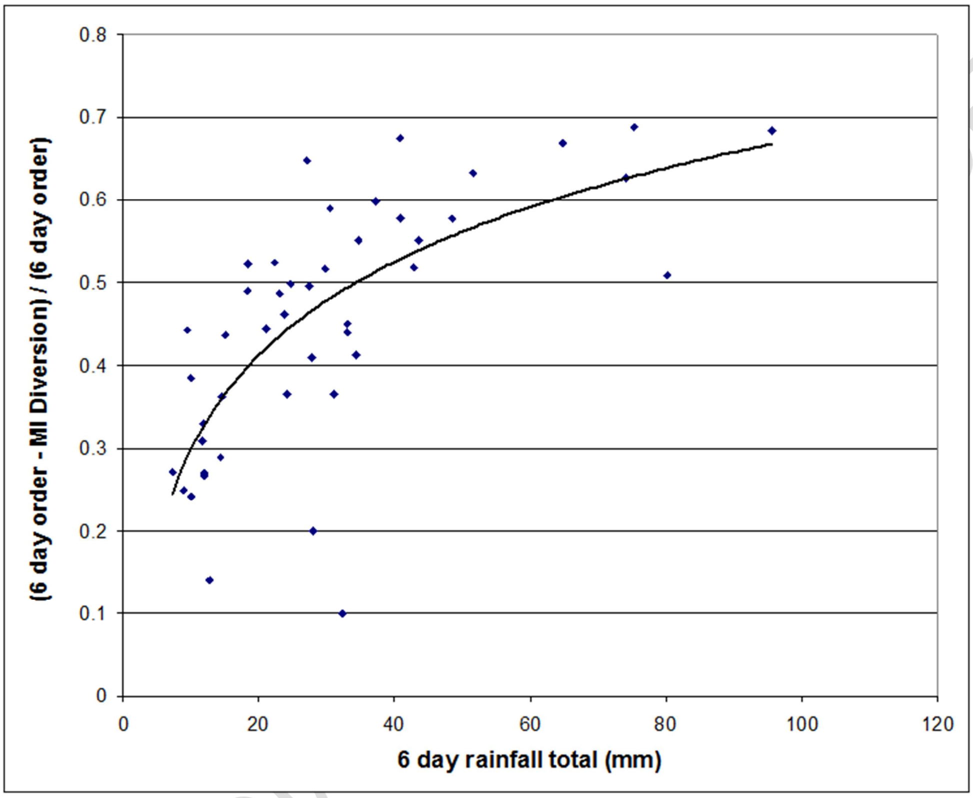
## Tributary utilisation

- Change in approach from fixed utilisation values to time varying
- Vary based on rising / falling limb, size of tributary flow
- Biggest variation in rising limb



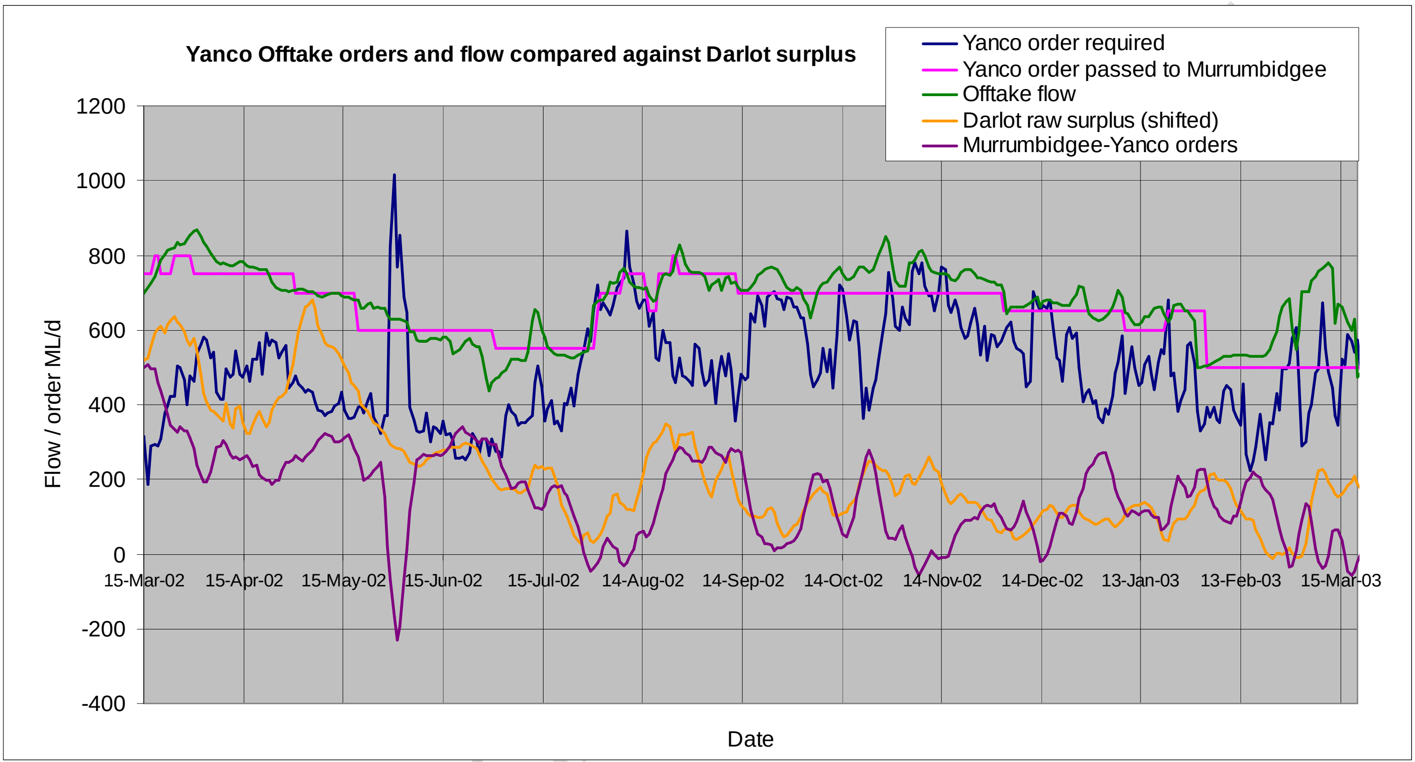
# Rainfall rejection

- Review of current relationship used to reject flows from MI at Berembed Weir
- Previously reduces orders to 70% when 5 day average 4mm/d or greater
- Extended to larger reduction at higher rainfalls



# Yanco Offtake operation

- CAIRO operations show smoothing, scaling of orders passed from Yanco Offtake to Bidgee
- Can produce surplus flow at Darlot
- October – February inclusive typically 25%
- Applied as a scaling factor to the order at Yanco Offtake



# Appendix C – Revision of Yanco Creek Loss Relationships and Residual Inflows

Hemal Hemakura, DPI Water; Shahadat Chowdhury, DPI Water; Donna Hughes, Watermation; Daren Barma, Barmawater

The calibration in the 2005 and 2007 versions of the Water Sharing Plan models uses very flat flow – loss curves to simulate transmission losses in Yanco Colombo Billabong Creeks (i.e. the loss is the same even if the flow doubles). This means any long term reduction in flow through the creek system through efficiency or using irrigation corporation escapes produces little simulated benefit.

DPI Water have recalibrated the loss functions in the Yanco Colombo Billabong system to produce updated functions and new residual catchment inflow time series. The updated loss functions are more sensitive to change in flow and are expected to produce a more realistic transmission loss assessment.

**Derivation of Loss Relationships**

Re-derived loss relationships have been based upon four Yanco Reach IQQM sub models. These are:

1. Reach 2: Yanco Creek from Morundah to Yanco Bridge (d/s DC800) - YancR2_19.sqq, run period 01/07/1995-30/06/2006
2. Reach 3: Yanco Creek from Yanco Bridge to Conargo/Puckawidgee - YancR3_7.sqq, run period 01/07/1995-30/06/2006
3. Reach 6: Billabong Creek from Jerilderie to Hartwood Weir - BillR2_6.sqq, run period 01/10/1984-30/06/2006
4. Reach 7: Billabong Creek from Conargo to Darlot - BillR3_7.sqq, run period 01/9/1994 -30/06/2006

Loss functions from the models are presented below in Tables 1 to 4.

**Table 1 - River Losses in YancR2_19.sqq**

| Loss 1 | | | Loss 2 | |
|---|---|---|---|---|
| River (ML/d) | Loss (ML/d) | | River (ML/d) | Loss (ML/d) |
| 0 | 0 | | 0 | 0 |
| 60 | 2 | | 60 | 9 |
| 100 | 3 | | 100 | 13 |
| 130 | 4 | | 130 | 17 |
| 200 | 9 | | 200 | 35 |
| 350 | 14 | | 350 | 56 |
| 700 | 28 | | 700 | 112 |
| 900 | 37 | | 900 | 147 |
| 1100 | 43 | | 1100 | 173 |
| 2000 | 65 | | 2000 | 259 |
| 5000 | 86 | | 5000 | 346 |

**Table 2 - River Losses in YancR3_7**

| River (ML/d) | Loss (ML/d) |
|---|---|
| 0 | 0 |
| 100 | 15 |
| 200 | 25 |
| 400 | 40 |
| 600 | 45 |
| 700 | 50 |
| 800 | 55 |
| 1000 | 60 |
| 1200 | 65 |
| 1400 | 100 |
| 2000 | 200 |
| 5000 | 300 |



**Table 3 - River Losses in BillR2_6.sqq**

| River (ML/d) | Loss in reckoner |
|---|---|
| 0 | 0 |
| 60 | 9 |
| 100 | 13 |
| 300 | 30 |
| 600 | 70 |
| 2000 | 180 |
| 10000 | 300 |

**Table 4 - River Losses in BillR3_7.sqq**

| River (ML/d) | Loss (ML/d) |
|---|---|
| 0 | 0 |
| 100 | 35 |
| 200 | 50 |
| 400 | 70 |
| 1000 | 150 |

| River (ML/d) | Loss (ML/d) |
|---|---|
| 2500 | 500 |
| 5000 | 600 |

**Residual Inflow Estimation**

Re-derivation of losses has required the derivation of residual inflows along four reaches of the Yanco system. Sacramento rainfall runoff models were developed to estimate residual flows for:

1. Reach 2: Yanco Creek from Morundah to Yanco Bridge (d/s DC800)
2. Reach 3: Yanco Creek from Yanco Bridge to Conargo/Puckawidgee
3. Reach 6: Billabong Creek from Jerilderie to Hartwood Weir
4. Reach 7: Billabong Creek from Conargo to Darlot

The main steps undertaken to derive residual inflows have consisted of:

Step 1 – extracting rainfall and evaporation from the Murrumbidgee IQQM Benchmark model.
Step 2 - deriving a time series of flow at each downstream gauge without residual inflows using the reach IQQM models provided by DPI Water.
Step 3 – Calibrating Sacramento models for residual catchments with output from Step 2 and observed flows.
Step 4 – checking results and potentially modifying rainfall stations used.

## *Data Compilation*

**Rainfall and evaporation from the Murrumbidgee IQQM Benchmark model**

Rainfall data for Leeton (74062), Coleambally (74249), Deniliquin (74128), Hay (75031) and Balranald (49002) were extracted from BIDG_R.idx (rainfall input file from the Murrumbidgee benchmark model. Similarly evaporation for Deniliquin (74128) was extracted from BIDG_E.idx (evaporation input file from the Murrumbidgee benchmark model).

**Residual catchment areas**

Areas for relevant residual catchments are noted below. Appendix C1 presents a figure showing sub-catchment areas.

- Reach 2: Yanco Creek from Morundah gauge 410015 to Yanco Bridge gauge 410169 - Residual area 752km2
- Reach 3: Yanco Creek from Yanco Bridge (410169) and Billabong Creek at Hartwood (410168) to Billabong Creek at Conargo/Puckawidgee (410017) - Residual area total of subcatchment areas for 410017 and 410018 - 1414km2

- Reach 6: Billabong Creek from Jerilderie (gauge 410016) to Hartwood Weir (gauge 410168) – The residual area for this reach was not clear from mapping. In the interim, an initial calibration was done using an approximate area.

- Reach 7: Billabong Creek from Conargo (gauge 410017) to Darlot (gauge 410134) - Residual area is 6570km$^2$ and is shown to include a large area north of Yanco River which may drain as part of Coleambally drainage system and thus already considered in the IQQM. An initial calibration was done using an approximate area.

## *Sacramento Modelling*

Sacramento models were developed to represent residual flows for each Reach noted above. Calibration periods were limited to the concurrent period of available IQQM reach model results and gauged flows unless noted otherwise. The period varied for reaches but generally covered a period from 1995 to 2006.

Areas used for Sacramento models were chosen to reflect the actual residual catchments between gauges but was limited to information available from DPI Water.  All Sacramento models used evaporation for Deniliquin (74128) from the Benchmark Murrumbidgee IQQM. Different combinations of rainfall stations were tested as noted for each reach.

The approach for calibrating the models was to use the estimate of simulated flows at the downstream gauge with the re-derived loss estimates as inflows to the Sacramento model. The model was then calibrated to observed flows at the downstream gauge. Results from a calibration run were visually checked against gauged flows and using standard statistics in SOURCE.

Each reach calibration trial had three runs – “a” was a preliminary run to get initial parameters values, output from this run are not provided; “b” was the reported calibration run with initial parameters from run “a” and “c” simulation of residual time series over the available period of rainfall, this run used calibrated parameters from run “b”. Run c is provided for the preferred trial for each reach.

## *Results*

### Reach 2 residual catchment from Morundah (410015) to Yanco Bridge (410169)

Three trials were done in the Sacramento model using different rainfall stations. The calculated contributions from each rainfall station in the trials are presented in Table 5. Sacramento parameters are presented in Appendix C2.  Statistics (from Source) for simulated flows at gauge 410169 verses observed flows are presented in Table 6.  DPI Water advised to adopt Trial 2 to simulate 114 years of flow. Results for Trials 1 and 3 are presented in the previous draft memo for comparison with results from Trial 2.

Figure 2 present the time series of observed flow (410169_obs) and simulated flow from model calibration for Trial 2.  Appendix C3 presents shorter duration plots for observed data, estimated flow at 410169 from YancR2_reckoner.sqq and the simulated flow from the model calibration. Time series plots show times when Sacramento generated residuals result in better representation of flows than 410169_IQQM in April 1999, Oct 1999, May 2003, Dec 2004 and July 2005. For reference the calculated and simulated residual catchment flows are presented in Appendix C.

Figure 3 presents the flow duration curve for simulated flow without residual flow and simulated flows with residual from Trial 2, Figure 4 includes observed data.

**Table 5 – Trials for various rainfall contributions in FORS, Reach 2**

| Rainfall Station | | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|---|
| | Rfsum | 2.89 | 1.31 | 1.64 |
| | | Contribution | | |
| Leeton | 74062 | 2.25 | | |
| Coleambally | 74249 | 0.63 | 1.31 | 0.78 |
| Deniliquin | 74128 | | | 0.85 |
| Hay | 75031 | 0.01 | | |

**Table 6 - Statistics of simulated flows at 410169 compared with observed flow (Statistics from Source) Period 18/9/1995 to 30/6/2006**

| | r | Volume | Efficiency |
|---|---|---|---|
| Review YancR2_IQQM | 0.857 | 0.056 | 0.716 |
| FORS Trial 1 | 0.894 | 0.696 | 0.785 |
| FORS Trial 2 | 0.89 | 0.815 | 0.781 |
| FORS Trial 3 | 0.891 | 0.906 | 0.78 |

**Figure 2 410169 - Observed verses simulated flow, Simulated with residual flow from Sacramento model Trial 2**

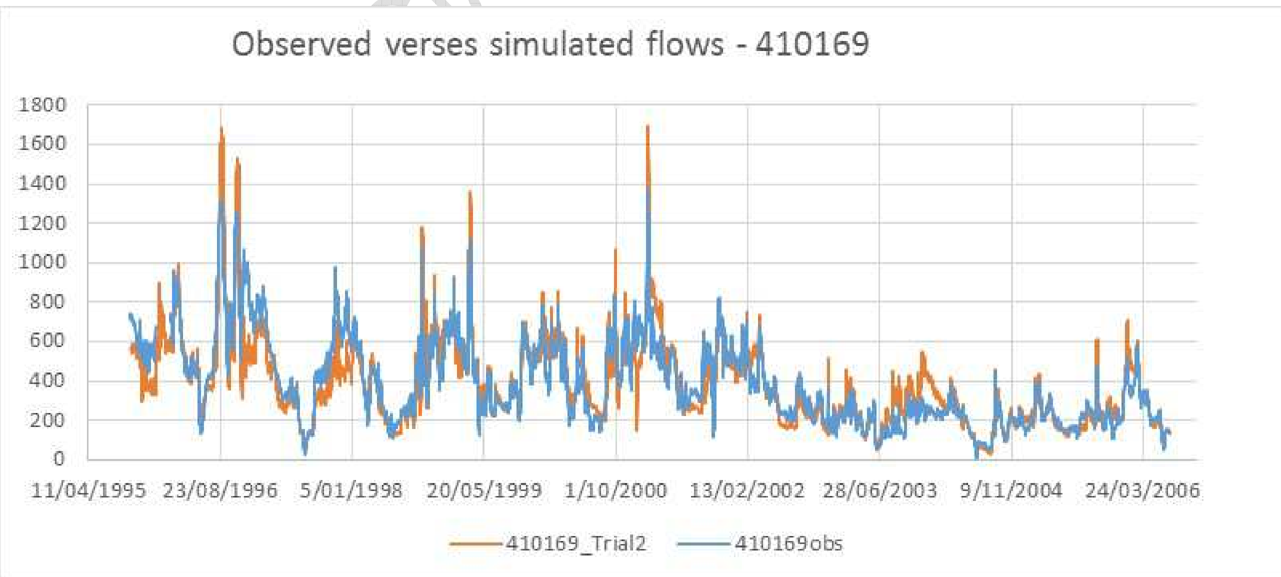


Figure 3 410169 – Flow duration curve, Simulated without residual flow and simulated with residual from Sacramento model Trial 2

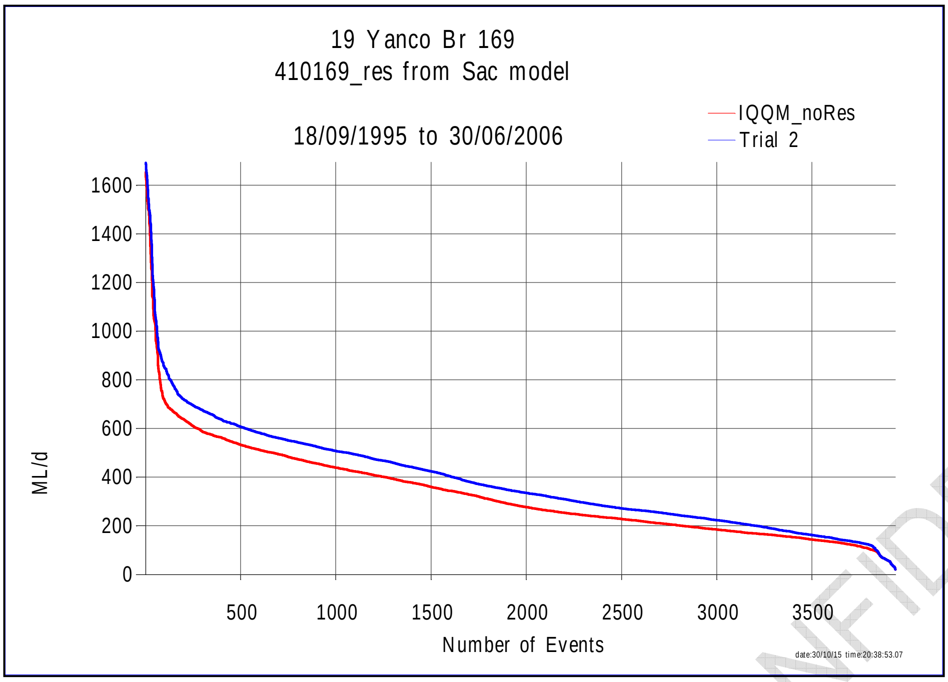
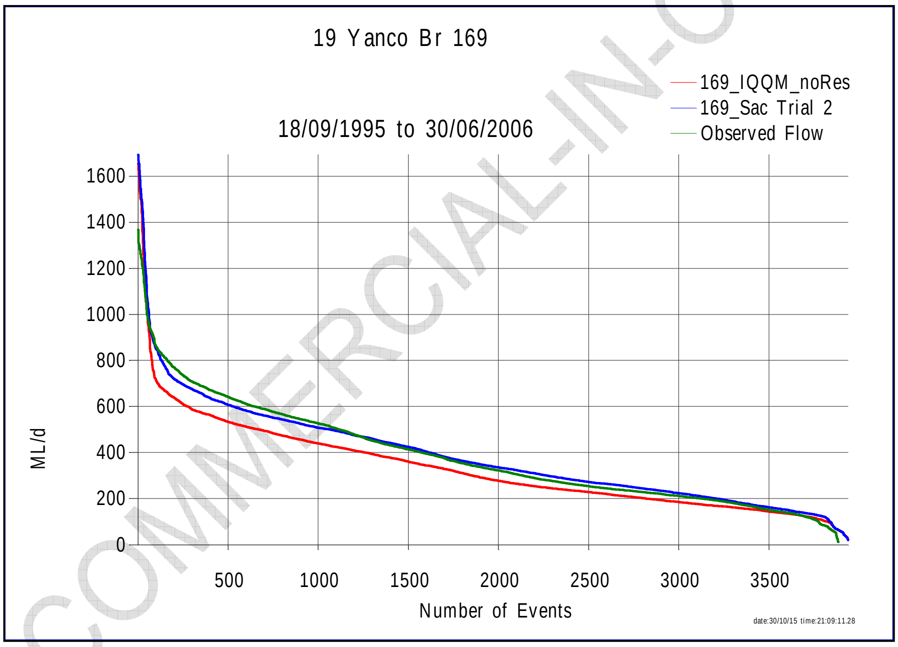



Figure 4 410169 – Flow duration curve, Observed data, Simulated without residual flow and simulated with residual from Sacramento model Trial 2






## Reach 3 residual catchment from Yanco Bridge (410169) and Hartwood to Billabong Creek at Conargo (410017)

Residual flows were estimated using the Sacramento model calibrated with an inflow node for “410017_R3_7_noRes.csv”. The model was calibrated to observed flow at 410017 from 1/10/1995 to 30/6/2006. Catchment area used for the Sacramento model was 1400 km2. Four trials were done using different rainfall stations. The calculated contributions from the trials are presented in Table 7. Results indicate that rainfall at Coleambally and Deniliquin best represent the residual flows, therefore Trial 4 calibrated parameters was used simulate 114 years of residual flows.

The simulated time series of flow at 410017 over the calibration period was compared to observed flows. Statistics (from Source) are presented in Table 8. Figure 7 show flows over the whole calibration period for Trial 4 against the gauged. Appendix C3 presents shorter duration graphs of simulated flow at 410017 for Trial 4, results and observed flow. For reference the calculated and simulated residual catchment flows are presented in Appendix C.

Figure 8 presents the flow duration curve for simulated without residual flow and simulated with residual from Sacramento model Trial 4; Figure 9 is the flow duration curve with observed data.

**Table 7 – Trials for various rainfall contributions, Reach 3**

| Rainfall Station | | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| | Rfsum | 2.25 | 2.24 | 2.26 | 2.27 |
| Leeton | 74062 | 0.00 | | | |
| Coleambally | 74249 | 0.26 | 0.34 | 0.30 | 0.28 |
| Deniliquin | 74128 | 1.99 | 1.90 | 1.96 | 1.98 |
| Hay | 75031 | 0.00 | 0.00 | 0.00 | |
| Balranald | 49002 | | 0.00 | | |

**Table 8 - Statistics of simulated flows at 410017 verses observed flow (Statistics from Source from 1 Oct 1995 to 30 June 2006)**

| | r | Volume | Efficiency |
|---|---|---|---|
| Review YancR3_7 | 0.944 | 1.201 | 0.86 |
| YancR3_7_noRes | | | |
| FORS Trial 1 | 0.945 | 0.623 | 0.866 |
| FORS Trial 2 | 0.945 | 0.609 | 0.867 |
| FORS Trial 3 | 0.945 | 0.562 | 0.867 |
| FORS Trial 4 | 0.945 | 0.567 | 0.867 |

**Figure 7 410017 - Observed versus simulated flow, Simulated with residual flow from Sacramento model Trial 4**

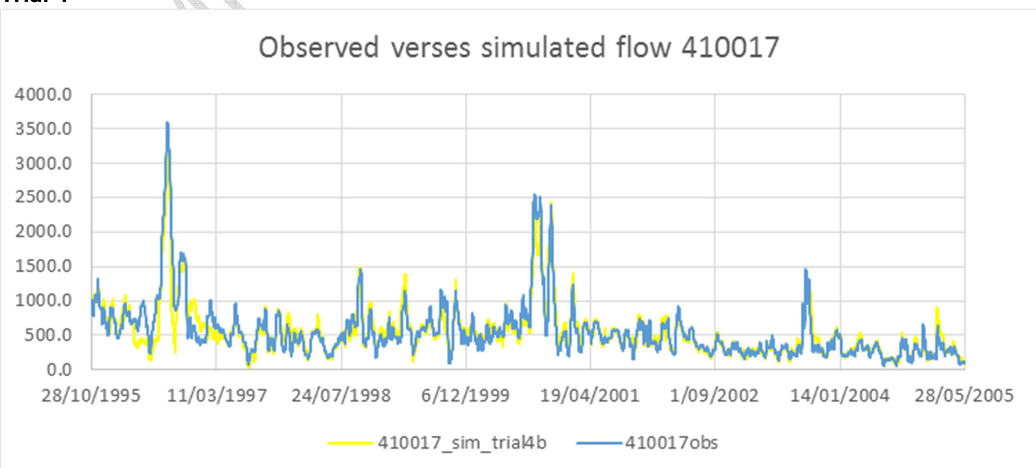


**Figure 8 410017 – Flow duration curve, Simulated without residual flow and simulated with residual from Sacramento model Trial 4 (all flow, high flows, low flows)**

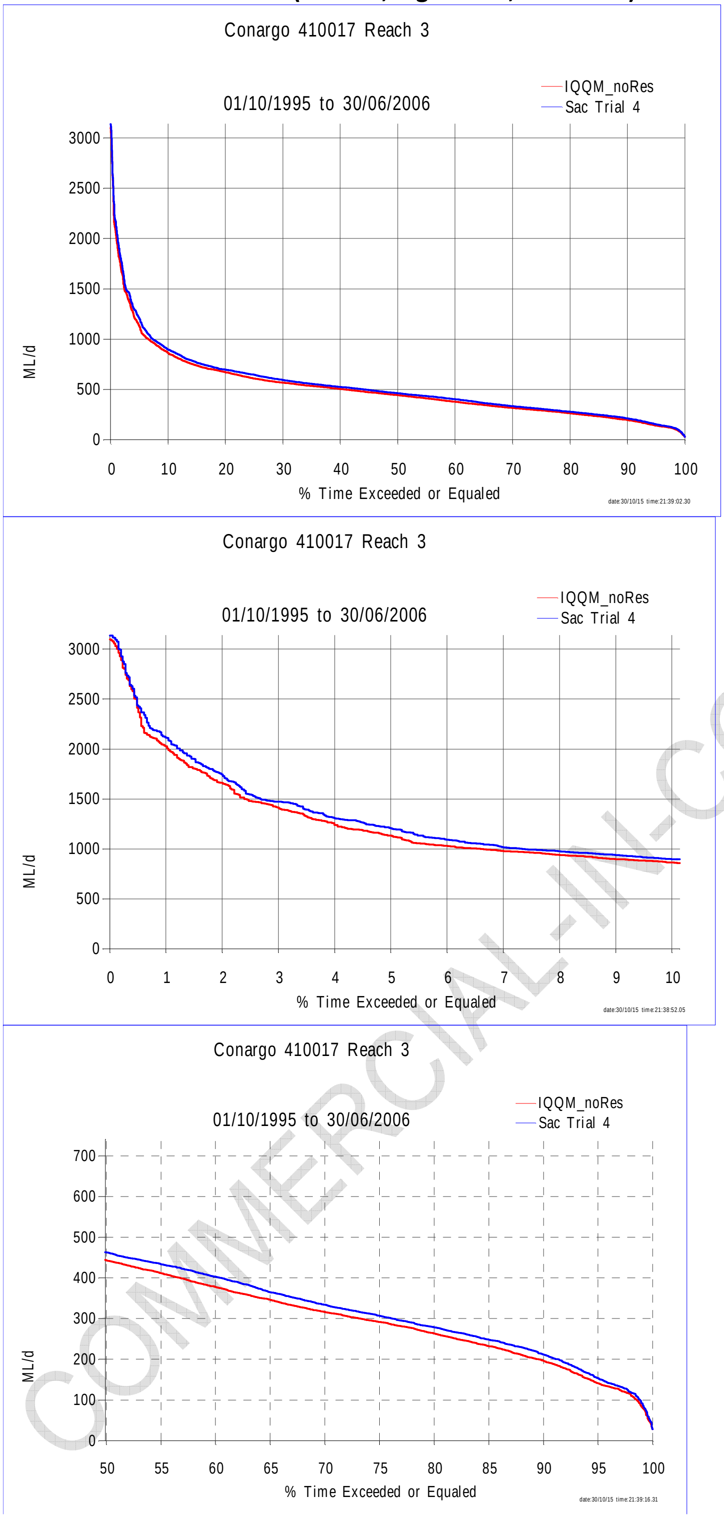
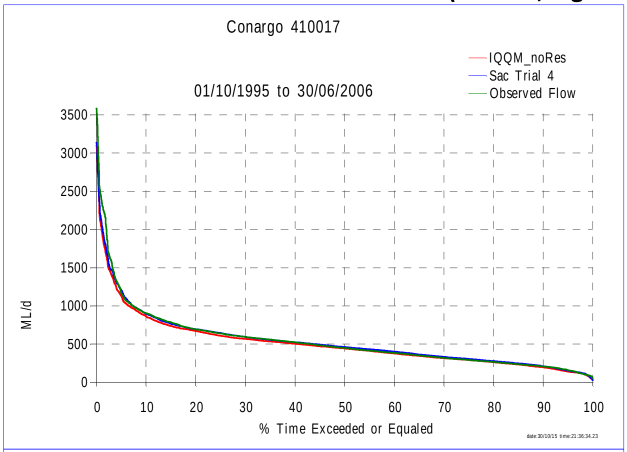
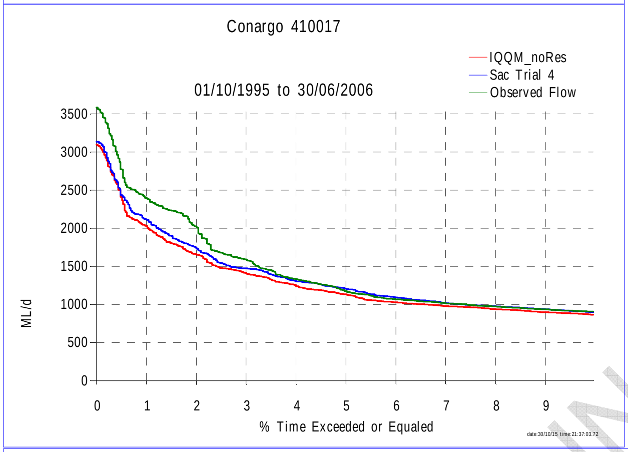
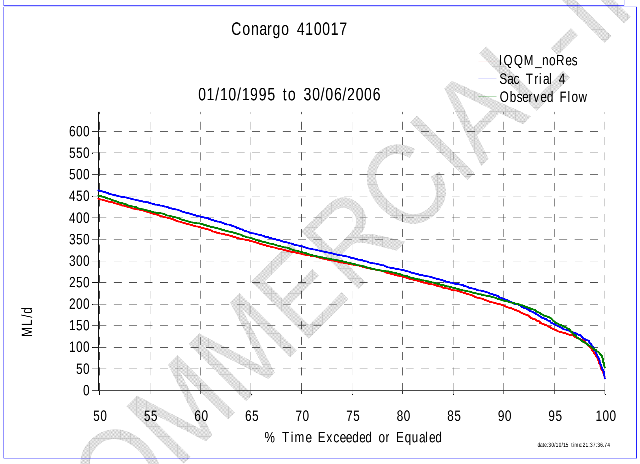


**Figure 9 410017 – Flow duration curve, Observed data, Simulated without residual flow and simulated with residual from Sacramento model Trial 4 (all flow, high flows, low lows)**



## Reach 6 residual catchment from Billabong Creek at Jerilderie (410016) to Billabong Creek at Hartwood (410168)

Residual flows were estimated using the Sacramento model calibrated with FORS. The contributing catchment area from available mapping was not clear, so an estimate of 500km2 was used which was based on length of the reach in IQQM (approximately 50km) and a nominal catchment width of 10km. The calibration was based on the period from 1/7/1999 to 30/6/2006.

Rainfall stations at Deniliquin, Leeton and Coleambally were trialled in the calibration process. Rainfall for Balranald was tested as this rainfall station is used in the Benchmark IQQM for irrigation nodes in this reach, however the automatic calibration method used in the Sacramento model resulted in a small contribution from this station and thus this station was not used. The combinations tested are noted in Table 9.

Sacramento parameters for Trials are presented in Appendix C2. Statistics (from Source) for simulated flows at gauge 410186 verses observed flows are presented in Table 10. Plots of results for Trials 1 and 2 against observed is shown in Figure 12. Appendix C3 presents shorter duration graphs of simulated flow at 410186 for Trials 1 and 2, results from the IQQM reach model and observed flow.

Figure 13 presents the flow duration curve for simulated without residual flow and simulated with residual from Sacramento model Trial 1, Fiure 14 is the flow duration curve with observed data.

At the conclusion of this work a preference for Trial 1 or 2 was not agreed upon with DPI Water, therefore parameters for both trials were used to simulate flows for 114 years. DPI Water has subsequently adopted Trial 2 for analysis.

**Table 9 Trials for various rainfall contributions in FORS, Reach 6**

| Rainfall Station | | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| | *RFsum* | 2.05 | 1.72 | 2.12 | 2.85 |
| Leeton | 74062 | 0.55 | | | |
| Coleambally | 74249 | 0.22 | 0.64 | 2.12 | |
| Deniliquin | 74128 | 1.28 | 1.08 | | 2.85 |

**Table 10 Statistics of simulated flows at 410168 verses observed flow (Statistics from Source), 1/7/1999 to 30/6/2006**

| | r | Volume | Efficiency |
|---|---|---|---|
| Review BillR2_reckoner | 0.962 | 6.33 | 0.92 |
| *Method 1* | | | |
| FORS Trial 1 | 0.962 | 1.224 | 0.917 |
| FORS Trial 2 | 0.959 | 1.394 | 0.91 |
| FORS Trial 3 | 0.962 | 1.74 | 0.91 |
| FORS Trial 4 | 0.958 | 1.467 | 0.908 |

**Figure 12 410168, Observed and simulated flow using Trials 1 and 2**

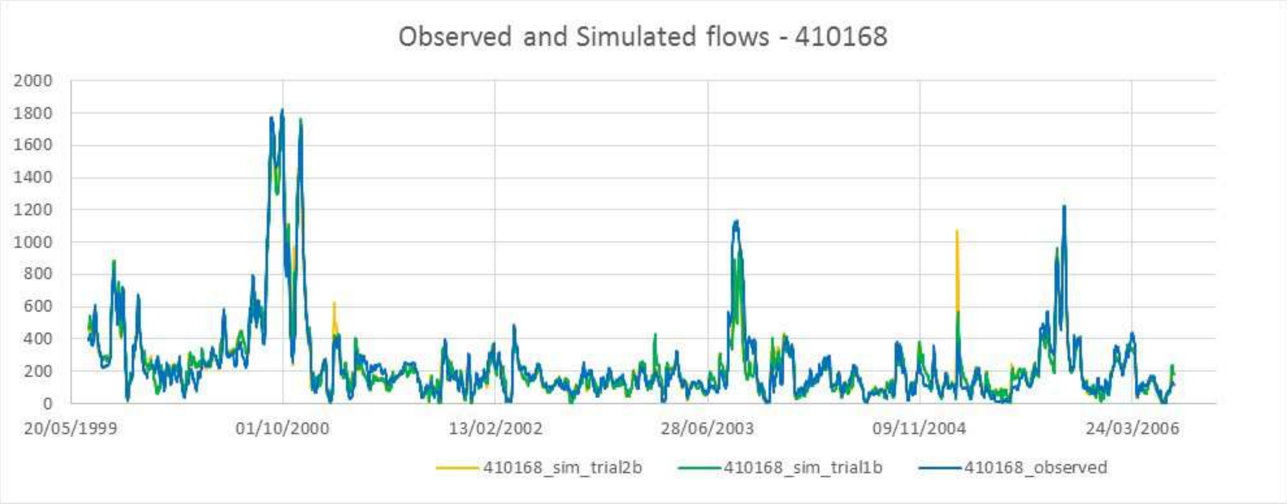



**Figure 13 410168 – Flow duration curve. Simulated without residual flow and simulated with residual from Sacramento Trial 1**

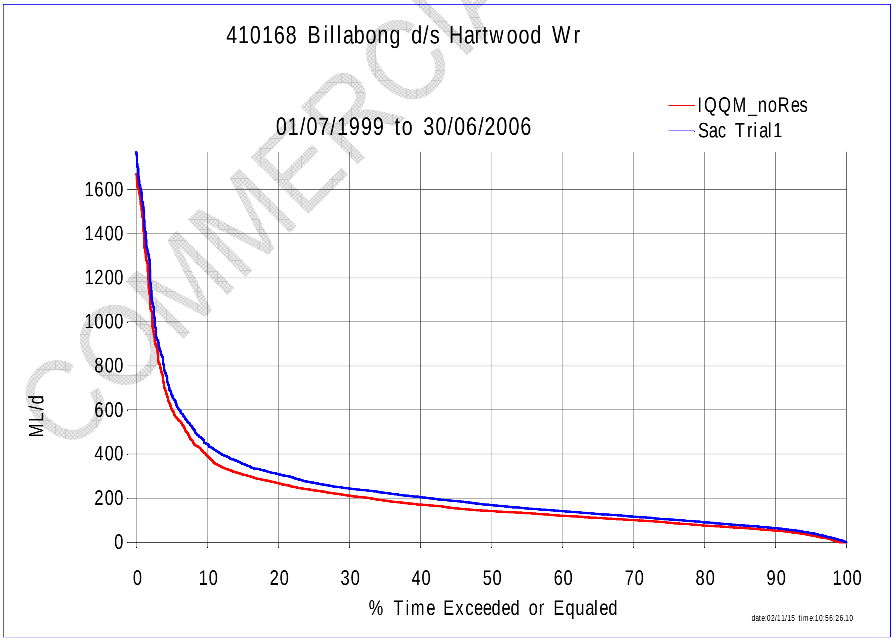
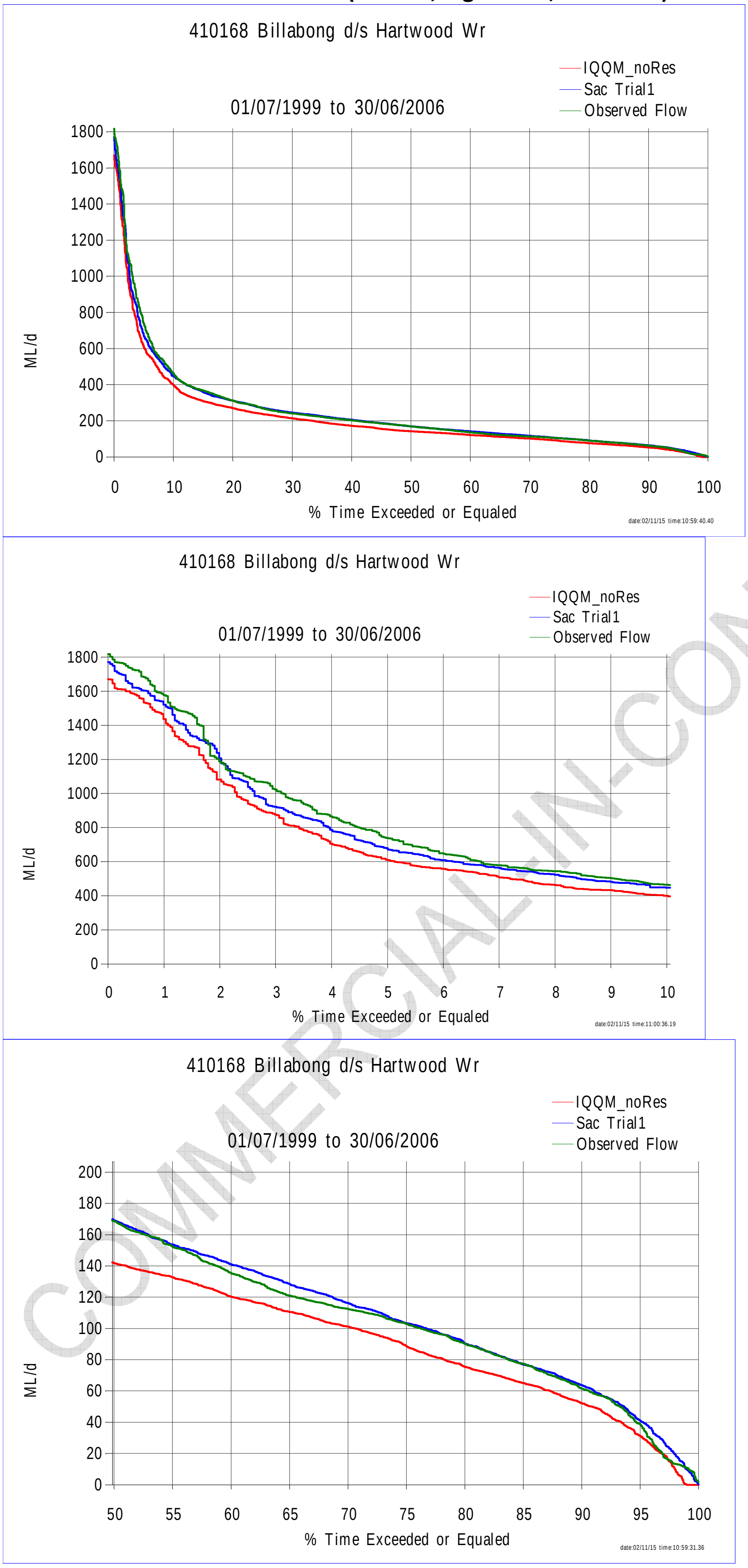


**Figure 14 410168 – Flow duration curve. Observed flow, Simulated without residual flow and simulated with residual from Sacramento Trial 1 (all flow, high flows, low flows)**



## Reach 7 residual catchment from Billabong Creek at Puckawidgee (410017) to Billabong Creek at Darlot (410134)

Residual flows were estimated using the Sacramento model calibrated with an inflow from “410134_R3_7_noRes.csv” and calibrated to observed flow at gauge 410134. The contributing catchment area from available mapping was not clear so an approximate area of 840km$^2$ was used in modelling which is based on length of reach in IQQM (approximately 84km) by a nominal width of 10km. Four trials were done in the model using different rainfall stations. The calculated contributions from the trials are presented in Table 11. Sacramento parameters for Trials are presented in Appendix C2.

Statistics (from Source) for simulated flows for gauge 410134 verses observed flows are presented in Table 12. Based on these results Trial 2 was selected as resulting in more favourable representation of flow at 410134 and was used to present further results. Plot of time series of flow for Trial 2 against observed flows for the whole calibration period is shown in Figure 16. Appendix C3 presents shorter duration graphs within the calibration period for observed flow, generated flow from the IQQM reach model (“410134_R3_7.csv”) and simulated flow from the Sacramento model run.

Figure 17 presents the flow duration curve for simulated without residual flow and simulated with residual from Sacramento model Trial 2, Figure 18 is the flow duration curve with observed data.

**Table 11 Trials for various rainfall contributions in FORS, Reach 7**

| Rainfall Station | | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| | RFsum | 1.24 | 2.93 | 1.24 | 2.86 |
| | | Contribution | | | |
| Coleambally | 74249 | 0.47 | 1.55 | 0.62 | 1.80 |
| Deniliquin | 74128 | 0.61 | 1.38 | 0.62 | 0.97 |
| Hay | 75031 | 0.16 | | | 0.10 |
| Balranald | 49002 | 0.00 | | 0.00 | |

**Table 12 Statistics of simulated flows at 410134 verses observed flow for period 01/09/1994 to 30/06/2006 (Statistics from Source)**

| | r | Volume | Efficiency |
|---|---|---|---|
| Review BillR3_7 | 0.98 | -3.466 | 0.958 |
| FORS Trial 1 | 0.977 | 2.62 | 0.936 |
| FORS Trial 2 | 0.982 | 1.829 | 0.949 |
| FORS Trial 3 | 0.976 | 2.791 | 0.933 |
| FORS Trial 4 | 0.98 | 2.003 | 0.945 |

Figure 16 Observed and simulated flow at 410134 Trial 2

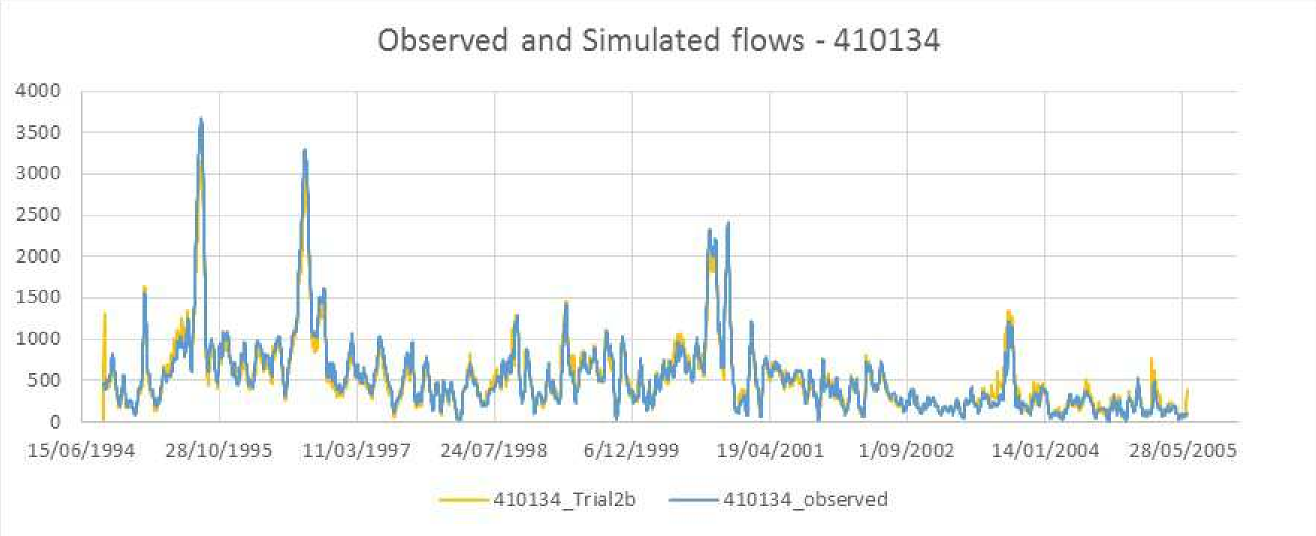



Figure 17 410134 – Flow duration curve. Simulated without residual flow and simulated with residual from Sacramento Trial 2

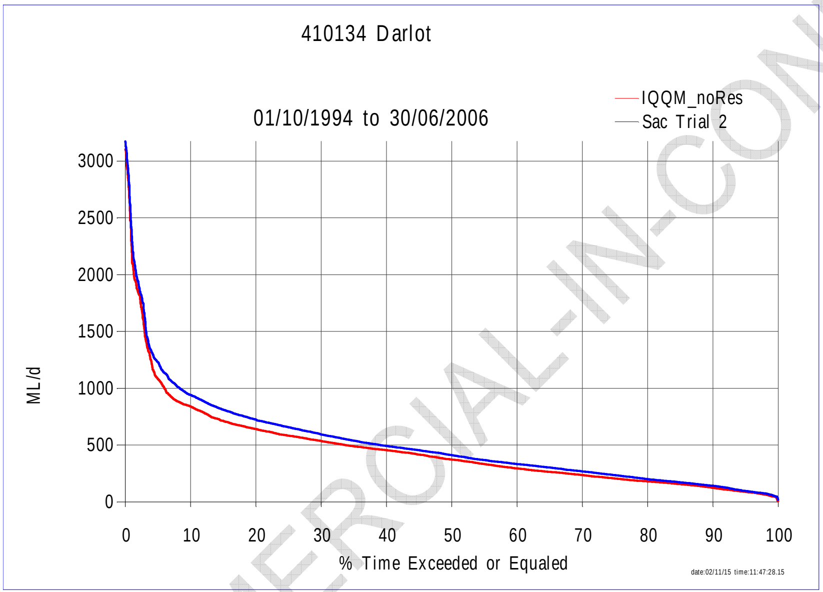
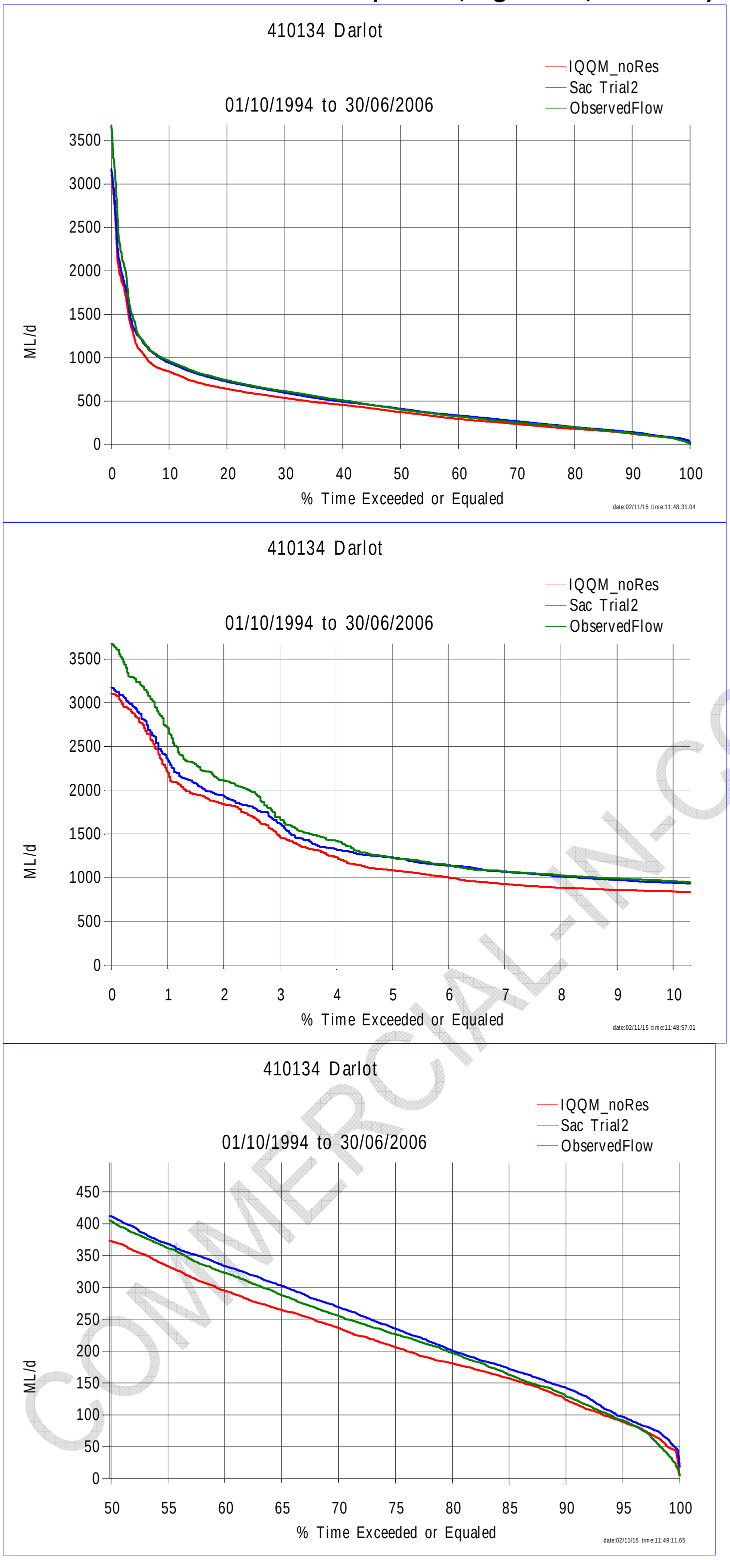
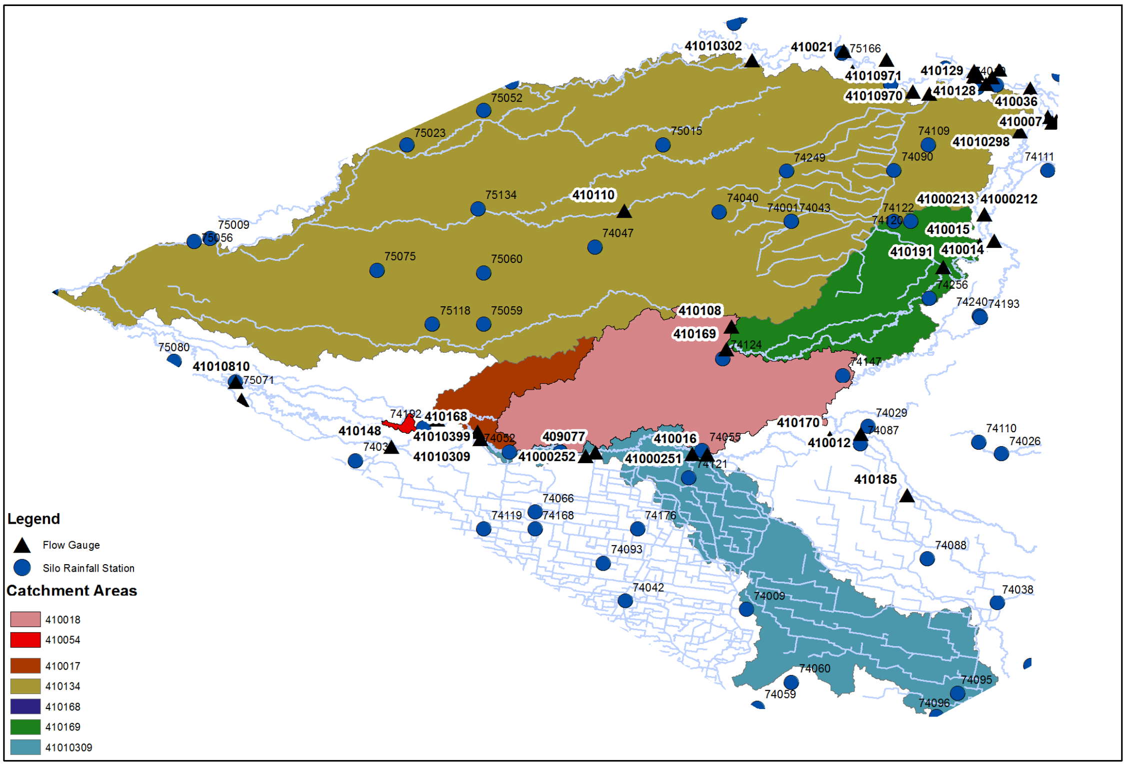


**Figure 18 410134 – Flow duration curve. Observed flow, Simulated without residual flow and simulated with residual from Sacramento Trial 2 (all flow, high flows, low flows)**



## Appendix C1 – Catchment Area map



**Appendix C2 Sacramento model parameters**

*Reach 2 Residual catchment*

| | | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|---|
| Catchment area modelled | | 752 | 752 | 752 |
| Rain | | | | |
| | Rfsum | 2.89 | 1.31 | 1.64 |
| Leeton | 74062 | 2.25 | | |
| Coleambally | 74249 | 0.63 | 1.31 | 0.78 |
| Deniliquin | 74128 | | | 0.85 |
| Hay | 75031 | 0.01 | | |
| | | | | |
| | adimp | 0.002 | 0.000 | 0.003 |
| | lzfpm | 2.5 | 1.0 | 4.3 |
| | lzfsm | 249.3 | 349.9 | 97.8 |
| | lzpk | 0.002 | 0.006 | 0.016 |
| | lzsk | 0.084 | 0.013 | 0.019 |
| | lztwm | 322.6 | 71.1 | 401.7 |
| | pctim | 0.000 | 0.000 | 0.000 |
| | pfree | 0.045 | 0.412 | 0.265 |
| | rexp | 2.025 | 2.968 | 1.522 |
| | sarva | 0.000 | 0.000 | 0.000 |
| | side | 0.000 | 0.011 | 0.000 |
| | ssout | 0.000 | 0.100 | 0.068 |
| | uzfwm | 7.9 | 5.0 | 5.0 |
| | uzk | 0.146 | 0.401 | 0.545 |
| | uztwm | 12.0 | 12.0 | 12.0 |
| | zperc | 170.5 | 171.1 | 48.7 |
| | uh0 | 0.000 | 0.000 | 0.000 |
| | uh1 | 0.415 | 0.000 | 0.000 |
| | uh2 | 0.585 | 0.352 | 0.638 |
| | uh3 | | 0.648 | 0.362 |

**Reach 3 residual catchment – Sacramento model parameters**

| | | Trial 1 | Trial 2 | Trial 3 | *Trial 4* |
|---|---|---|---|---|---|
| | Rfsum | 2.25 | 2.24 | 2.26 | 2.27 |
| | Contribution | | | | |
| Leeton | 74062 | 0.00 | | | |
| Coleambally | 74249 | 0.26 | 0.34 | 0.30 | 0.28 |
| Deniliquin | 74128 | 1.99 | 1.90 | 1.96 | 1.98 |
| Hay | 75031 | 0.00 | 0.00 | 0.00 | |
| Balranald | 49002 | | 0.00 | | |
| | | | | | |
| | adimp | 0.001 | 0.000 | 0.000 | 0.000 |
| | lzfpm | 1.2 | 1.0 | 10.8 | 1.4 |
| | lzfsm | 310.1 | 242.0 | 336.6 | 333.8 |
| | lzpk | 0.000 | 0.016 | 0.006 | 0.006 |
| | lzsk | 0.039 | 0.039 | 0.039 | 0.038 |
| | lztwm | 147.0 | 137.0 | 260.2 | 314.8 |
| | pctim | 0.001 | 0.001 | 0.001 | 0.001 |
| | pfree | 0.047 | 0.049 | 0.051 | 0.050 |
| | rexp | 3.339 | 1.952 | 5.997 | 2.322 |
| | sarva | 0.001 | 0.001 | 0.001 | 0.001 |
| | side | 0.000 | 0.000 | 0.000 | 0.000 |
| | ssout | 0.000 | 0.000 | 0.000 | 0.000 |
| | uzfwm | 7.4 | 15.5 | 26.3 | 26.7 |
| | uzk | 0.260 | 0.304 | 0.389 | 0.179 |
| | uztwm | 12.0 | 12.0 | 12.0 | 12.0 |
| | zperc | 544.0 | 600.0 | 295.0 | 390.0 |
| | uh0 | 0.000 | 0.000 | 0.000 | 0.000 |
| | uh1 | 0.000 | 0.000 | 0.000 | 0.000 |
| | uh2 | 0.322 | 0.081 | 0.454 | 0.370 |
| | uh3 | 0.678 | 0.919 | 0.546 | 0.630 |

### Reach 6 residual catchment – Sacramento model parameters

| | | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| Catchment area modelled | | 500 | 500 | 500 | 500 |
| Rain | | | | | |
| | Rfsum | 2.05 | 1.72 | 2.12 | 2.85 |
| Leeton | 74062 | 0.55 | | | |
| Coleambally | 74249 | 0.22 | 0.64 | 2.12 | |
| Deniliquin | 74128 | 1.28 | 1.08 | | 2.85 |
| | | | | | |
| | adimp | 0.000 | 0.000 | 0.029 | 0.150 |
| | lzfpm | 3.7 | 8.9 | 300.0 | 3.7 |
| | lzfsm | 262.0 | 16.1 | 34.8 | 112.3 |
| | lzpk | 0.005 | 0.036 | 0.012 | 0.029 |
| | lzsk | 0.080 | 0.097 | 0.121 | 0.102 |
| | lztwm | 76.6 | 197.9 | 593.0 | 585.0 |
| | pctim | 0.003 | 0.002 | 0.002 | 0.001 |
| | pfree | 0.075 | 0.116 | 0.129 | 0.046 |
| | rexp | 2.016 | 3.028 | 4.548 | 2.789 |
| | sarva | 0.000 | 0.000 | 0.001 | 0.000 |
| | side | 0.002 | 0.000 | 0.043 | 0.000 |
| | ssout | 0.000 | 0.000 | 0.031 | 0.000 |
| | uzfwm | 7.0 | 31.9 | 8.9 | 5.0 |
| | uzk | 0.325 | 0.515 | 0.777 | 0.546 |
| | uztwm | 12.7 | 13.5 | 12.0 | 12.0 |
| | zperc | 590.3 | 309.4 | 47.7 | 587.2 |
| | uh0 | 0.000 | 0.000 | 0.000 | 0.000 |
| | uh1 | 0.000 | 0.000 | 0.000 | 0.000 |
| | uh2 | 0.434 | 0.477 | 0.474 | 0.317 |
| | uh3 | 0.566 | 0.523 | 0.526 | 0.683 |

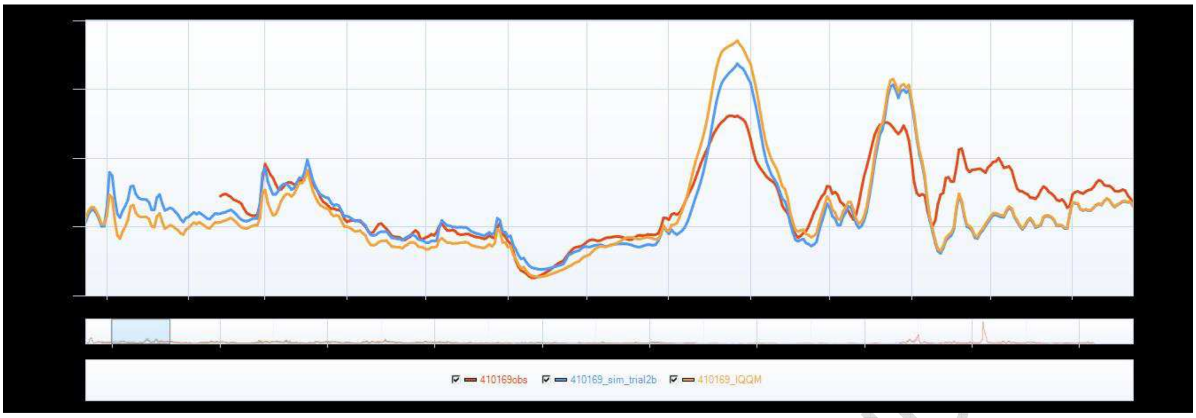
**Reach 7 residual catchment**

| catchment | trial 1 | trial 2 | trial 3 | Trial 4 |
|---|---|---|---|---|
| 840km2 | | | | |
| Rfsum | 1.24 | 2.93 | 1.24 | 2.86 |
| | | | | |
| 74062 | | | | |
| 74249 | 0.47 | 1.55 | 0.62 | 1.80 |
| 74128 | 0.61 | 1.38 | 0.62 | 0.97 |
| 75031 | 0.16 | | | 0.10 |
| 49002 | 0.00 | | 0.00 | |
| | | | | |
| adimp | 0.000 | 0.005 | 0.001 | 0.000 |
| lzfpm | 1.8 | 1.4 | 10.2 | 2.1 |
| lzfsm | 324.4 | 97.7 | 196.5 | 350.0 |
| lzpk | 0.002 | 0.019 | 0.024 | 0.014 |
| lzsk | 0.024 | 0.019 | 0.027 | 0.014 |
| lztwm | 49.0 | 599.8 | 292.5 | 238.1 |
| pctim | 0.004 | 0.005 | 0.002 | 0.005 |
| pfree | 0.500 | 0.143 | 0.500 | 0.249 |
| rexp | 5.830 | 2.820 | 2.890 | 3.082 |
| sarva | 0.002 | 0.005 | 0.002 | 0.005 |
| side | 0.010 | 0.000 | 0.000 | 0.000 |
| ssout | 0.000 | 0.000 | 0.000 | 0.000 |
| uzfwm | 32.7 | 21.8 | 19.2 | 32.3 |
| uzk | 0.231 | 0.677 | 0.248 | 0.232 |
| uztwm | 12.3 | 12.0 | 13.4 | 25.6 |
| zperc | 277.4 | 587.3 | 56.7 | 540.4 |
| uh0 | 0.000 | 0.000 | 0.000 | 0.000 |
| uh1 | 0.000 | 0.000 | 0.000 | 0.000 |
| uh2 | 0.150 | 0.414 | 0.549 | 0.455 |
| uh3 | 0.850 | 0.586 | 0.451 | 0.545 |

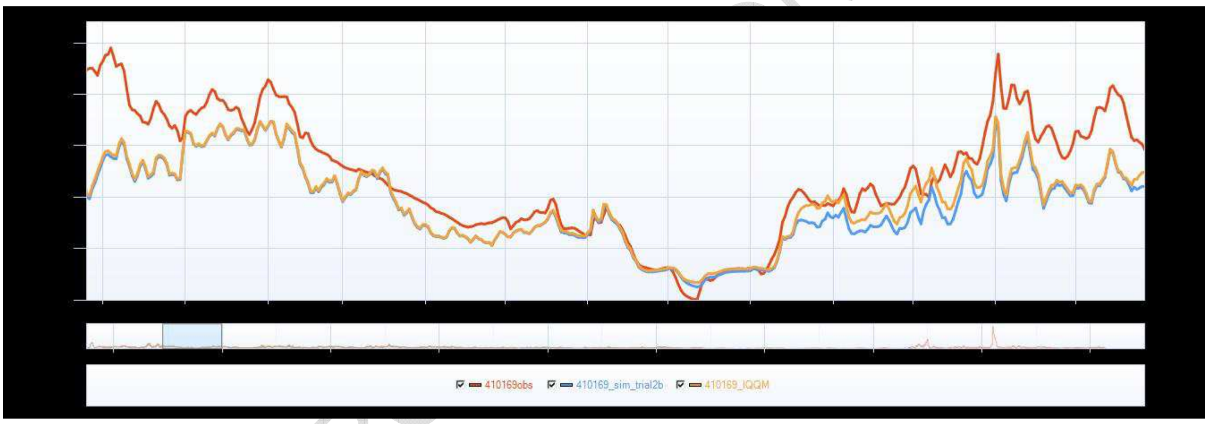
**Appendix C3 Time Series Plots in calibration periods**

**Reach 2 Time series plots of observed flows at 410169 (red line), 410169_IQQM.csv (simulated flows from IQQM reach model, orange line) and Sacramento simulated flows at 410169 for Trial 2 (blue line)**

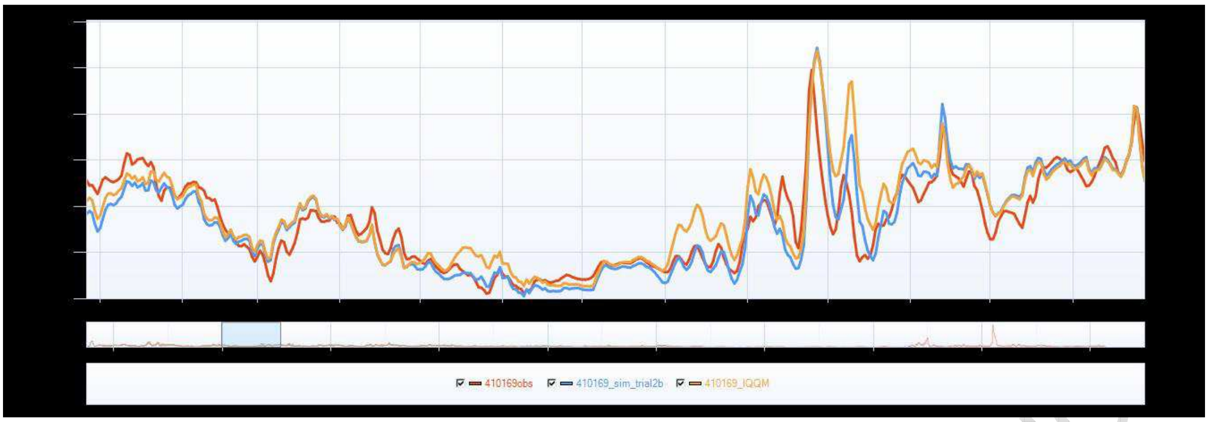
**Observed and simulated flow – 1996**



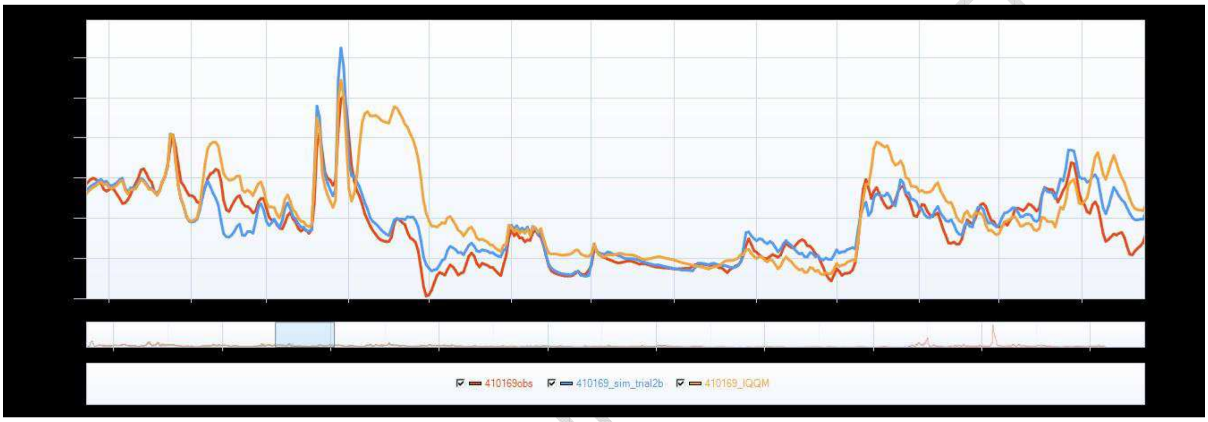

**Observed and simulated flow – 1997**



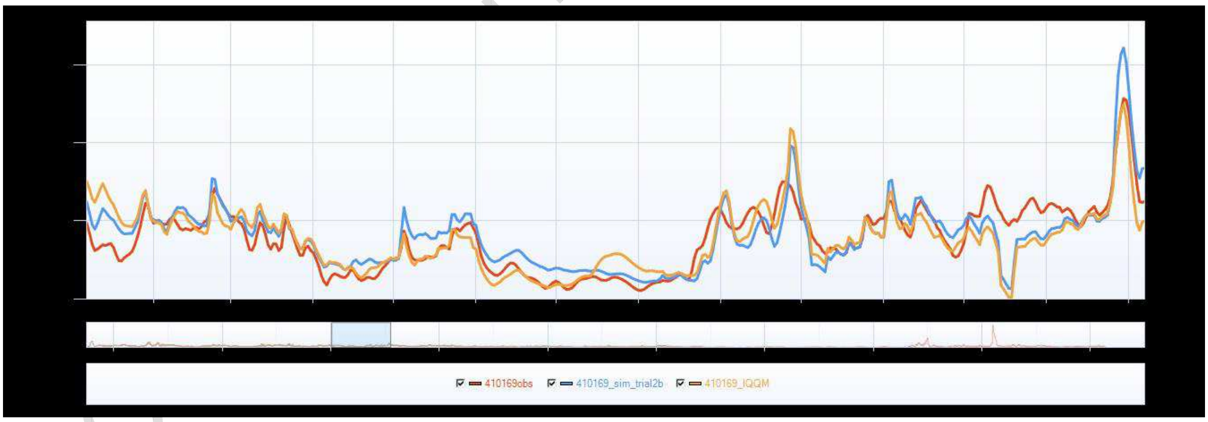
### Observed and simulated flow – 1998



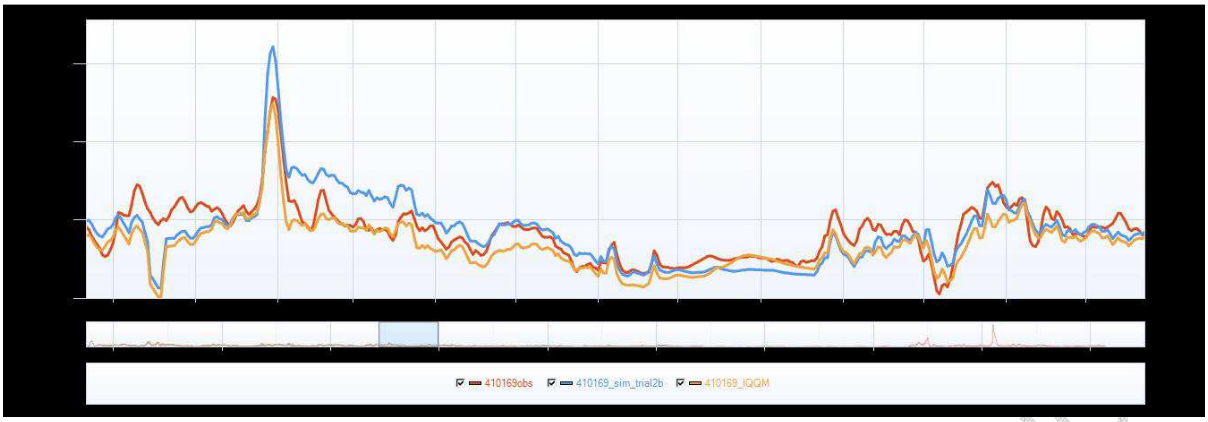

### Observed and simulated flow – 1999



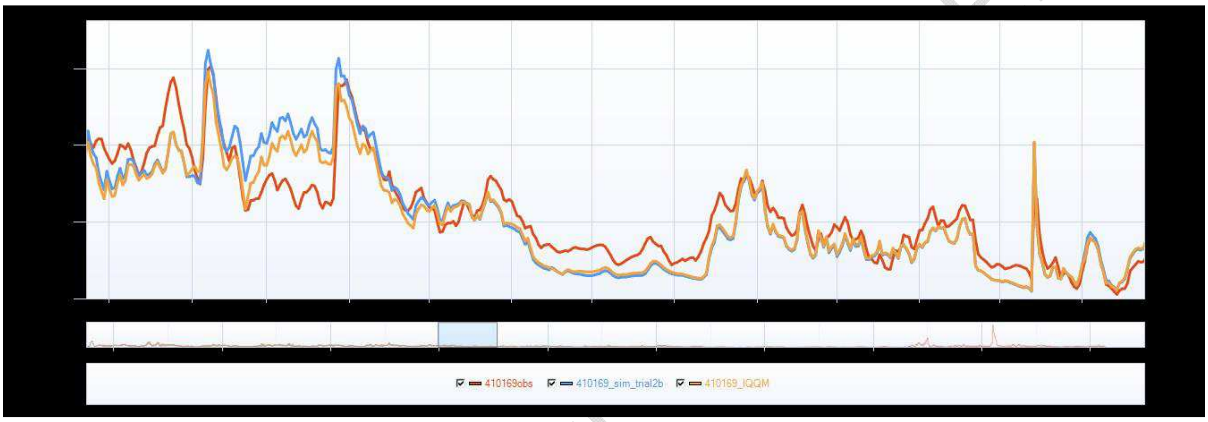

### Observed and simulated flow – 2000



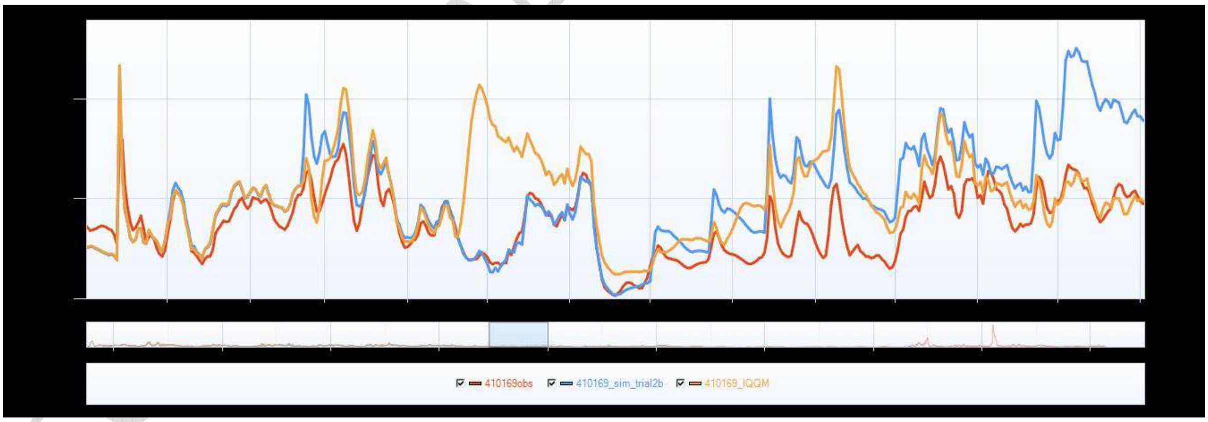
**Observed and simulated flow – 2001**



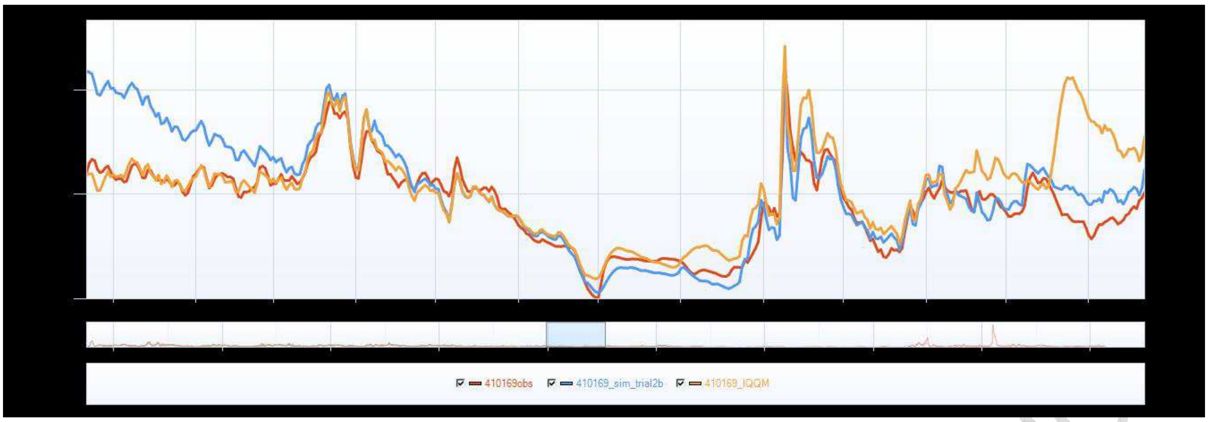

**Observed and simulated flow – 2002**



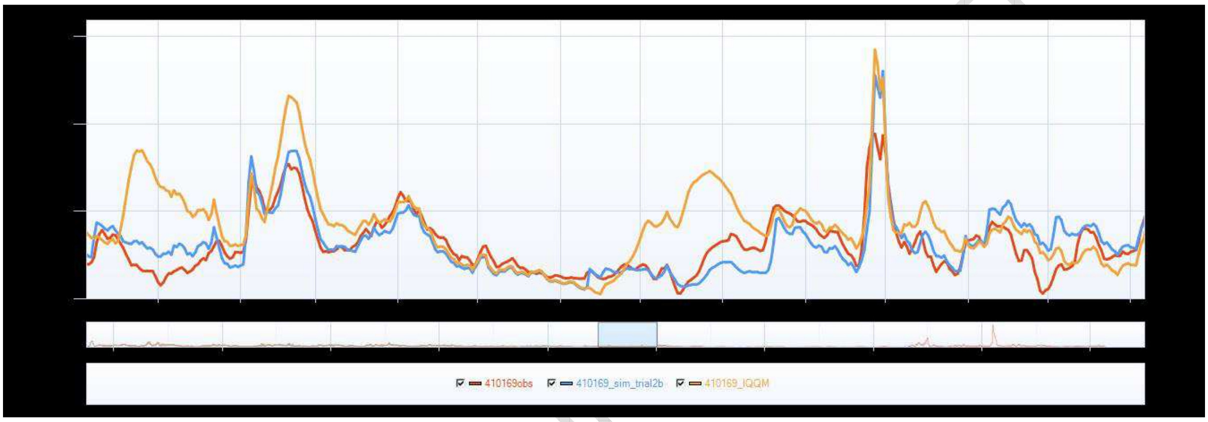

**Observed and simulated flow – 2003**



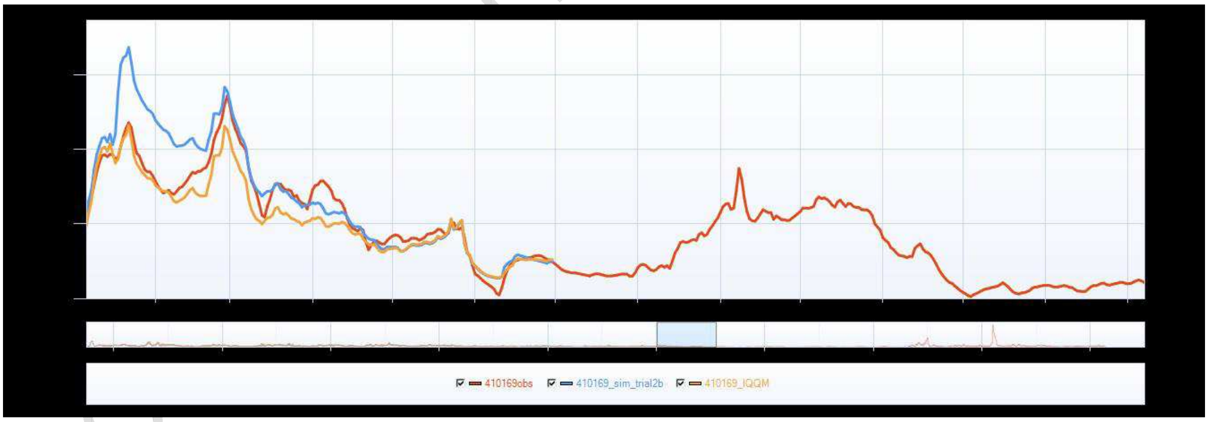
**Observed and simulated flow – 2004**



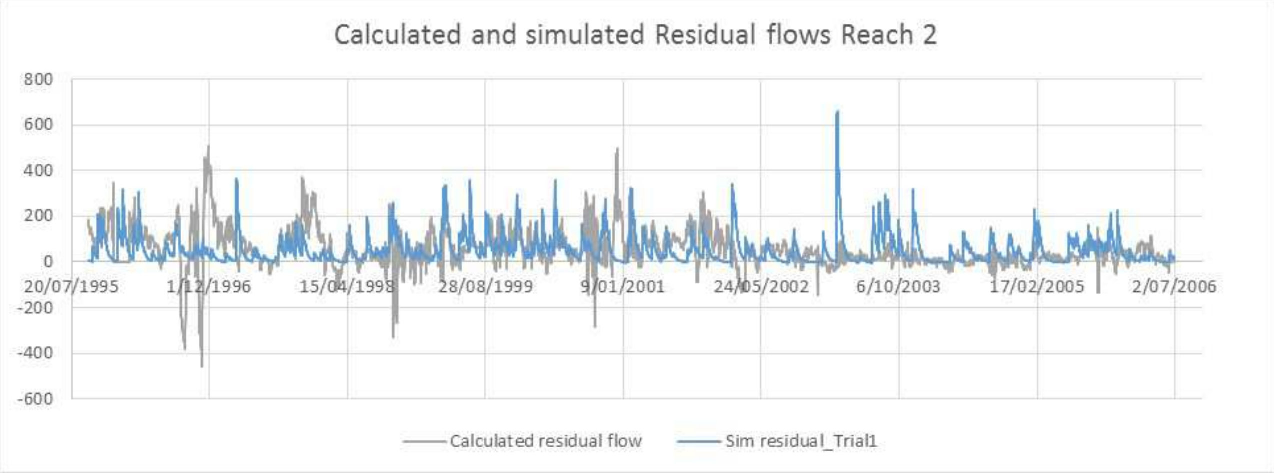

**Observed and simulated flow – 2005**



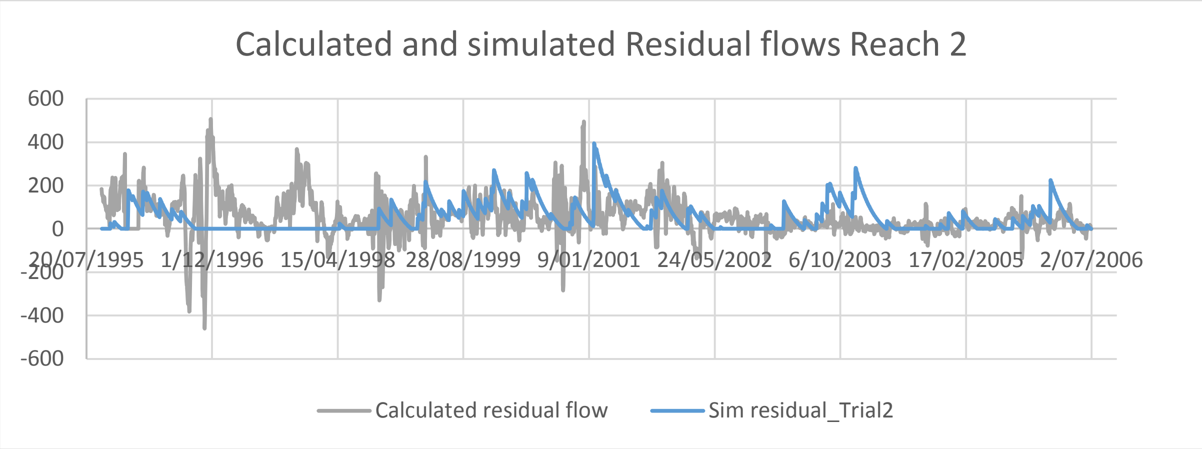

**Observed and simulated flow – 2006**



**Residual flows Reach 2 – Calculated and simulated from Sacramento model Trial 1**

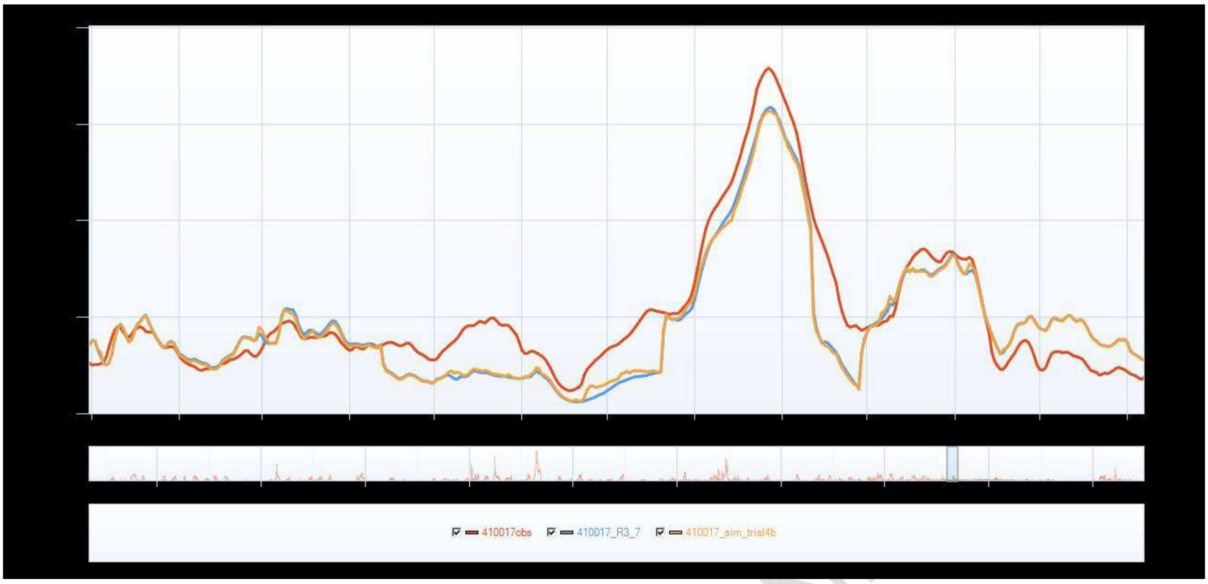



**Residual flows Reach 2 – Calculated and simulated from Sacramento model Trial 2**

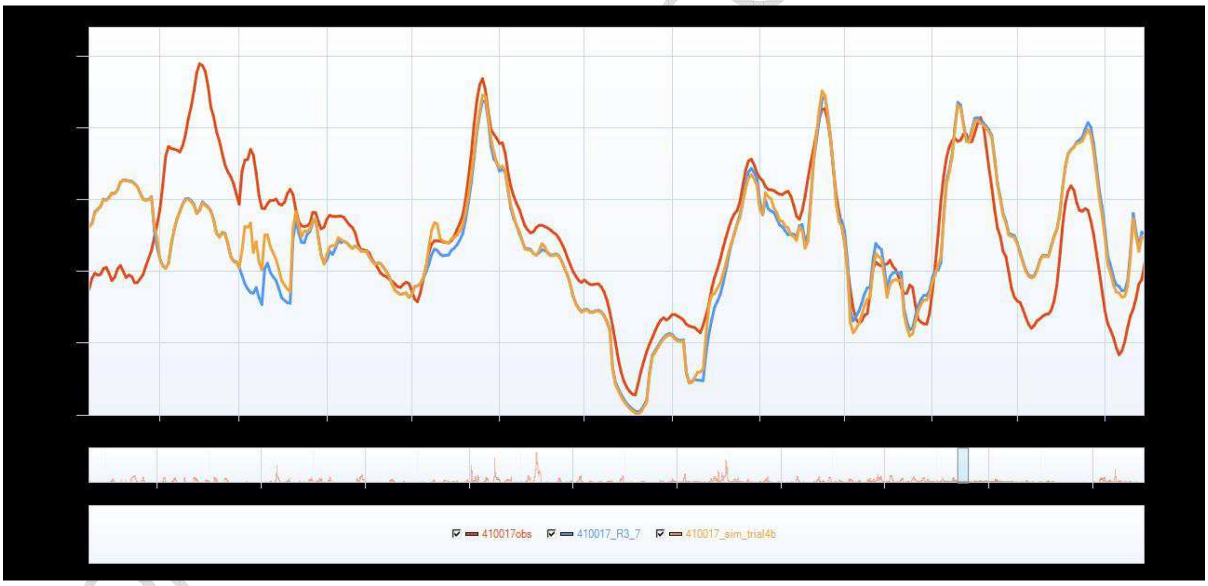


**Reach 3 Time series plots of observed flows at 410017 (red line), 410017_R3_7 (blue line, simulated flows from IQQM reach model) and Trial 4 (orange line)**

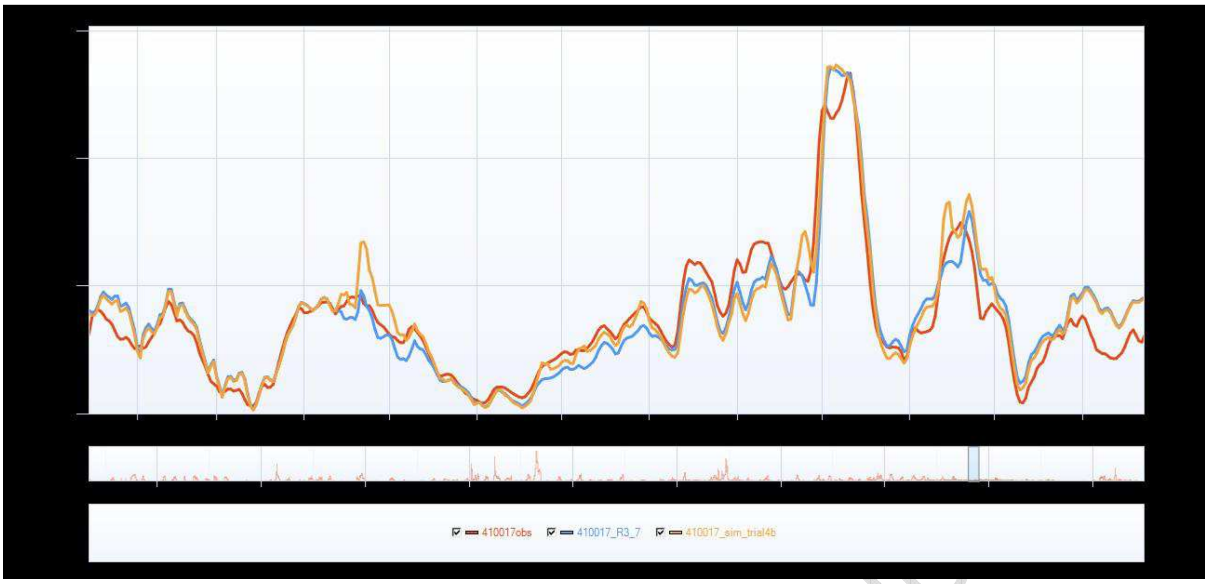
**Observed and simulated flow – 1996**



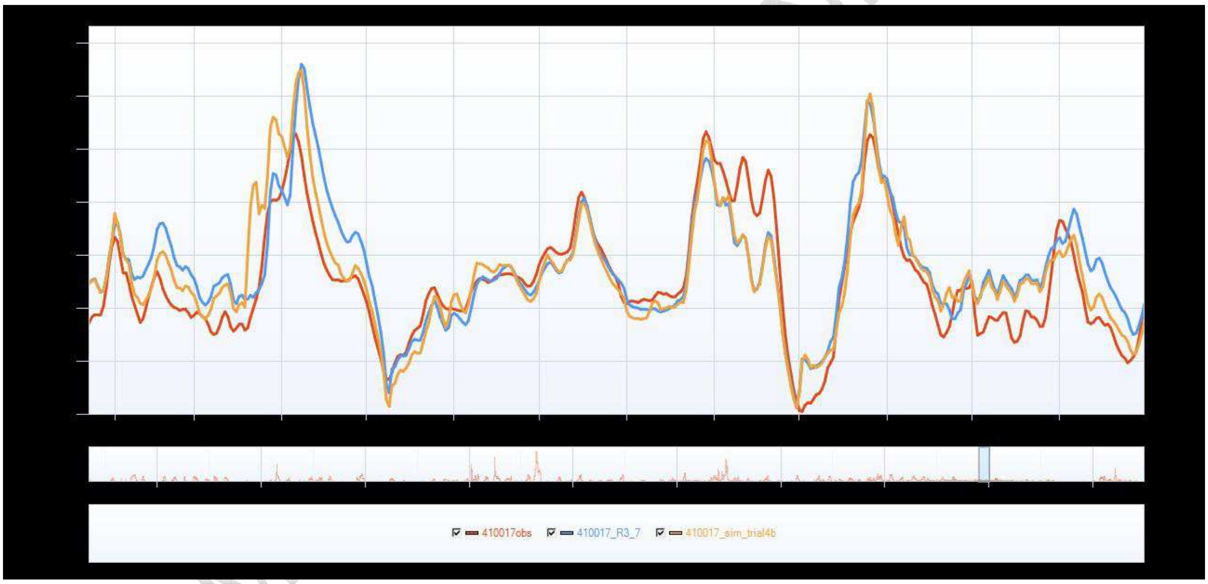

**Observed and simulated flow – 1997**



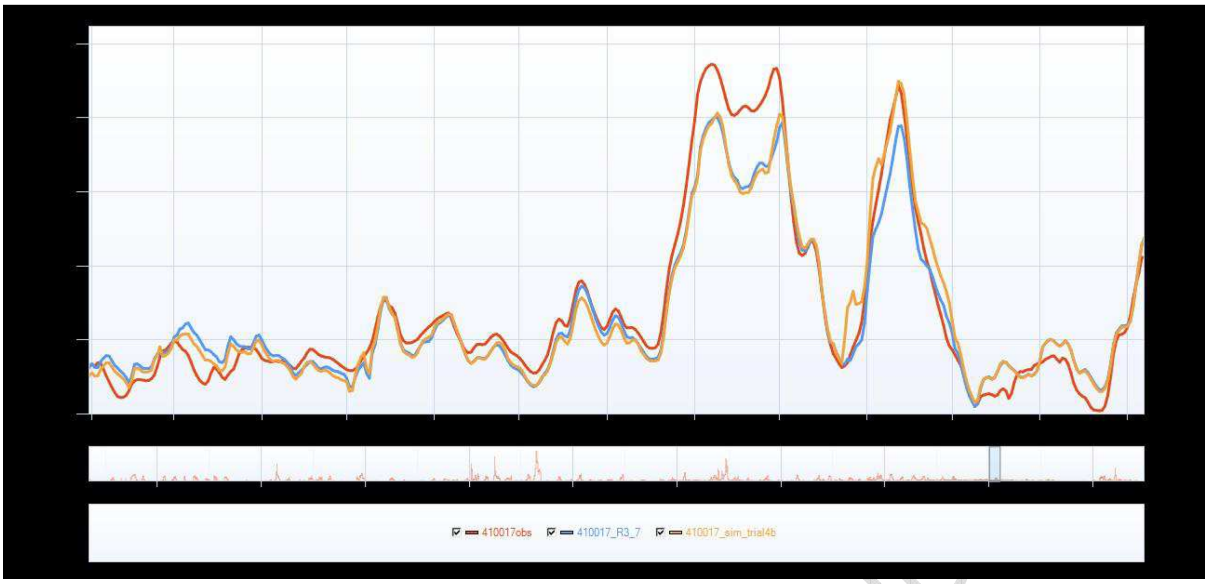
**Observed and simulated flow – 1998**



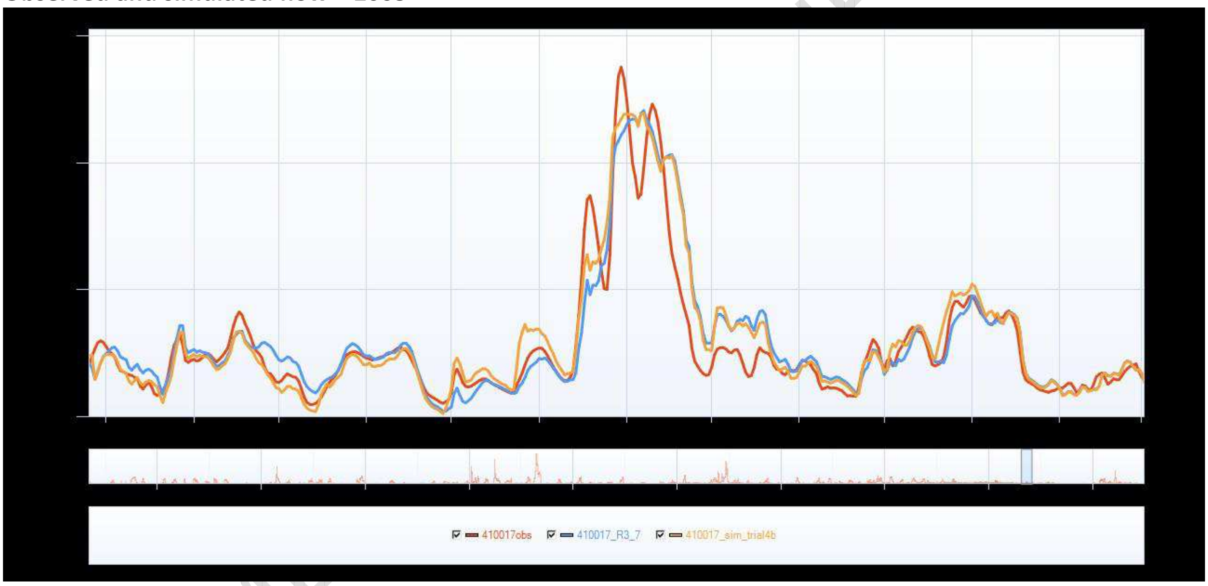

**Observed and simulated flow – 1999**



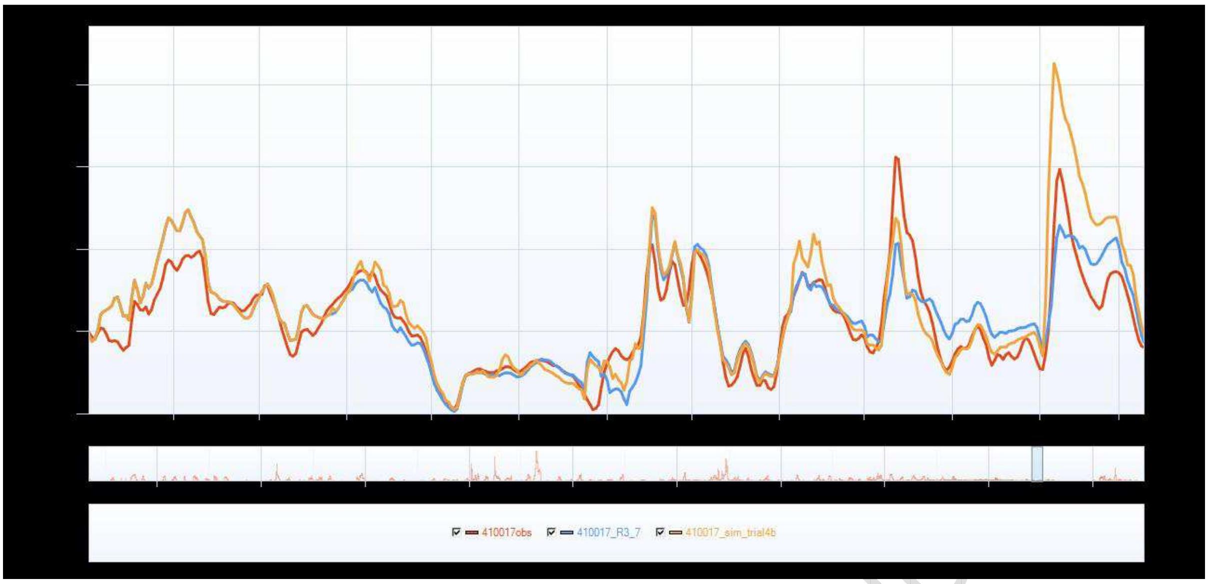
**Observed and simulated flow – 2000**



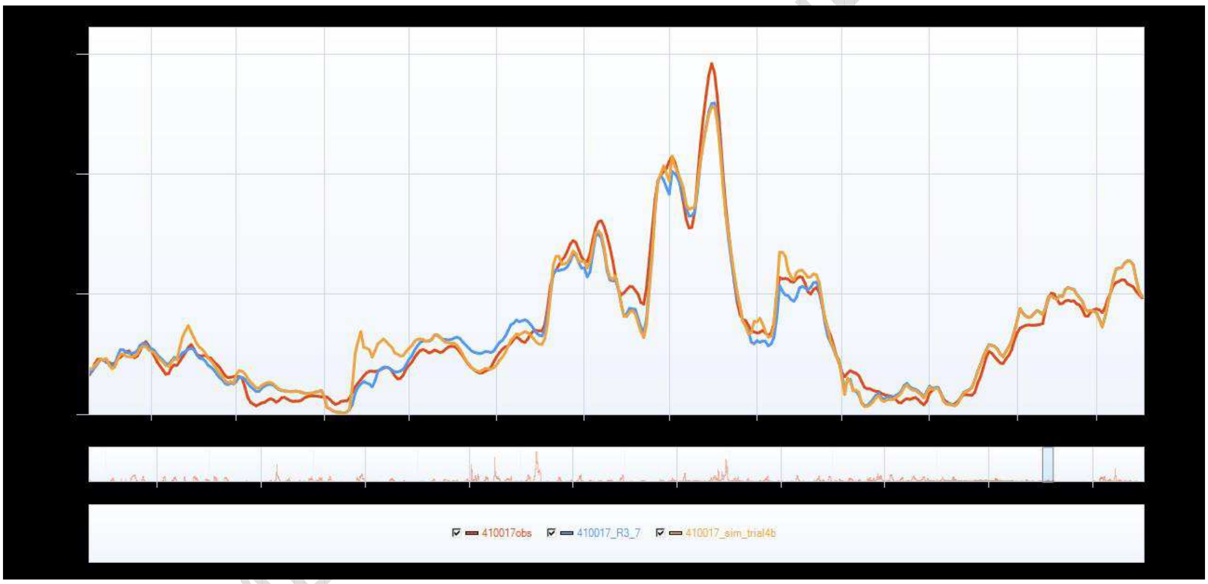

**Observed and simulated flow – 2003**



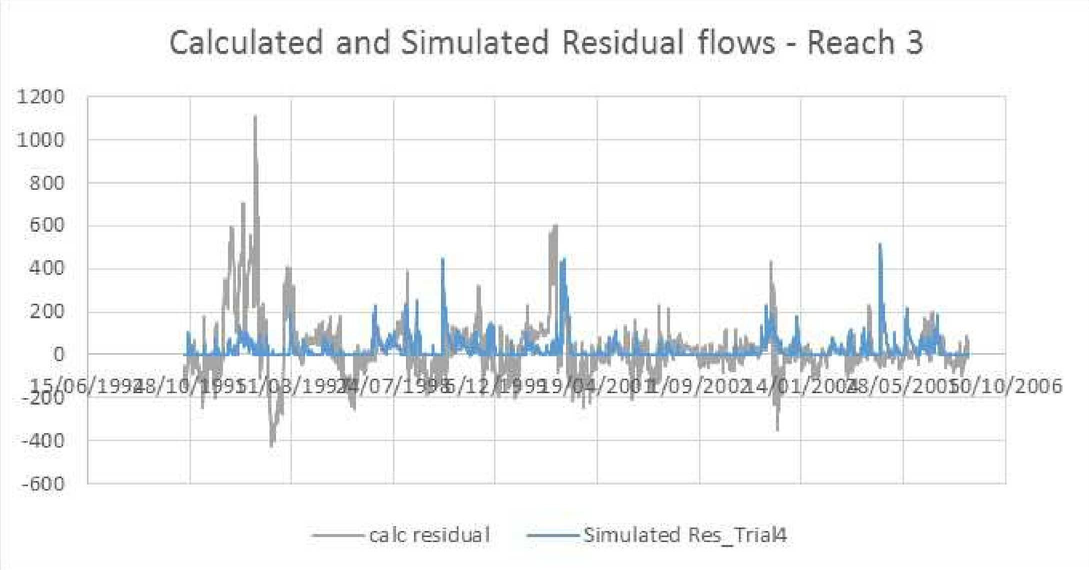
**Observed and simulated flow – 2004**




**Observed and simulated flow – 2005**



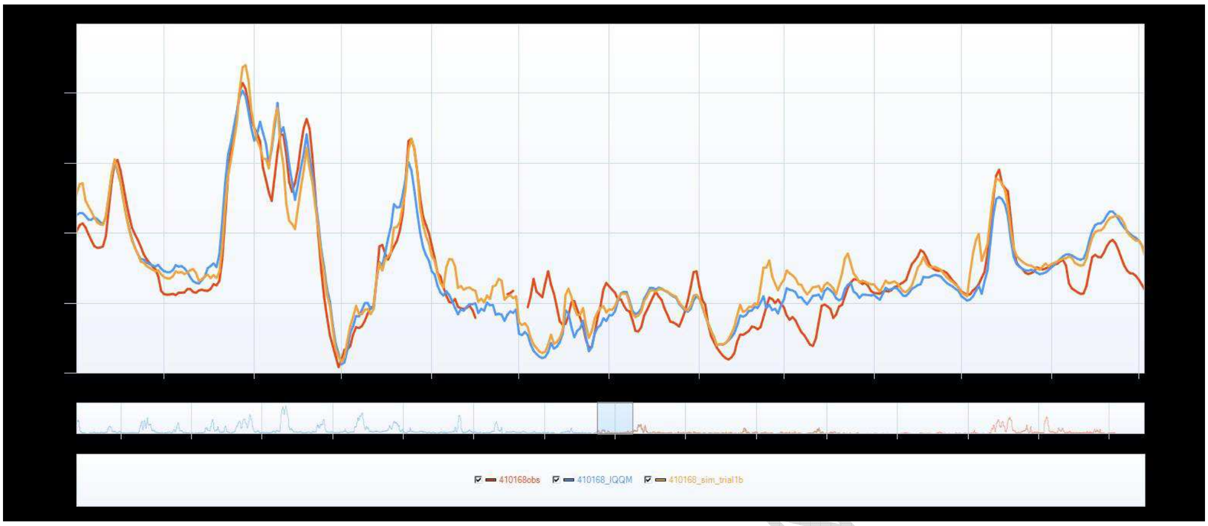
**Residual flows Reach 3 – Calculated and simulated from Sacramento model Trial 4**



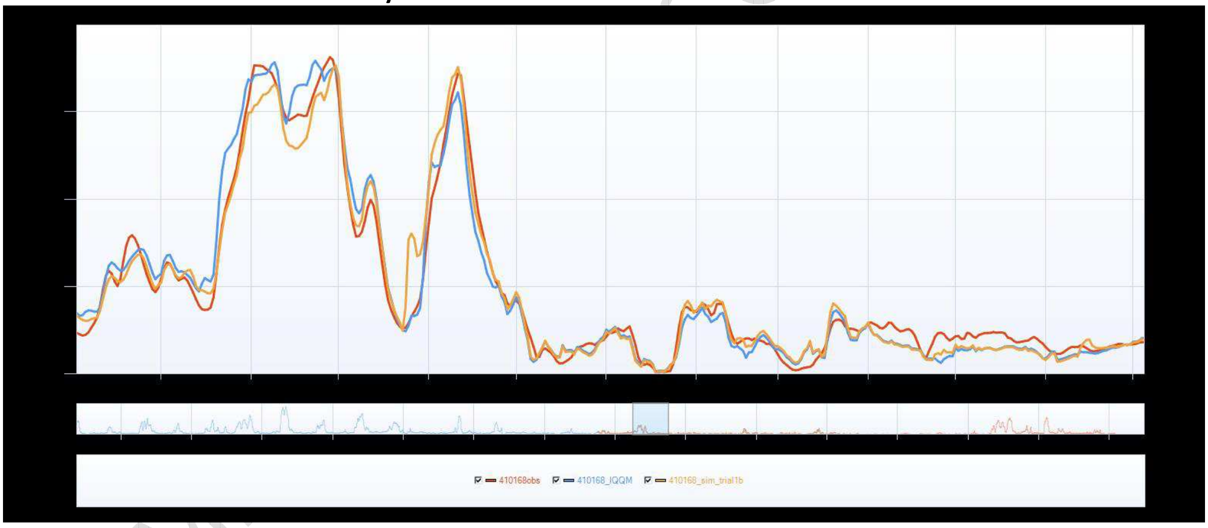
**Reach 6**

**Time series plots of observed flows at 410186 (red line), 410186_IQQM (blue line, simulated flows from IQQM reach model) and resultant flows using Sacramento models Trial 1 (orange line)**

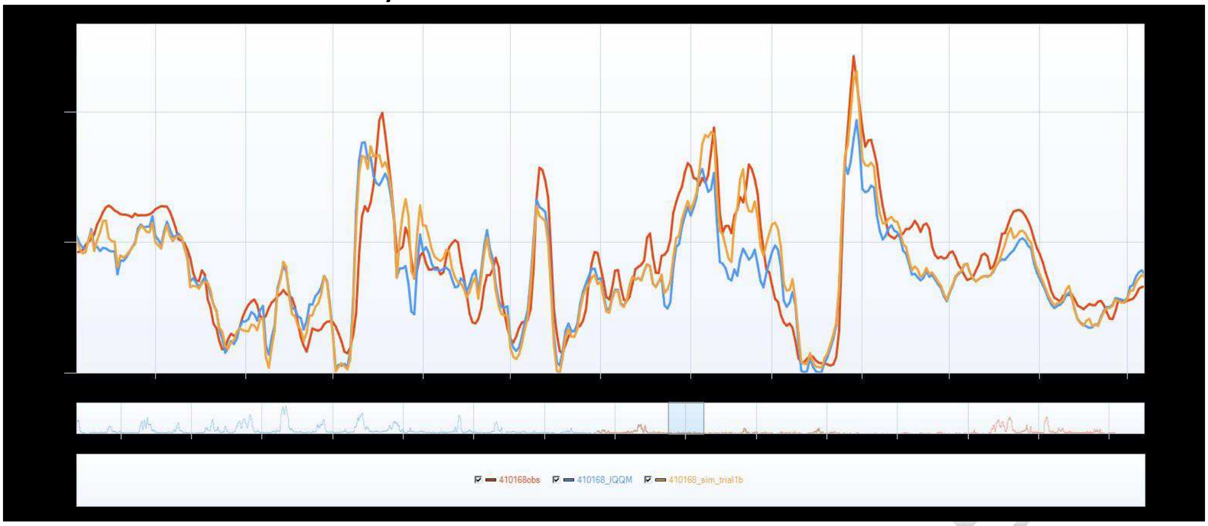
**Observed and simulated flow – 1999 to 2000**



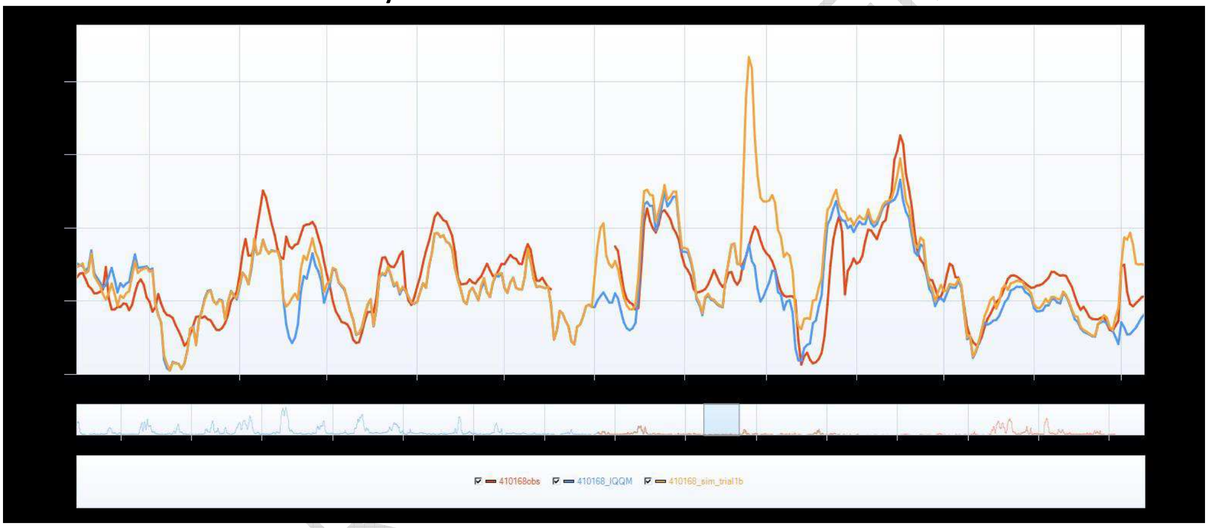

**Observed and simulated flow – July 2000 to June 2001**



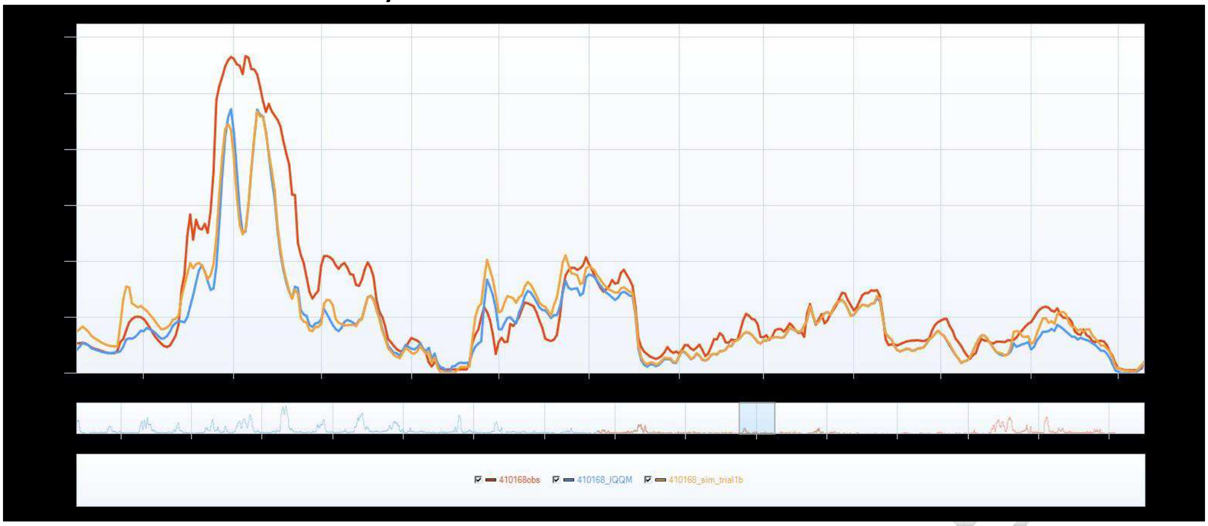
**Observed and simulated flow – July 2001 to June 2002**



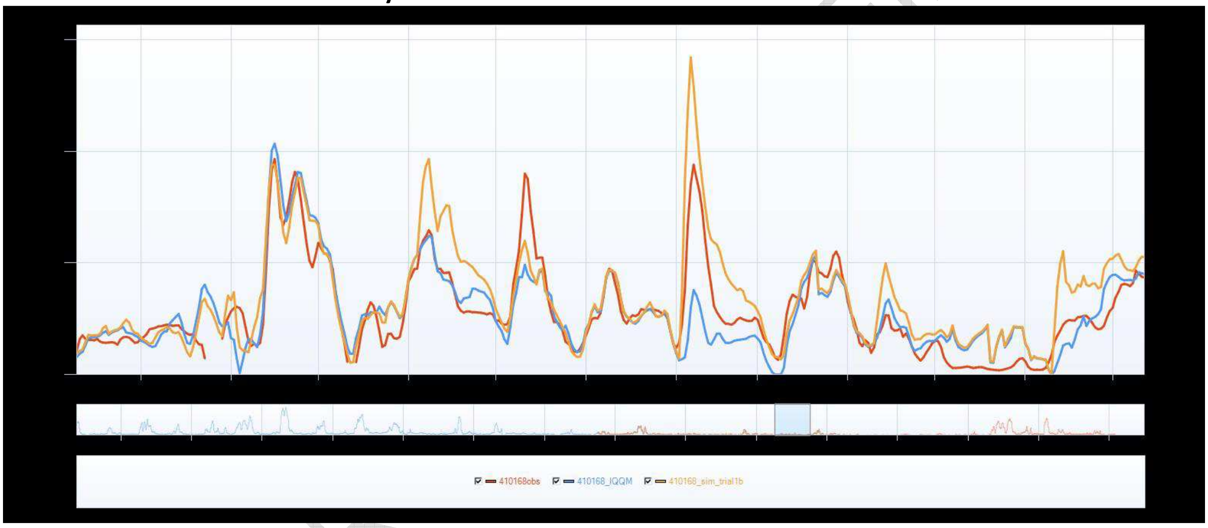

**Observed and simulated flow – July 2002 to June 2003**



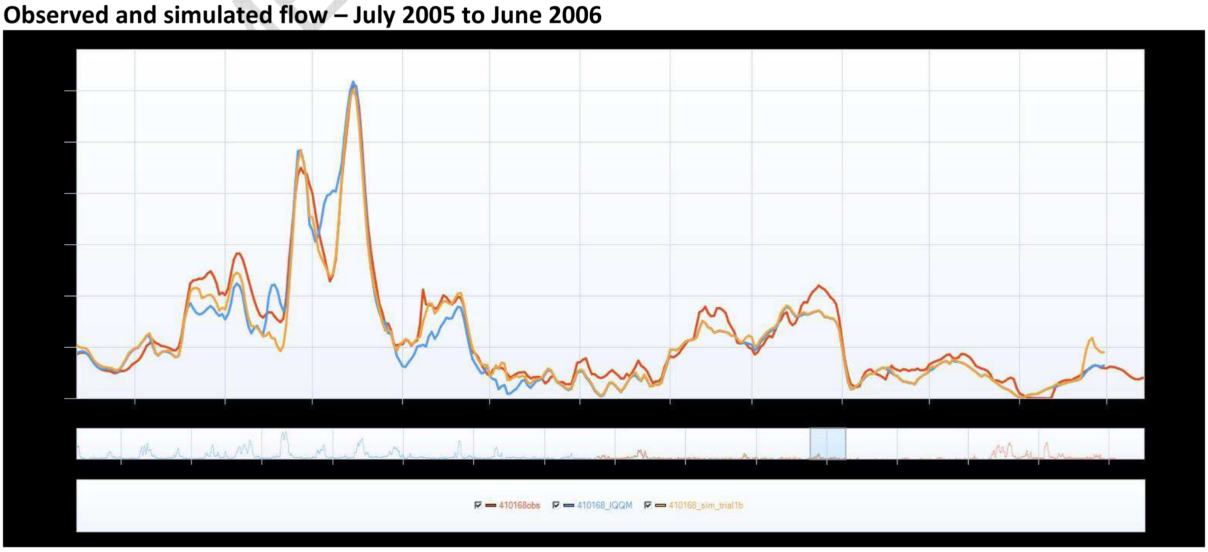
**Observed and simulated flow – July 2003 to June 2004**




**Observed and simulated flow – July 2004 to June 2005**

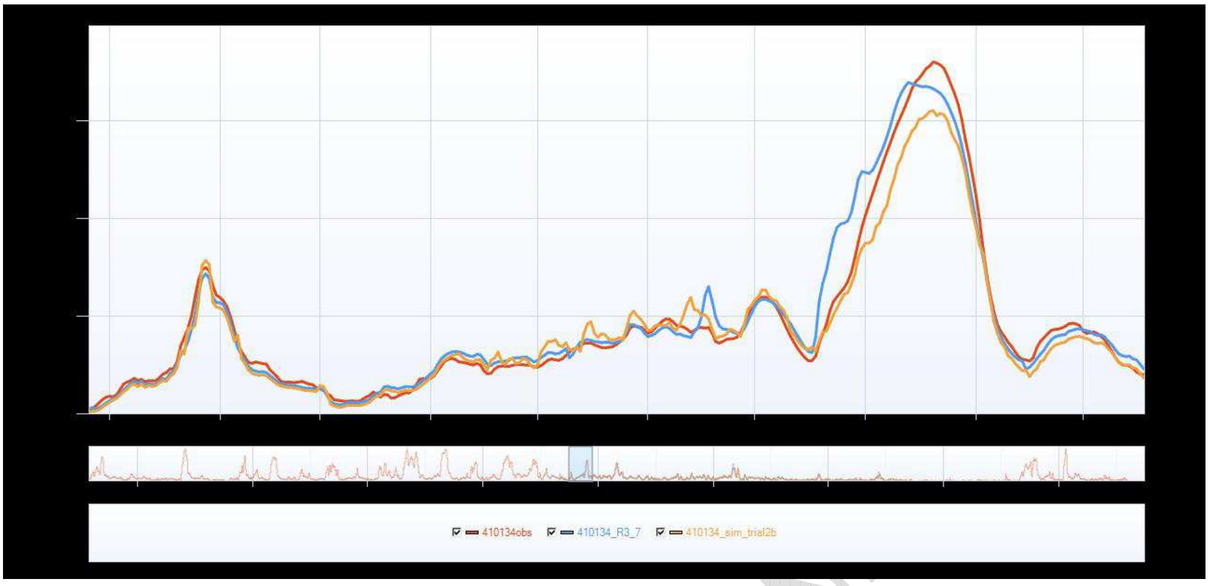



**Observed and simulated flow – July 2005 to June 2006**

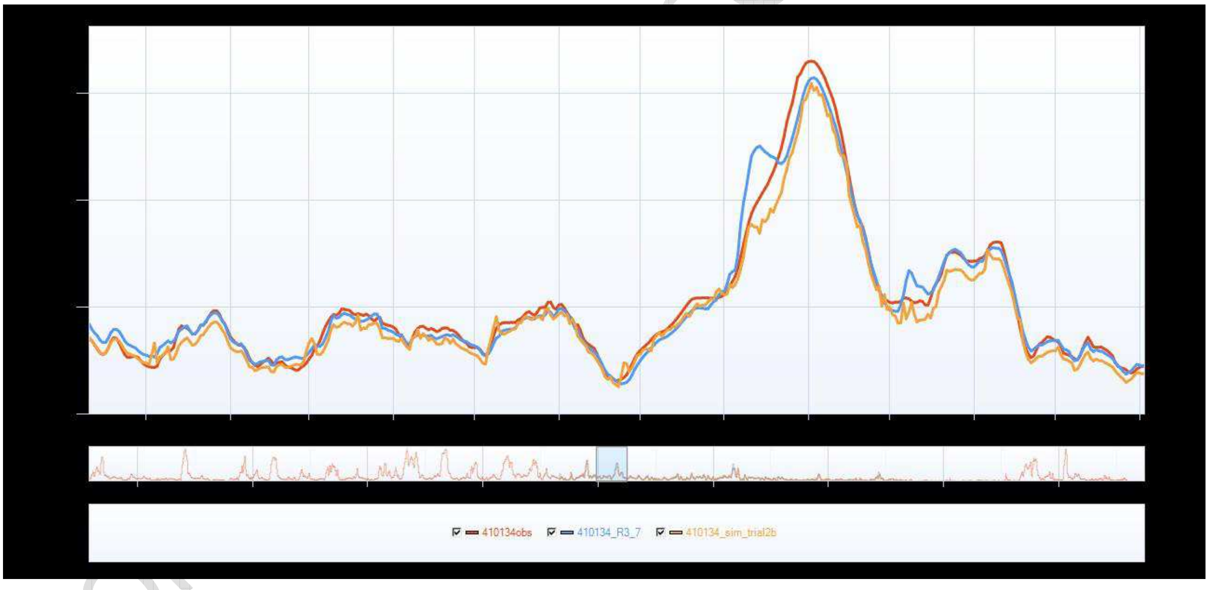


**Reach 7 Time series plots of observed flows at 410134 (red line), 410134_R3_7 (blue line, simulated flows from IQQM reach model) and Trial 2 (orange line)**

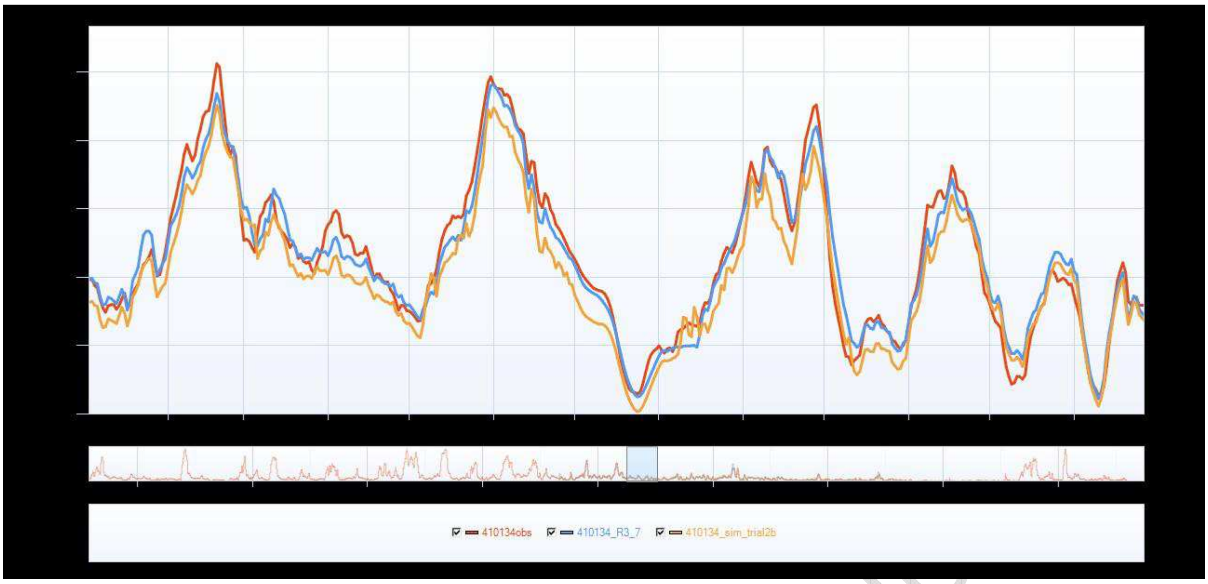
**Observed and simulated flow – 1995**



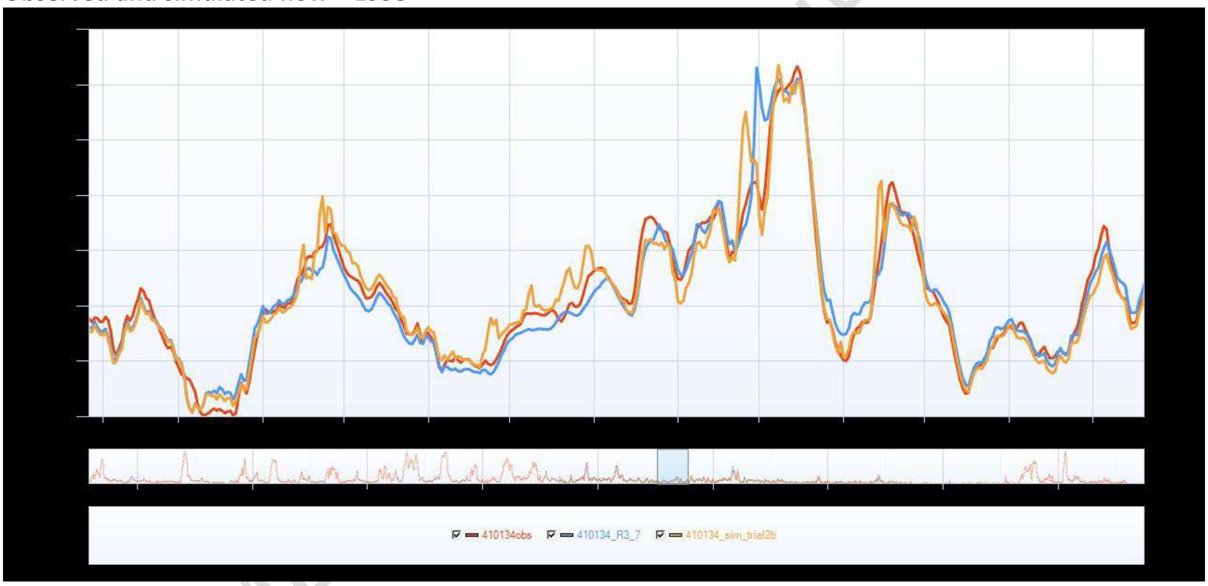

**Observed and simulated flow – 1996**



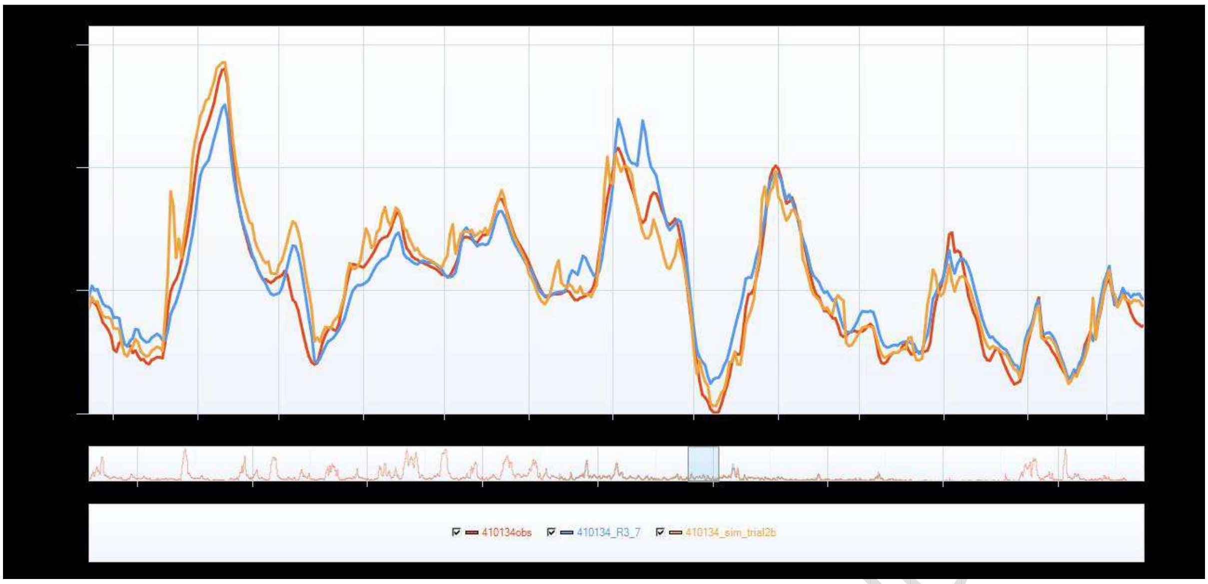
**Observed and simulated flow – 1997**



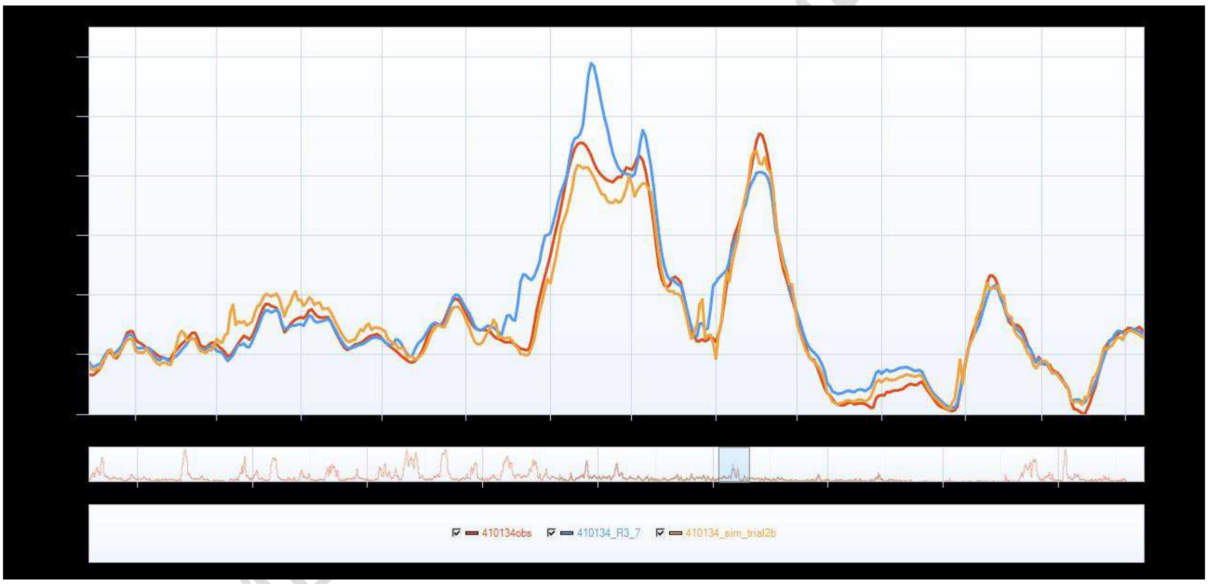

**Observed and simulated flow – 1998**



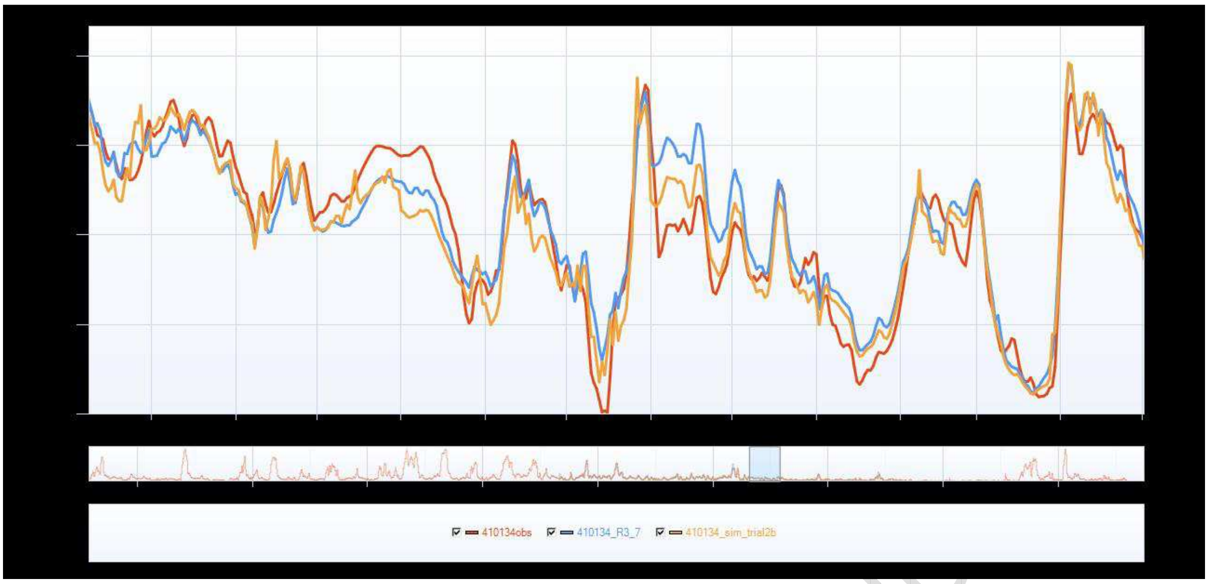
**Observed and simulated flow – 1999**



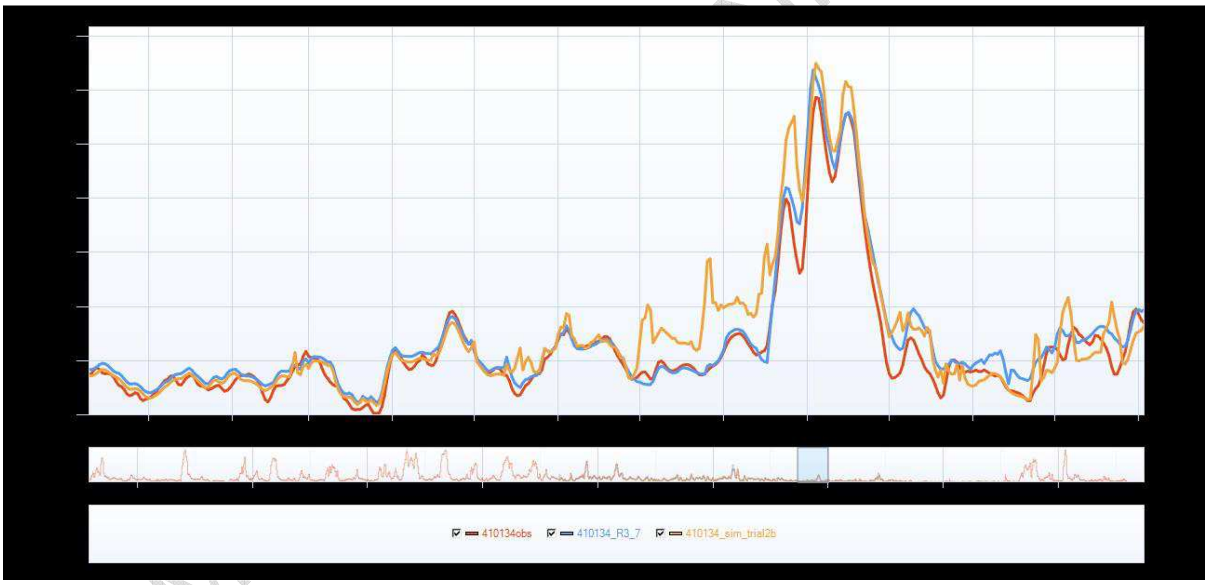

**Observed and simulated flow – 2000**



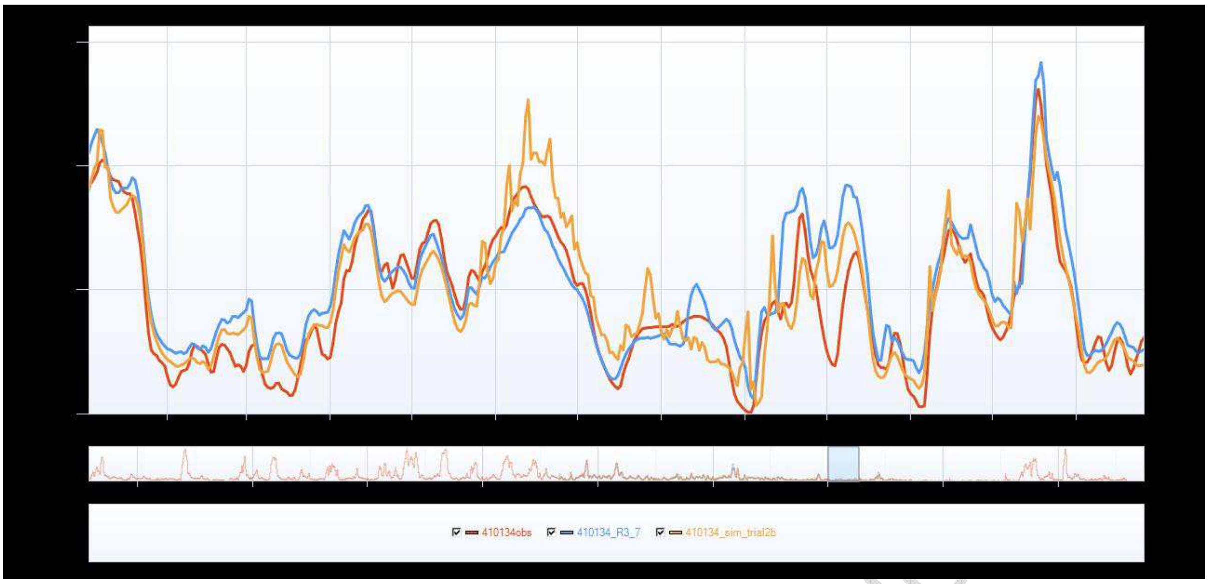
**Observed and simulated flow – 2001**



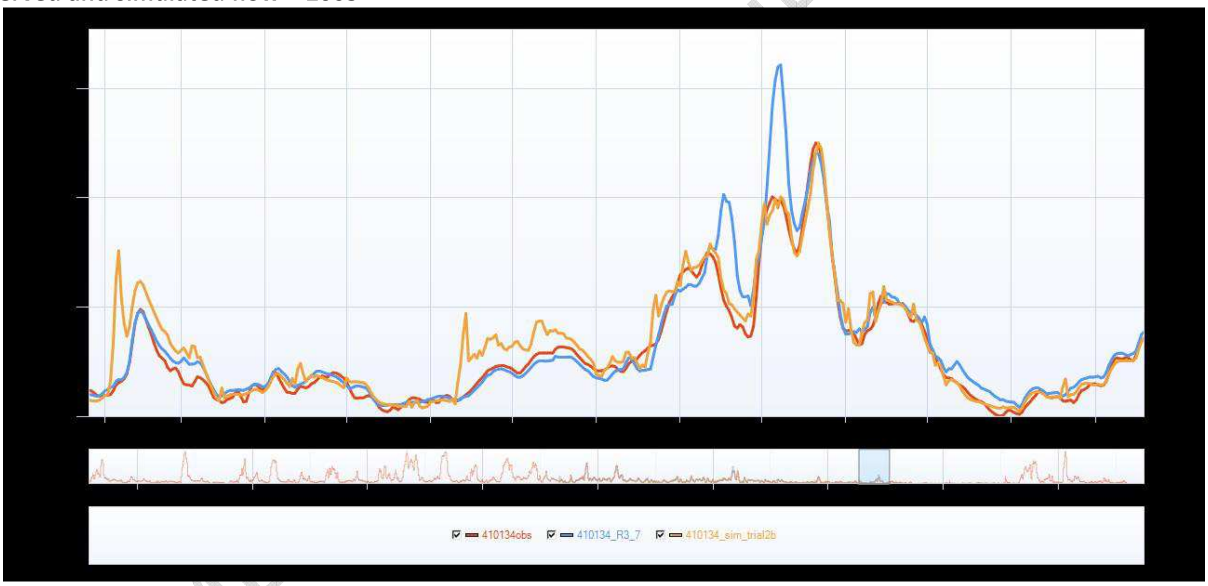

**Observed and simulated flow – 2003**



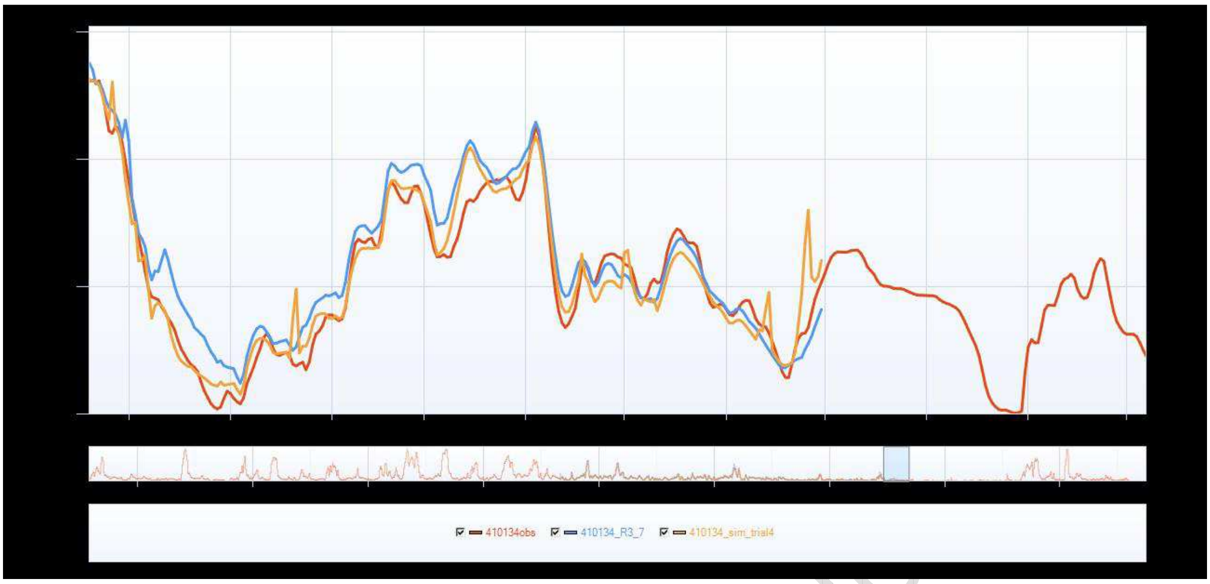
**Observed and simulated flow – 2004**




**Observed and simulated flow – 2005**



**Observed and simulated flow – 2006**



# Murrumbidgee SDLA – Project models

**22 March 2016**

# 1 Project model overview

This report describes:

- The project model cases that have been developed
- How the models were developed from the Adjusted Benchmark model
- Key assumptions

The MDBA's Benchmark model was altered to produce an Adjusted Benchmark model (see note *Murrumbidgee SDLA – Update of Benchmark Model*, DHI, 2016). The Adjusted Benchmark was then changed to include the proposed SDLA projects for the Murrumbidgee. These include:

- Water for Rivers projects post 2009 (tripartite projects including CARM)
- Yanco Colombo Billabong modernisation project
- Yanco Offtake project
- Nimmie Caira project
- Yanga National Park project

Individual project models were produced for each of the above, as well as a combined overall model including all projects.

# 2 Project model development

## 2.1 Water for Rivers projects post 2009 (tripartite works)

This project includes a number of sub-projects which were carried out under the tripartite agreement between NSW Office of Water, Water for Rivers and State Water. These include:

- Wilson Anabranch and associated losses
- Beavers Creek existing offtake structure, and losses and return flows on the Beavers / Old Man Creek system
- Augmented supply via Irrigation Corporations:
  - Coleambally Irrigation Area escape drain operation and historical loss provision, and
  - Murray Irrigation Finley Escape drain operation,
- Oak and Gras Innes Wetland losses on Bundidgerry Creek
- Tributary utilisation for regulated orders (for CARM)
- Yanco Offtake operation (for CARM)
- Rainfall rejection from Murrumbidgee Irrigation (for CARM)

Prior to adding these tripartite projects, the Adjusted Benchmark model had been produced to allow better representation of these changes between the Benchmark and the post-project case. These changes are outlined in *Murrumbidgee SDLA – Update of Benchmark Model* (DHI, 2016).

The tripartite projects were added to the Adjusted Benchmark model to produce the post-project Tripartite works model. The significant changes to the model included:

- Wilson anabranch: adding a regulator that opens and closes the anabranch inlet on a seasonal basis, and change of the outlet relationship to reflect the outlet gate being left permanently open
- Beavers Creek / Old Man Creek: Replacement of the old weir structure with new gates, with these operated on a seasonal basis, and including some supplementary flow sharing; addition of the Dog Fall and Old Old Man Creek anabranch structures;; addition of the seasonal minimum flow target at the end of Old Man Creek
- Coleambally Irrigation Area Drains: Change of the ordering priority through Yanco Offtake, to provide a minimum 50 Ml/d through offtake, then to supply all additional Yanco Creek orders through the CI drains until they are at full capacity
- Murray Irrigation Finley Escape: Change of operation to alter drains flows in respond to orders at Puckawidgee, with this reducing orders being passed up Billabong Creek to the Yanco Offtake
- Oak Creek and Gras Innes Regulators (Bundidgerry): Removal of these wetland areas from the creek, to represent supply from environmental water volumes as required
- CARM tributary utilisation: change of the “available flow to use for orders” time series, with more flow now available then in the Adjusted Benchmark, to reflect better tributary forecasting
- CARM Yanco Offtake Operation: Reduction of the seasonal oversupply factor through Yanco Offtake from 1.25 to 1.20, to reflect improved operational information on Yanco Billabong under CARM
- CARM rainfall rejection: Reduction of orders into MI Main Canal at Berembed in response to rainfall to represent improved river forecasting capacity under CARM (Benchmark only reduces extractions, not orders)

These changes are implemented in the model BIDGDA3.sqq.

As part of the tripartite agreement, licences were granted to Water for Rivers for the water savings produced by these projects. These included a 20,000 unit share High Security licence and a 13,000 unit share General Security licence. These licences have been added into the post-project model, and are placed in the model at two dummy irrigation nodes immediately downstream of Blowering Dam (one for General Security and one for High Security licences). These are the same nodes used to represent the pre-2009 Water for Rivers projects in the Adjusted Benchmark, with the licence volumes increased to include the additional tripartite projects licence.

The increased utilisation of Finley Escape also increases the volume coming through into the Murrumbidgee Valley from the Murray. This additional volume has to be returned to the Murray to ensure there is no net change in the intervalley trade balance. This is done in the model by adding a dummy irrigation node downstream of Balranald. This node orders and diverts a long-term average amount that is the same as the increase in Finley Escape outflow. This dummy node effectively sets aside water from the allocation to restore the IVT balance.

The addition of the projects also reduces the surplus flows within the system, including reducing end of system flows at Balranald and Moulamein. In the model, this reduction in surplus flow is linked to a reduction in dam releases, as unnecessary releases are reduced. This produces an increase in storage in the model, and an associated increase in allocations occurs. In the version of the post-project model provided, the allocation is allowed to increase, and there are no specific nodes calling this retained surplus out of the dams.

The projects also reduces the long-term average inflow to Lowbidgee by approximately 2,800 ML/yr compared to the Adjusted Benchmark case. This reduction has not been restored in the post-CARM case, as the combined model includes diversion into Nimmie Caira and Yanga to satisfy environmental inundation targets.

## 2.2 Yanco Colombo Billabong modernisation project

This project includes a number of modifications to the Yanco Colombo Billabong system, as outlined in the Effluents Business Case. These include:

- DC800: Increase of the capacity of the Coleambally Irrigation drain DC800 from 50 ML/d to 100 ML/d
- Lower Yanco Weir: A new weir to re-regulate flows
- Colombo Weirs: Addition of re-regulation structures on Colombo Creek, at 8 Mile, Chesneys Weir, Cocketdegong and Coonong Weir (these are modelled as one combined weir in the model)
- Murray Irrigation Berrigan Escape: Supply of up to 100 ML/d through Berrigan Escape in response to orders. This is done in the model based on the remaining order upstream of Finley Escape, though maintaining a minimum 60ML/d in the creek upstream of Berrigan Escape
- Hartwood Weir: Reconstruction of the weir to include re-regulation storage
- Downstream of Yanco and Billabong confluence: A new weir to re-regulate flows
- Wanganella: A new weir to re-regulate flows
- Piccanniny diversion: Extraction of surplus flows at the end of Forest Creek, and diversion of these through Piccanniny Creek back into Billabong Creek
- Existing structures on Billabong Creek at Algudgerie and on Mid Yanco Creek: Lowering of these fixed crest structures to reduce losses

These changes are implemented in the model BIDGEA9.sqq.

The utilisation of Berrigan Escape increases the volume coming through into the Murrumbidgee Valley from the Murray, as was noted for the tripartite works projects for Finley Escape. This additional Berrigan Escape volume also has to be returned to the Murray to ensure there is no net change in the intervalley trade balance. The dummy irrigation node downstream of Balranald created to balance the tripartite Finley Escape additional flow is adjusted in the model to balance the combined increase in both Finley and Berrigan Escapes.

The re-regulation structures in the model are represented using in-line storages. These storages accumulate excess discharge. When the weir has reached a threshold stored volume, it reduces the order being passed upstream by the amount it has stored. It subsequently releases this on the appropriate day to supply the downstream order.

Existing fixed crest structures on the Mid-Yanco and at Algudgerie on Billabong Creek are modelled as time series of evaporation losses. Different time series are used for the Adjusted Benchmark and post-project models.

## 2.3 Yanco Offtake project

This project involves construction of a regulator on Yanco Offtake, as described in the *Business Case: Yanco Offtake SDL Adjustment Supply Measure* (Alluvium, XXX). The changes to the Adjusted Benchmark model are in the model BIDGMFE6.sqq

The offtake itself is implemented in the model by adding a control structure in the model, with an assumed maximum diversion capacity for the structure.

The approach in the Benchmark model to surplus flow sharing between the Murrumbidgee River and Yanco Creek is changed in the post-project model. The surplus flow diversion is determined by a new time series that specifies large diversions into Yanco Creek, in order to achieve bankfull and overbank flows within the creek system. This is specified in the Yanco Offtake Business Case.

The post-project model also includes a minimum flow time series downstream of the Yanco Offtake. This minimum flow aims to preserve the flow regime in the creek when river flows are less than 15,000 ML/d. It does this by extracting the Benchmark time series of discharges through the offtake for river flows < 15,000 ML/d, and adding this as minimum flow node referring to the extracted time series.

## 2.4 Yanga National Park 1AS regulator project

This project is described in the *Business Case: Murray and Murrumbidgee Valley National Parks SDL Adjustment Supply Measure* (Alluvium, October 2015). One of the measures proposed by this project is reconstruction of the Yanga 1AS regulator. The Business Case estimates this leaks water from the river into Yanga National Park at an average rate of approximately 5,400 ML/yr.

To model this the river loss between Maude Weir and Redbank Weir was changed. The loss rate in the benchmark model is a constant 55 ML/d for all flows greater than 55ML/d. This was reduced to 40 ML/d in the post-project model (which is equivalent to an annual volume of 5,400 ML as flows do not fall below the 55 Ml/d threshold).

The changes to the Adjusted Benchmark model are in model BIDGFA2.sqq.

## 2.5 Nimmie Caira – Yanga National Park project

This project is described in the *Business Case: Nimmie-Caira SDL Adjustment Supply Measure* (Alluvium, XXX). The Business Case identifies target environmental water volumes inside Nimmie – Caira and Yanga National Park, which should be achieved on a target inter-annual frequency.

The project is modelled by diverting additional volumes out of the river to try and achieve these target volumes. Targets differ for different cases - the four cases considered were:

- Nimmie Caira with no rehabilitation: Target environmental volumes based on Nimmie Caira requirements, without any rehabilitation works of the floodplain inside Nimmie Caira having been carried out (i.e. current configuration)
- Nimmie Caira with rehabilitation: Target environmental volumes based on Nimmie Caira requirements, with rehabilitation works of the floodplain inside Nimmie Caira having been carried out
- Nimmie Caira and Yanga National Park with no rehabilitation: Target environmental volumes based on both Nimmie Caira and Yanga National Park requirements, without any rehabilitation works of the floodplain inside Nimmie Caira having been carried out (i.e. current configuration)
- Nimmie Caira and Yanga National Park with rehabilitation: Target environmental volumes based on both Nimmie Caira and Yanga National Park requirements, with rehabilitation works of the floodplain inside Nimmie Caira having been carried out

The targets specified in the business case were simplified in order to make them assessable in the model. The set of targets applied in the model were:

Table 1 Nimmie Caira and Yanga environmental water volume targets

| Case | Model Name | Supply Measure (GL) achieved in percentile of years | | | |
|---|---|---|---|---|---|
| | | 95% tile | 50% tile | 40% tile | 14% tile |
| Nimmie Caira (no Rehab) | BIDGA02 | 3 | 46 | 192 | 302 |
| Nimmie Caira (with Rehab) | BIDGA03 | 3 | 46 | 290 | 414 |
| Yanga and Nimmie Caira (no rehab) | BIDGA04 | 26 | 46 | 248 | 664 |
| Yanga and Nimmie Caira (with Rehab) | BIDGA05 | 26 | 46 | 346 | 774 |

In order to apply these targets in the model, the following approach was used:

- Years in which SFI targets at Maude Weir are met in the model are identified – this is taken as an indicator that sufficient flow may be available to divert water into Nimmie Caira / Yanga to reach a watering target event
- The volume of environmental water already diverted into Lowbidgee is calculated from the Benchmark model run
- The additional volume required to reach the target is then worked out in a spreadsheet; this is done for each of the four target columns in Table 1
- The additional volume required for the four targets is disaggregated into a daily diversion series, based on the time series of surplus flows available according to the Benchmark run results
- The resulting time series is set as a diversion series in the project model
- The project model is run, and it is checked whether the target volumes are achieved, and whether the frequency of reaching these volumes is within the range specified in the business case

The project model is modified from the Adjusted Benchmark model. It includes an additional Lowbidgee floodplain storage that is separate to the "bucket" storages in the benchmark model. All additional discharge to meet the target event volume is diverted into the separate floodplain bucket.

Furthermore, it is assumed that none of the additional diverted flow to meet the environmental targets returns to the Murrumbidgee River. It is assumed that the entire volume is retained within Lowbidgee and eventually lost to the system.

# 3 Combined project model

The combined model includes all of the individual SDLA project model changes. As there four different Nimmie-Caira and Yanga National Park cases, there are four different versions of the combined project model file, as outlined in Table 2.

Table 2 Combined project model files

| Case | Model Name |
|---|---|
| Nimmie Caira (no Rehab) | BIDGCA2 |
| Nimmie Caira (with Rehab) | BIDGCA3 |
| Yanga and Nimmie Caira (no rehab) | BIDGCA4 |
| Yanga and Nimmie Caira (with Rehab) | BIDGCA5 |

The key issues and assumptions regarding the combined model are summarised here:

- The models do not include nodes to utilise any water “produced” by the projects, instead any gain will result in an increased long-term allocation in the model
- Changes to Finley and Berrigan escapes increase the amount of water diverted from the Murray into Billabong Creek, and a dummy irrigation node downstream of Balranald is used to balance the IVT
- The water savings licences associated with the tripartite projects (including CARM) are included in the model, and are added to dummy irrigation nodes situated immediately downstream of Blowering Dam (these nodes also include the pre-2009 Water for Rivers project licences)
- There is a small decrease in Lowbidgee diversions in the post-CARM model (2.8 GL/yr), however the combined model includes the Nimmie-Caira environmental targets which override this
- Yanco Offtake is modelled with a fixed low flow regime, which is based on the MDBA Benchmark model discharge time series through the offtake (instead of specific low flow targets at the offtake)

# Attachment D: Amendment 1 – Murrumbidgee proposals

This amendment applies to the following proposals:

1. Nimmie-Caira Infrastructure Modifications Proposal
2. Improved flow management works at Murrumbidgee Rivers - Yanco Creek offtake
3. Modernising supply systems for effluent creeks
4. Computer Aided River Management (CARM)
5. Murray and Murrumbidgee Valley National Parks

Note: this amendment applies to the Murrumbidgee component of the Murray and Murrumbidgee Valley National Parks proposal. The Murray component, though retained in the notification, will not be modelled under the SDL adjustment mechanism and as such will not form part of the M D BA's adjustment determination.

The proposals are all incorporated in the NSW IQQM model of the Murrumbidgee River. This model has been developed by NSW DPI and subsequently reviewed by MDBA modellers. The model is linked to the MDBA MSM Bigmod as part of the overall modelling framework for the Southern Connected Basin.

The NSW projects Effluent Creeks and CARM have entitlements associated with them. NSW has confirmed that the entitlements will be provided as a single unencumbered NSW General Security entitlement. An Inter Valley Trade account will either be established or an existing account modified to mitigate any third party issues in terms of reliability impacts for Murray downstream users.

MDBA has conducted modelling assessment to determine the volume of general security entitlements and IVT account from the CARM and Modernising supply system for Effulent Creeks projects. The modelling assessment is presented at Appendix E.

## *Appendix A: Murrumbidgee model updated by NSW*

The original Murrumbidgee Basin Plan Benchmark model for the SDL adjustment had a number of deficiencies preventing the Murrumbidgee supply measures from being assessed in a sensible technical manner. MDBA received the Murrumbidgee models from NSW which addressed deficiencies. The latest models (MDBA Trim No: D17/20418) have been incorporated into the MDBA's modelling framework (Rev No: 4625) to form a basis of modelling assessment for SDL adjustment. The changes made to the model by NSW are well documented in the NSW DPI Water reports.

MDBA has subsequently merged each of the Murrumbidgee SDLA project models into one combined model and incorporated it into the modelling framework (Rev No: 4626).

The reports from NSW that describe these changes are set out in Attachment E.

## Appendix B: Further changes made by MDBA

There are two specific changes made by the MDBA to improve model fitness, as follows:

### Representing Water for Rivers

To model a reduction in the required annual release from the Snowy, extraction nodes from Blowering Dam have been included by NSW. MDBA has adjusted Murrumbidgee entitlements and irrigation area so that the long term average extracts are equal to the LTCE numbers of 96 GL for the Benchmark (ie prior to 2009) and 123.3 GL for the SLDA model (post 2009) as shown in Table 1.

*Table 1: Water recovered through the Water for Rivers initiatives*

| | Measures | HS | Conveyance | GS | LTCE |
|---|---|---|---|---|---|
| **Prior to 2009** | Water Purchase | | | 40.4 | 25.7 |
| | On-farm reconfig | | | 21.5 | 13.7 |
| | Coleambally conveyance | | 3.5 | | 3.4 |
| | Mbidgee irrig (Barren Box Swamp) | | 20.0 | | 19.3 |
| | Hay PID | | 1.0 | | 1.0 |
| | Forest Ck | 34.7 | | | 33.0 |
| | Total | 34.7 | 24.5 | 61.9 | **96.0** |
| **Post 2009** | Tripartite works | 20.0 | | | 19.0 |
| | | | | 13.0 | 8.3 |
| | Total | 20.0 | 0.0 | 13.0 | **27.3** |

### Tributary utilisation

In consultation with NSW, MDBA has applied redeveloped tributary utilisation time-series from modelled tributary inflows. Table 2 presents annual averages before and after the MDBA's update.

*Table 2: Annual average of tributary utilisation*

**Benchmark**

| | As provided by NSW (GL/yr) | Updated by MDBA (GL/yr) |
|---|---|---|
| **Gundagai - Wagga** | 319 | 288 |
| **Muttama upstream** | 32 | 32 |
| **Jugiong** | 197 | 197 |
| **Tumut downstream** | 207 | 207 |
| **Tumut upstream** | 290 | 290 |

**Post CARM**

| | As provided by NSW (GL/yr) | Updated by MDBA (GL/yr) |
|---|---|---|
| **Gundagai - Wagga** | 411 | 390 |
| **Muttama upstream** | 38 | 38 |
| **Jugiong** | 255 | 255 |
| **Tumut downstream** | 261 | 261 |
| **Tumut upstream** | 290 | 318 |

## Appendix C: Spatial data describing the inundation extent associated with the Improved Flow Management Works (Yanco Creek) proposal

To represent the impact of the Yanco Creek proposal on inundations areas, it is assumed that the area of the floodplain affected by the Improved Flow Management Works (i.e. upstream of Yanco Creek) would reach the inundation area associated with the Specific Flow Indictors (SFI) at a 10% lower flow threshold.

To illustrate, without Improved Flow Management works SFI 1 is associated with a flow of 26,850 ML/d for 45 days.

For the part of the floodplain affected by the works, SFI 1 would be considered successful if a flow of 24,621 ML/d for an appropriate number of days is achieved.

The inundation areas associated which each SFI flow band have been split into that part affected by the works and that part unaffected. This provides separate hydrological assessment units (HAUs) for the assessment of Ecological Outcome scores. Total floodplain area affected and unaffected by the works is presented in Table 3.

*Table 3: Total area (Ha) of the floodplain targeted by the Specific Flow Indicators, split in an area not affected by the works, and an area affected by the work.*

| Mid Murrumbidgee Floodplain | Inundation area (ha) |
|---|---|
| Floodplain area not affected by works | 66942 |
| Floodplain area affected by works | 26234 |
| Total floodplain area | 93176 |

The areas for the separate hydrological assessment units (HAU) are provided in Tables 4 and 5. The areas for the specific flow thresholds represent the inundation area *additional* to the area already inundated by a lower flow threshold.

*Table 4: Inundation area (hectares) additional to the area already inundated by a lower flow threshold for hydrologic assessment units outside the area impacted by the works.*

| | SFI Bands ML/day | | | |
|---|---|---|---|---|
| **Ecological Element** | **26,850** | **34,650** | **44,000** | **63,250** |
| General health and abundance - all Waterbirds | 6715.4 | 3770.8 | 15151.0 | 41305.3 |
| Bitterns, crakes and rails | 1538.2 | 290.4 | 551.3 | 41.3 |
| Breeding - Colonial-nesting waterbirds | 6715.4 | 3770.8 | 15151.0 | 41305.3 |
| Breeding - other waterbirds | 1538.2 | 290.4 | 551.3 | 41.3 |
| Redgum Forest | 2681.7 | 1211.3 | 4359.9 | 402.7 |
| Redgum Woodlands | 12.3 | 11.6 | 81.4 | 12.4 |
| Forests and Woodlands: Black Box | 166.3 | 112.1 | 305.6 | 48.4 |
| Lignum (Shrublands) | 0.0 | 0.0 | 0.0 | 0.0 |
| Tall Grasslands, Sedgelands and Rushlands | 1525.6 | 285.9 | 507.4 | 40.6 |
| Benthic Herblands | 0.0 | 0.0 | 0.0 | 0.0 |
| Short lived fish | 1538.2 | 290.4 | 551.3 | 41.3 |
| Long lived fish | 6715.4 | 3770.8 | 15151.0 | 41305.3 |

*Table 5: Inundation area (hectares) additional to the area already inundated by a lower flow threshold for hydrologic assessment unit impacted by the works*

| | SFI Bands ML/day | | | |
|---|---|---|---|---|
| **Ecological Element** | **24,621** | **31,522** | **39,912** | **56,700*** |
| General health and abundance - all Waterbirds | 15337.7 | 3864.6 | 7031.3 | 0.0 |
| Bitterns, crakes and rails | 2411.2 | 211.9 | 227.3 | 0.0 |
| Breeding - Colonial-nesting waterbirds | 15337.7 | 3864.6 | 7031.3 | 0.0 |
| Breeding - other waterbirds | 2411.2 | 211.9 | 227.3 | 0.0 |
| Redgum Forest | 10824.4 | 2386.4 | 3958.3 | 0.0 |
| Redgum Woodlands | 319.7 | 141.4 | 186.2 | 0.0 |
| Forests and Woodlands: Black Box | 1732.4 | 539.9 | 871.9 | 0.0 |
| Lignum (Shrublands) | 0.0 | 0.0 | 0.0 | 0.0 |
| Tall Grasslands, Sedgelands and Rushlands | 2410.1 | 211.9 | 227.3 | 0.0 |
| Benthic Herblands | 0.0 | 0.0 | 0.0 | 0.0 |
| Short lived fish | 2411.2 | 211.9 | 227.3 | 0.0 |
| Long lived fish | 15337.7 | 3864.6 | 7031.3 | 0.0 |

*The flow rate is beyond regulating capacity of the proposed works and therefore no additional benefits counted.

## *Appendix D: Spatial data describing the inundation extent for the Lower-Murrumbidgee reach*

The figures below represent the inundated areas of the separate hydrological assessment units (HAU) for the Nimmie Caira without rehabilitation scenario. The areas for the specific flow thresholds represent the inundation area *additional* to the area already inundated by a lower threshold.

*Table 6 Inundation areas in hectares for hydrologic assessment unis in the without rehabilitation scenario*

| | SFI Bands GL | | | | | |
|---|---|---|---|---|---|---|
| **Ecological Element** | **175** | **270** | **400** | **800** | **1700** | **2700** |
| General health and abundance - all Waterbirds | 34,362.9 | 968.2 | 4,777.0 | 26,705.4 | 28,624.4 | 16,561.3 |
| Bitterns, crakes and rails | 7,291.5 | 97.8 | 376.6 | 1,120.7 | 1,065.5 | 543.6 |
| Breeding - Colonial-nesting waterbirds | 34,362.9 | 968.2 | 4,777.0 | 26,705.4 | 28,624.4 | 16,561.3 |
| Breeding - other waterbirds | 7,291.5 | 97.8 | 376.6 | 1,120.7 | 1,065.5 | 543.6 |
| Redgum Forest | 10,964.0 | 157.6 | 673.8 | 5,832.0 | 4,022.7 | 1,188.5 |
| Redgum Woodlands | 801.7 | 31.6 | 188.4 | 1,049.9 | 830.0 | 311.1 |
| Forests and Woodlands: Black Box | 6,338.7 | 196.7 | 917.8 | 7,387.7 | 7,646.3 | 3,289.0 |
| Lignum (Shrublands) | 5,446.9 | 299.3 | 1,111.4 | 4,388.8 | 7,945.2 | 6,446.8 |
| Tall Grasslands, Sedgelands and Rushlands | 6,623.8 | 96.8 | 373.9 | 1,063.9 | 1,021.3 | 532.7 |
| Benthic Herblands | 667.7 | 1.0 | 2.7 | 56.8 | 44.2 | 10.9 |
| Short lived fish | 7,291.5 | 97.8 | 376.6 | 1,120.7 | 1,065.5 | 543.6 |
| Long lived fish | 34,362.9 | 968.2 | 4,777.0 | 26,705.4 | 28,624.4 | 16,561.3 |

Australian Government

MURRAY–DARLING BASIN AUTHORITY

# Assessment of the CARM and Modernisation projects for entitlement creation

Technical Report No. 2017/08

July 2017

Published by the Murray-Darling Basin Authority

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## History and Status

| Status | Version | Date | Author | Reviewed | Approved for Finalisation | Internal or Web Publication |
|---|---|---|---|---|---|---|
| Preliminary Draft | 1.0 | Jul 17 | JL | | | |
| Draft | | | | | | |
| Final | | | | | | |
| | | | | | | |
| | | | | | | |
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# Contents



# Tables

# 1 Introduction

Chapter 7 of the Basin Plan allows SDLs to be adjusted if equivalent environmental outcomes can be achieved through works and measures with less environmental water recovery. For assessing potential SDL adjustments possible, MDBA in consultation with the states has been incorporating a number of SDL offset proposals developed by the states.

As SDL offset proposals, NSW has put forward multiple business cases with operational and structural changes for the Murrumbidgee system. Among those, there are two projects that have specifications to issue environmental entitlements. These two projects are:

- Computed Aided River Management (CARM) system for the Murrumbidgee River (NSW DPI Water, 2015a) and
- Modernising supply systems for effluent creeks – Murrumbidgee River (NSW DPI Water, 2015b).

The CARM is an expert Decision Support System (DSS) specifically for river operations so that operators can make better informed decisions on daily releases from dams and weirs. This project will improve system operations by capturing operational surplus.

The modernisation project improves operational efficiency by multiple measures within the Yanco creek system including re-regulating flows, use of neighbouring irrigation corporations to supply demands and other operational changes.

These projects are developed to save water which can be called out to meet environmental needs. At the same time, however, harvesting surplus flows at the head storage leads to less inflows to the Murray system. Therefore Murray users including environment can be affected by the reduced inflows.

This report describes modelling undertaken to determine the callout volume from the two projects and Murrumbidgee IVT account to mitigate third party impacts to Murray users.

# 2 Agreed approach

In consultation with NSW, an assessment approach has been determined. It involves two steps including:

- Determination of the total available water from the two projects
- Breaking up the total volume into two accounts – one for callable entitlement within the Murrumbidgee system and another for Murrumbidgee IVT account to mitigate third party impacts in the Murray system.

# 3 Application of the agreed approach

## 3.1 First step

There are 4 scenarios modelled by changing the size of general security unit shares that can be extracted at the end of the system. For the modelling purpose, a fictitious license holder is created at the end of the system and 4 different unit shares are assigned, that are 0 GL, 30 GL, 40 GL and 100 GL. Table 1 presents the changes of system outcomes due to the different entitlement sizes. At the table, the GS extraction is a long term averaged annual volume that is extracted from the fictitious license holder. The extracted volume is considered to be the best indication of the long term average yield from the two projects. When there is no extract (i.e. 0 GL unit share), water saved at major storages is socialised thereby improving irrigation diversions and reliability at expense of reduced flow at the end of the system. As the unit shares increased, the third party benefits are reduced. When 100 GL is assigned, system indicators are worse than the Benchmark outcomes, indicating that the size of entitlements should be lower than 100 GL. The two intermediate runs show that some third party benefits exist with 30 GL entitlement but quite close outcomes to the benchmark are expected with 40 GL entitlement.

**Table 1: Comparison of water balance and allocations against the Benchmark for the 4 different entitlement sizes**

| | Benchmark | 0 GS extracted | 24 GS extracted | 32 GS extracted | 76 GS extracted |
|---|---|---|---|---|---|
| **Water Balance (GL/yr)** | | | | | |
| MIA diversions | 751.5 | 753.8 | 750.9 | 750.2 | 744.0 |
| CIA diversions | 230.8 | 233.03 | 231.1 | 230.6 | 228.0 |
| NIA diversions | 377.6 | 383.54 | 379.8 | 378.2 | 369.4 |
| Township water supply | 12.9 | 12.9 | 12.9 | 12.9 | 12.9 |
| WfR extraction | 97.0 | 122.6 | 122.4 | 122.1 | 121.5 |
| Darlot flows | 258.9 | 245.78 | 245.6 | 245.6 | 245.8 |
| Forest Creek flows | 9.8 | 7.35 | 7.3 | 7.3 | 123.7 |
| Balranald flows before GS extraction | 1,575.8 | 1,564.1 | 1,574.3 | 1,578.2 | 1,597.7 |
| EOS GS unit modelled | - | - | 30.0 | 40.0 | 100.0 |
| Balranald flows after GS extraction | 1,575.8 | 1,564.1 | 1,550.2 | 1,546.3 | 1,521.8 |
| **Allocation (%)** | | | | | |
| Announced allocation (Jun) | 77 | 79 | 78 | 77 | 76 |
| Announced allocation (Jan) | 65 | 67 | 66 | 65 | 63 |
| Announced allocation (Oct) | 49 | 51 | 50 | 50 | 48 |
| Effective allocation (Jun) | 85 | 86 | 86 | 85 | 84 |
| Effective allocation (Jan) | 78 | 79 | 79 | 78 | 76 |
| Effective allocation (Oct) | 67 | 69 | 68 | 67 | 65 |

By comparing flows at Balranald before and after GS extraction at Table 1, it indicates that flows are increased as the size of entitlements increased to supply their demands but flows arriving Murray after the extraction point are reduced.

Table 2 shows achievements of environmental outcomes at Murrumbidgee. Due to reduced surplus flows along the system, all indicators are met less frequently than the benchmark outcomes. In summary,

- At Mid-Bidgee, the highest flow indicator that is actively managed (i.e. indicator 3) is mostly affected.
    - Environmental outcomes are decreased as the extraction is increased.
    - However, the Limits of Change (LoC) are maintained for most indicators except one failure for the 100 GL scenario.
- At Lower-Bidgee, flow indicators are measured as volumetric requirements.
    - Medium events (i.e. indicators 2 and 3) are improved as the extraction is increased.
    - For the all cases, changes in environmental outcomes are not significant.

Based on this, general security entitlements of 40 GL (or a long term annual yield of 32 GL) would be an appropriate size which can maintain irrigation and system outcomes at the Benchmark level without significantly compromising environmental outcomes.

**Table 2: Achievement of environmental indicators depending on extracted volumes at the end of the system**

| Mid-Bidgee Floodplain | Target | WOD | Baseline | Benchmark | LoC | 0 GL | 24 GL | 32 GL | 76 GL |
|---|---|---|---|---|---|---|---|---|---|
| 26,850 ML/d for a total duration of 45 days (with min duration of 1 day) between Jul & Nov | | | | | | | | | |
| 26,850 ML/d for 5 consecutive days between Jun & Nov | | | | | | | | | |
| 34,650 ML/d for 5 consecutive days between Jun & Nov | | | | | | | | | |
| 44,000 ML/d for 3 consecutive days between Jun & Nov | | | | | | | | | |
| 63,250 ML/d for 3 consecutive days between Jun & Nov | | | | | | | | | |
| **Lower-Bidgee Floodplain** | | | | | | | | | |
| Total volume of 175 GL (flow > 5,000 ML/d) between Jul & Sep | 70 - 75 % | 94% | 68% | 94% | 85% | 93% | 93% | 93% | 93% |
| Total volume of 270 GL (flow > 5,000 ML/d) between Jul & Sep | 60 - 70 % | 92% | 57% | 86% | 77% | 86% | 86% | 86% | 89% |
| Total volume of 400 GL (flow > 5,000 ML/d) between Jul & Oct | 55 - 60 % | 92% | 52% | 83% | 75% | 79% | 80% | 80% | 84% |
| Total volume of 800 GL (flow > 5,000 ML/d) between Jul & Oct | 40 - 50 % | 78% | 39% | 60% | 54% | 58% | 58% | 58% | 58% |
| Total volume of 1,700 GL (flow > 5,000 ML/d) between Jul & Nov | 20 - 25 % | 56% | 18% | 30% | 27% | 29% | 29% | 29% | 29% |
| Total volume of 2,700 GL (flow > 5,000 ML/d) between May & Feb | 10 - 15 % | 44% | 9% | 18% | 16% | 18% | 18% | 18% | 18% |

## 3.2 Second step

At the second step, the long term average extract of 32 GL is reviewed to determine a volume of IVT account required to neutralise any third party impacts to Murray users. For this modelling, it is assumed that the IVT account will be created with Murrumbidgee general security licenses.

As presented at Table 3, when there is no IVT account assigned, NSW Murray users are affected (i.e. less allocations leading to smaller diversions than Benchmark). This is because NSW available resources is reduced as a result of reduced flows from Murrumbidgee by around 30 GL/yr at Balranald. It should be noted that there is no significant changes in environmental outcomes even though some are improved slightly and others are a bit worse off (Table 4 and Table 5). Some improvements especially for the low flow targets at the Upper Murray are mostly due to increased Hume releases to count balance the reduced flows at Balranald. However, when a long term average of 16 GL is assigned to the IVT account, the Murray third party impacts are reduced and return back to Benchmark level without affecting overall environmental outcomes.

**Table 3: Comparison of water balance and allocations for different volumes assigned to the Murrumbidgee IVT account**

| **Water Balance (GL/yr)** | **Benchmark** | **0 GL** | **16 GL** |
|---|---|---|---|
| NSW Murray Diversions | 1,226 | 1,218 | 1,226 |
| Lower Darling Diversions | 39 | 39 | 39 |
| Vic Murray Diversions | 1,196 | 1,196 | 1,196 |
| SA Murray Diversions | 481 | 481 | 481 |
| Barrage flows | 7,092 | 7,061 | 7,069 |
| **NSW Murray allocation** | | | |
| Long term average of %-age allocation at the start of year (HS) | 95.6 | 95.8 | 96.0 |
| Long term average of %-age allocation in February (HS) | 99.4 | 99.3 | 99.4 |
| Long term average of %-age allocation at the end of year (HS) | 99.4 | 99.4 | 99.4 |
| Minimum %-age allocation at the end of year (HS) | 97.0 | 97.0 | 97.0 |
| 1999-2009 average of %-age allocation at the end of year (HS) | 97.8 | 97.8 | 97.8 |
| Long term average of %-age allocation at the start of year (GS) | 53.3 | 52.8 | 54.7 |
| Long term average of %-age allocation in September (GS) | 71.0 | 69.8 | 71.6 |
| Long term average of %-age allocation at the end of year (GS) | 90.6 | 89.7 | 90.6 |
| Minimum %-age allocation at the end of year (GS) | - | - | - |
| 1999-2009 average of %-age allocation at the end of year (GS) | 61.4 | 60.7 | 61.6 |
| **Vic Murray allocation** | | | |
| Percentage of years with full HRWS allocation in February | 98.2 | 98.2 | 98.2 |
| Percentage of years with full LRWS allocation in February | 93.0 | 93.9 | 93.0 |
| Percentage of years with LRWS allocation in February > 0 | 98.2 | 98.2 | 98.2 |
| Minimum February allocation | 42.0 | 42.0 | 41.0 |
| Long term average HRWS February allocation | 99.3 | 99.3 | 99.3 |
| Long term average LRWS February allocation | 96.5 | 96.4 | 96.3 |
| 1999-2009 average HRWS February allocation | 93.0 | 93.1 | 92.7 |
| 1999-2009 average LRWS February allocation | 77.4 | 77.1 | 77.1 |
| **SA Murray allocation** | | | |
| Percentage years with full entitlement in June | 85.1 | 85.1 | 85.1 |
| Percentage years with full entitlement in May | 88.6 | 87.7 | 86.8 |

| | | | |
|---|---|---|---|
| Long term average % entitlement in June | 96.3 | 96.2 | 96.2 |
| Long term average % entitlement in May | 98.8 | 98.7 | 98.7 |
| Minimum % entitlement in May | 51.0 | 50.8 | 50.3 |
| 1999-2009 average % entitlement in June | 79.4 | 79.3 | 78.7 |
| 1999-2009 average % entitlement in May | 91.3 | 91.3 | 91.2 |
| Percentage of years with spill at Dartmouth Dam | 39.5 | 37.7 | 39.5 |
| Percentage of years with spill at Hume Dam | 57.9 | 57.9 | 57.9 |
| % years of SA entitlement allocation < 90% | 3.5 | 3.5 | 3.5 |
| Long term average of SA entitlement allocation | 98.9 | 98.7 | 98.9 |
| **Lower Darling allocation** | | | |
| Long term average of Lower Darling General Security November Allocation | 93.6 | 92.8 | 93.9 |
| Long term average of Lower Darling LWU End of year Allocation | 100.0 | 100.0 | 100.0 |

### Table 4: Comparison of environmental outcomes for different volumes assigned to the Murrumbidgee IVT account

| **Upper Murray** | **Target** | **WoD** | **Base-line** | **Bench-mark** | **LoC** | **0 GL** | **16 GL** |
|---|---|---|---|---|---|---|---|
| 12,500 ML/d for a total duration of 70 days (with min duration of 7 consecutive days) between Jun & Nov | 70 - 80 % | 87% | 50% | 78% | 70% | 78% | 78% |
| 16,000 ML/d for a total duration of 98 days (with min duration of 7 consecutive days) between Jun & Nov | 40 - 50 % | 66% | 30% | 52% | 47% | 54% | 52% |
| 25,000 ML/d for a total duration of 42 days (with min duration of 7 consecutive days) between Jun & Nov | 40 - 50 % | 66% | 30% | 47% | 42% | 48% | 48% |
| 35,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May | 33 - 40 % | 53% | 24% | 35% | 33% | 34% | 34% |
| 50,000 ML/d for a total duration of 21 days (with min duration of 7 consecutive days) between Jun & May | 25 - 30 % | 39% | 18% | 18% | 18% | 18% | 18% |
| 60,000 ML/d for a total duration of 14 days (with min duration of 7 consecutive days) between Jun & May | 20 - 25 % | 33% | 14% | 15% | 14% | 15% | 15% |
| 15,000 ML/d for a total duration of 150 days (with min duration of 7 consecutive days) between Jun & Dec | 30% | 44% | 11% | 34% | 31% | 33% | 34% |
| **Mid-Upper Murray** | | | | | | | |
| 16,000 ML/d for a total duration of 90 days (with min duration of 7 consecutive days) between Jun & Nov | 70 - 80 % | 86% | 31% | 68% | 61% | 68% | 67% |
| 20,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Nov | 60 - 70 % | 87% | 34% | 64% | 60% | 64% | 64% |
| 30,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & May | 33 - 50 % | 60% | 25% | 39% | 35% | 39% | 39% |
| 40,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & May | 25 - 33 % | 39% | 11% | 25% | 25% | 25% | 25% |
| 20,000 ML/d for a total duration of 150 days (with min duration of 7 consecutive days) between Jun & Dec | 30% | 43% | 7% | 25% | 23% | 25% | 25% |
| **Mid Murray** | | | | | | | |
| 40,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec | 40 - 50 % | 67% | 30% | 46% | 41% | 45% | 45% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 50,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec | 30 - 40 % | 47% | 19% | 30% | 30% | 30% | 30% |
| 70,000 ML/d for a total duration of 42 days (with min duration of 7 consecutive days) between Jun & Dec | 20 - 33 % | 38% | 11% | 18% | 16% | 18% | 18% |
| 85,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May | 20 - 30 % | 33% | 10% | 11% | 10% | 11% | 11% |
| 120,000 ML/d for a total duration of 14 days (with min duration of 7 consecutive days) between Jun & May | 14 - 20 % | 23% | 8% | 8% | 8% | 8% | 8% |
| 150,000 ML/d for a total duration of 7 days (with min duration of 7 consecutive days) between Jun & May | 10 - 13 % | 17% | 5% | 6% | 5% | 6% | 6% |
| **Lower Murray** | | | | | | | |
| 20,000 ML/d for 60 consecutive days between Aug & Dec | 71 - 80 % | 89% | 43% | 68% | 68% | 68% | 68% |
| 40,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & Dec | 50 - 70 % | 80% | 37% | 54% | 50% | 54% | 53% |
| 40,000 ML/d for a total duration of 90 days (with min duration of 7 consecutive days) between Jun & Dec | 33 - 50 % | 58% | 22% | 38% | 34% | 38% | 38% |
| 60,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec | 25 - 33 % | 41% | 12% | 25% | 25% | 25% | 25% |
| 80,000 ML/d for a total duration of 30 days (with min duration of 7 consecutive days) between Jun & May | 17 - 25 % | 34% | 10% | 13% | 11% | 14% | 14% |
| 100,000 ML/d for a total duration of 21 days (with min duration of 1 day) between Jun & May | 13 - 17 % | 19% | 6% | 8% | 7% | 8% | 8% |
| 125,000 ML/d for a total duration of 7 days (with min duration of 1 day) between Jun & May | 10 - 13 % | 17% | 4% | 5% | 4% | 5% | 5% |
| **Edward-Wakool**<br>1,500 ML/d for a total duration of 180 days (with | | | | | | | |
| 5,000 ML/d for a total duration of 60 days (with min duration of 7 consecutive days) between Jun & Dec | 60 - 70 % | 82% | 39% | 65% | 60% | 65% | 65% |
| 5,000 ML/d for a total duration of 120 days (with min duration of 7 consecutive days) between Jun & Dec | 35 - 40 % | 52% | 22% | 33% | 30% | 34% | 33% |
| 18,000 ML/d for a total duration of 28 days (with min duration of 5 consecutive days) between Jun & Dec | 25 - 30 % | 39% | 15% | 17% | 15% | 16% | 16% |
| 30,000 ML/d for a total duration of 21 days (with min duration of 6 consecutive days) between Jun & Dec | 17 - 20 % | 28% | 12% | 14% | 12% | 14% | 14% |
| **Lower Darling**<br>7,000 ML/d for 10 consecutive days between Jun | | | | | | | |
| 17,000 ML/d for 18 consecutive days between Jun & May | 20 - 40 % | 47% | 18% | 21% | 20% | 21% | 21% |
| 20,000 ML/d for 30 consecutive days between Jun & May | 14 - 20 % | 27% | 10% | 11% | 10% | 11% | 11% |
| 25,000 ML/d for 45 consecutive days between Jun & May | 8 - 10 % | 14% | 8% | 8% | 8% | 8% | 8% |
| 45,000 ML/d for 2 consecutive days between Jun & May | 7 - 10 % | 10% | 7% | 7% | 7% | 7% | 7% |
| **Coorong , Lower Lakes and Murray Mouth** | | | | | | | |
| Lake Alexandrina salinity: Percentage of days that Lake Alexandrina salinity is less than 1,500 EC | | 87% | 96% | 100% | 100% | 100% | 100% |
| Lake Alexandrina salinity: Percentage of days that Lake Alexandrina salinity is less than 1,000 EC | | 85% | 89% | 99% | 95% | 99% | 99% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Barrage flows: Percentage of years that barrage flows are greater than 2,000 GL/yr (measured on a three year rolling average) with a minimum of 650 GL/yr | 97% | 77% | 98% | 95% | 98% | 98% |
| Barrage flows: Percentage of years that barrage flows are greater than 600 GL for any two year period | 100% | 97% | 100% | 100% | 100% | 100% |
| Coorong Salinity: Percentage of days South Lagoon average daily salinity is less than 100 grams per litre. | 100% | 93% | 100% | 96% | 100% | 100% |
| Mouth Openness: Percentage of years mouth open to an average annual depth of 1.0 meters (-1.0 m AHD) or more | 100% | 76% | 93% | 90% | 93% | 93% |
| Mouth Openness: Percentage of years mouth open to an average annual depth of 0.7 metres (-0.7 m AHD) or more | 100% | 84% | 96% | 95% | 96% | 96% |

**Table 5: Comparison of outcomes for CLLMM ESLT indicators with different volumes assigned to Murrumbidgee IVT account**

| CLLMM ESLT indicator | Benchmark | 0 GL | 16 GL |
|---|---|---|---|
| % of days when Salinity in Lake Albert > 2000 EC | - | - | 0.2 |
| % of days when Salinity in Lake Alexandrina > 1000 EC | 0.8 | 0.9 | 0.9 |
| % of time when Lake Alexandrina level < 0.4 m | 6.9 | 6.1 | 6.5 |
| Maximum salinity in south Coorong (g/L) | 113.6 | 111.0 | 114.5 |
| Maximum Salinity in south Coorong: % of years < 100 g/L | 97.4 | 98.2 | 97.4 |
| Maximum period south Coorong salinity: > 130 g/L (days) | - | - | - |
| Average salinity in south Coorong (g/L) | 43.0 | 43.1 | |
| | 43.1 | | |
| Maximum salinity in north Coorong (g/L) | 63.8 | 63.4 | 63.4 |
| Maximum period north Coorong salinity: > 50 g/L (days) | 95.0 | 95.0 | 108.0 |
| Average salinity in North Coorong (g/L) | 22.0 | 22.0 | 22.0 |

# 4 Conclusion

A modelling study has been conducted to inform a long term yield that can be created from the CARM and effluent creek modernisation projects. In order to identify a right amount, a two staged approach is adopted. At the first step, the total amount is assessed. Out of the total, the size of Murrumbidgee IVT account is tested at the second step so that impacts to the Murray users are neutralised.

It is found that the two projects can yield a long term average of 16 GL/yr for Murrumbidgee environmental water and another 16 GL/yr for the Murrumbidgee IVT account.

## Reference

NSW DPI Water (2015a). Business Case: Computer Aided River Management system for the Murrumbidgee River.

NSW DPI Water (2015b). Business Case: Modernising supply systems for effluent creeks – Murrumbidgee River

Department of Primary Industries Water

# Technical Notes on Updating the Murrumbidgee SDLA Benchmark Model 2017

## Introduction

In order to be able to simulate a number of Sustainable Diversion Limit adjustment (SDLA) proposals it was necessary to increase the model resolution at various points in the Murrumbidgee. This resulted in a number of different benchmarks and an inconsistency between the relative differences when the results were compared. It was agreed with MDBA that NSW would build a single common SDLA benchmark model for the Murrumbidgee so that the proposals can be assessed from a common starting point.

In addition, the original Murrumbidgee Basin Plan Benchmark (SDL) model had a number of known deficiencies so the opportunity was taken to fix these and add a number of improvements that were material to the proposed SDLA projects. The deficiencies were primarily the quantum of water recovery assumed from Nimmie-Caira and the double counting of water that was intended to go to Lowbidgee but remained in the river and was also counted as flow past Balranald.

## Changes Made

The changes that were made to the Murrumbidgee SDLA Benchmark IQQM are described below.

### *Baseline*

The starting point for these changes was BIDGNX7 and BIDGDA3 which were created by DHI Water and Environment (2016) from BIDG (The MDBA SDL). BIDG itself was based on DPI Water's WSP model wsp05cue. As these files had previously been used by the MDBA we assumed that the changes made were acceptable and no further checks were made.

BIDGNX7 and BIDGDA3 are designed to represent the Tripartite Projects[1]; BIDGNX7 represents the before case and BIDGDA3 the after.

### *Reconfiguring the Nimmie-Caira High Flow Relationship*

The Nimmie-Caira environmental watering requirements prepared by Alluvium were developed based on estimates of volumes required to fill discrete areas and are hence expressed as an absolute volume and do not consider if the water was part of a regulated delivery or overbank flow. Previously the representation of Lowbidgee in the Murrumbidgee IQQM model was focused on representing the diversions made into Nimmie-Caira, and overbank or high flow effluents were generally treated as a loss for flow calibration purposes for the entire reach between Maude and Balranald. In order to make a reasonable estimate of the amount of controlled delivery to Nimmie-Caira, there was a need to better represent the overbank behaviour around Lowbidgee.

The original work on this was done by DHI Water and Environment and involved reanalysing historic data from the 1956, 1976 and 1984 flood events in the Murrumbidgee. From this an additional high flow effluent relationship was derived as shown in Figure 1.

[1] Wilson Anabranch and associated losses, Beavers Creek existing offtake structure, losses and return flows on the Beavers / Old Man Creek system, augmented supply via Irrigation Corporations (Coleambally Irrigation Area escape drain operation and Murray Irrigation Finley Escape operation), Oak and Gras Innes Wetland losses on Bundidgerry Creek, and CARMS.

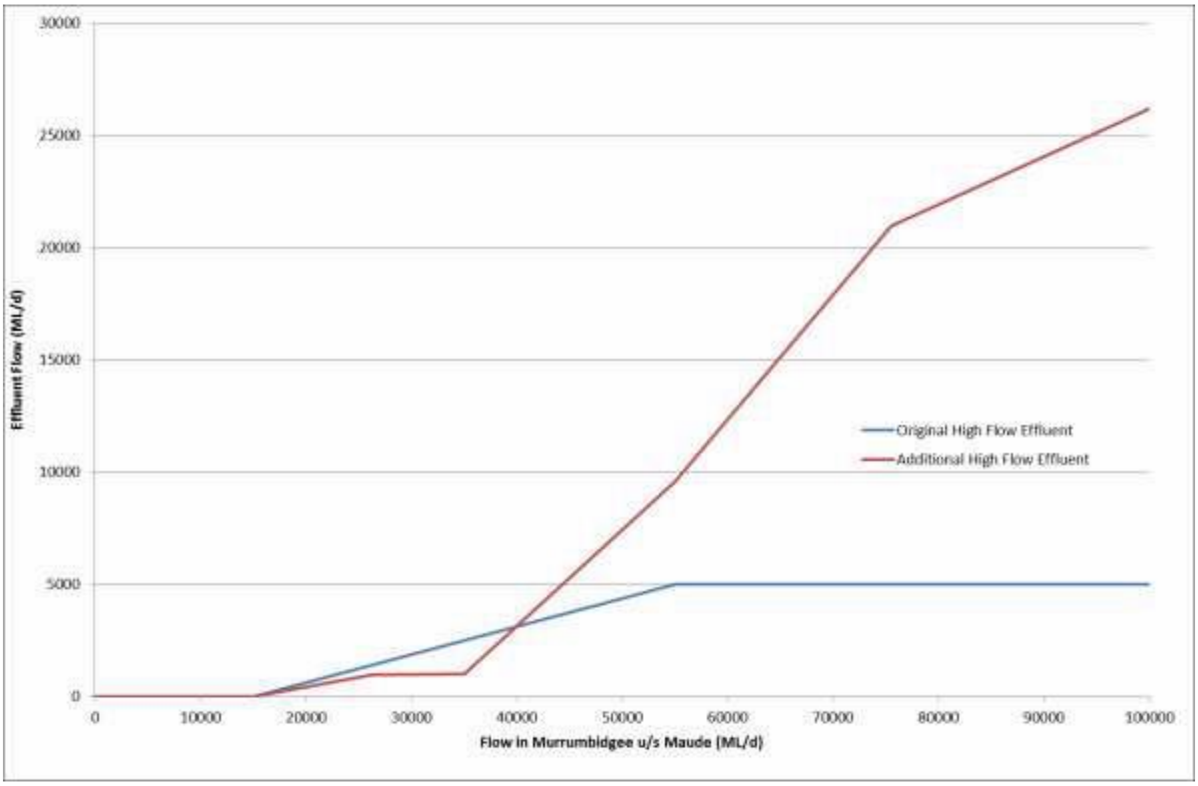


Figure 1 New Lowbidgee High Flow Effluent

The flow from this additional high flow effluent is put into a storage representing the Lowbidgee high floodplain. The return behaviour was based on the information in the 2012 business case for the purchase of Nimmie-Caira that approximately 3000 ML/d can drain back from the floodplain through Yanga to the river.

This new configuration was included in the SDLA benchmark and scenarios in a three-step process:

1. The configuration and parameters were copied from the DHI IQQM model (BIDGGA02) to the DPI WSP model (WSP05CUE).
2. The parameters were tweaked so that the annual mean flow at Balranald was not changed by adding the new configuration (WSP05CT).
3. The tweaked parameters and configuration was then copied into the SDLA benchmark family of models.

The matching of annual mean flow at Balranald ensures that the water return behaviour of Lowbidgee was not changed during efforts to describe at a higher resolution how flows behave between the known flow points at Maude and Balranald

*Increasing the Order Capacity at Old Man Creek Effluent to 60 000 ML/d*

This change was made by WaterNSW as part of the Yanco Creek Regulator proposal modelling.

The original Benchmark model did not include a limit on demands in the Murrumbidgee River at the Beavers Creek offtake. A limit of 30,000 ML/day was introduced at this point in the Murrumbidgee as part of the Tripartite modelling (DHI). Under recent changes this has been increased to 60,000 Ml/d in all models to allow environmental flow requirements downstream to be achieved.

*Fixing Non-mass-balancing KEA Nodes.*

In the original MDBA SDL model the accounting for the Key Environmental Assets (KEA) was simulated by using a combination of:

1. Water removed from the river using a bulk-access licence node (3.4), driven by a time series, and returned to the model below Balranald at a pumped return node (1.2).
2. A very large volume of water (1 TL/d) added back immediately below the 3.4 node using a tributary node (1.0).
3. The water not required to return the flow back to what it was above the 3.4 node was removed using a demand node (3.1).

It was discovered that this arrangement can cause a mass balance error due to the numerical problem of subtracting one large floating point number from another large floating point number. What happens is that the net effect is “lumpy” as IQQM uses floating point numbers with about 7 significant digits and it was found that the node arrangement could add up to 40 GL/a to the river.

To fix this problem additional functionality was add to the IQQM to allow the flow going from a 3.4 node to a 1.2 node to be “intercepted” by a 1.0 node. This allowed us to remove the very large inflow and extraction arrangement and removed the mass-balance problem.

### *Adjust Nimmie-Caira Diversions to Represent SFIs*

One of the key deficiencies of the original SDL model was that despite there being water ordered with the intent to inundate parts of the Lowbidgee floodplain, there was no additional water being diverted into Nimmie-Caira.

To compound the problem the inclusion of a pair of KEA nodes ordering to below the Nimmie-Caira offtake resulted in a reduction of both the surplus flow available to be diverted and the diversions into Nimmie-Caira by previously surplus flow now being accounted as regulated flow to meet the KEA order.

The flow that was not diverted into Nimmie-Caira remained in the river and later flow past the gauge at Balranald and was counted as meeting some or all of the environmental requirements there and was double counted by an external process as achieving inundation outcomes in Nimmie-Caira.

### Returning Nimmie-Caira and Redbank Diversions to WSP Level

The first step in adjusting the Nimmie-Caira diversions to represent the SFIs was to recalibrate the offtake control functions such that the diversions into Nimmie-Caira and Redbank were returned to the level prior to the introduction of the KEA nodes into the model. This was necessary as the introduction of the KEA nodes had reduced the availability of surplus flow for use by Lowbidgee and represented a third-party impact.

### Moving the Maude and Balranald KEA Nodes

It was found during the re-calibration that there was not enough surplus available at Maude to meet the SFI requirements (and enhanced Nimmie-Caira watering requirements) and the KEA nodes had to be moved upstream of the Nimmie-Caira offtake so that flows are seen as surplus (and therefore accessible) by the Nimmie-Caira offtake node rather than as a regulated delivery for some other water user.

Initially only the Maude KEA was moved but it was found that this didn’t result in enough surplus so the Balranald KEA was also moved. This required creating a new time series of requirements offset from the original to account for the travel time between Maude Weir and Balranald. As there is negligible irrigator development between Maude and Balranald it is expected that any water that was originally ordered to pass Balranald and not required to meet the Nimmie-Caira SFI will still pass Balranald.

The changes preserve the intent of the KEA nodes to order volumes to the end of system in a way that builds on existing flow events to achieve SFI flow targets.

### Adjusting the Volume of Storage in Lowbidgee to Represent Removing the Irrigators.

The storage volume in Nimmie-Caira system is represented in the IQQM by:

1. A 50 GL “Stock and Domestic” storage that represents the initial “loss” of the Nimmie-Caira system. That is, there has to be an inflow of at least 50 GL before water will return to the river.
2. The Pendlebury Buckets: two storages in series with a capacity of 325 GL each that represent the rest of the storage of the system.
3. A by-pass function around the Pendlebury Buckets. This function represents the progressively higher return of water to the river as there is more water stored in the Nimmie-Caira system. This is a linear function that by-passes 0% when the buckets are empty up to 20% when the buckets have a combined storage of 325 GL. Above 325 GL combined storage all of the water will by-pass the buckets.

As irrigation in Nimmie-Caira has ceased in the SDLA benchmark it is necessary to adjust the storage representing Nimmie-Caira to reflect that water will no longer be directed into bunded paddocks. This is required as there is a fundamental shift in the way water will behave in Nimmie-Caira; previously water was managed by moving it from irrigation bay to irrigation bay in such a way as to maximize the infiltration of water into the soil profile, whereas now water will be directed to areas in the floodways where it can do the most benefit for the environment.

To estimate the current storage capacity of Nimmie-Caira the various watering options in the Alluvium were reviewed and based on the largest scenario, which covered all of the floodways with an inflow of 297 GL, it was decided to use a total storage of 250 GL. The 250 GL was divided up into a 50 GL initial loss storage (the Alluvium report also estimated the initial loss at 50 GL) and two storages of 100 GL. The surface areas were adjusted to represent the area of the floodways. The by- pass function was also adjusted to pass 20% at 200 GL storage in the Pendlebury Buckets and 100% above that level.

### Meeting SFIs

The Nimmie-Caira access functions were then re-calibrated to represent the Nimmie-Caira diversions that would be required to achieve the inundation extent that was intended by Basin Plan, and assuming that diversions to Nimmie-Caira would now occur during the periods that the SFI conditions at Maude were being met. The re-calibration was done on the understanding that:

1. The SFI diversion targets (Table 1) were defined as the minimum required.
2. The SFI diversions were the sum of the diversions made through the Nimmie-Caira offtake and the flow entering Lowbidgee through the original high-flow effluent and the new high- flow effluent added as part of the high floodplain representation.

Table 1 MDBA SFIs for Nimmie-Caira

| SFI | SFI Volume - Total inflow volume past Maude Weir (GL) over SFI period | SFI period | Total inflow volume (GL) into Nimmie-Caira over SFI period |
|---|---|---|---|
| 1 | 175 | Jul - Sep | 21 |
| 2 | 270 | Jul - Sep | 33 |
| 3 | 400 | Jul - Oct | 43 |
| 4 | 800 | Jul - Oct | 80 |
| 5 | 1700 | Jul - Nov | 147 |
| 6 | 2700 | May - Feb | 241 |

The diversions into Redbank were kept at Water Sharing Plan levels while the re-calibration was carried out.

As discussed, the original MDBA Basin Plan scenario double counted water diverted into Nimmie- Caira as also achieving Balranald flow targets. NSW & MDBA agreed that the best reflection of the intent of the plan was to actually divert the water required to achieve the nominated inundation extent, and that this would consequently reduce apparent Balranald flow outcomes.

### *Adjust Water Recovery from Nimmie-Caira*

The water recovery in the original SDL modelling used a uniform 27% reduction in irrigation diversions from all of the regulated and an assumed 27% reduction in the diversions by the Nimmie- Caira irrigators. NSW & MDBA agreed that since the Nimmie-Caira purchase is well known, the entire Nimmie-Caira irrigation demand should be removed, and the remaining irrigation nodes be adjusted higher to maintain the overall 27% reduction.

### Quantum of Water Recovery from Nimmie-Caira

In the original MDBA SDL modelling the water recovery assumed to have been made from Nimmie- Caira was reduced by 41 GL/a to represent existing environmental outcomes within the Nimmie- Caira system based on MDBA's interpretation of the Basin Plan requirement that protects existing planned environmental water. NSW disputes this interpretation as it causes the Basin Plan to assert an uncompensated property right over environmental outcomes occurring on privately held land and through the actions of a privately held water entitlement, and that this is not permissible under the protects against 3rd party impacts. No agreement was able to be reached between NSW and MDBA officers, however NSW modellers identified that in the *HEADS OF AGREEMENT: AN AGREEMENT SUPPORTING THE NIMMIE-CAIRA SYSTEM ENHANCED ENVIRONMENTAL WATER DELIVERY PROJECT* it was agreed:

> "to jointly seek a review by the MDBA of the Murrumbidgee SDL, taking into account the Nimmie-Caira Entitlement, in the context of the next available opportunity for review of SDLs. Until that review, the Commonwealth will treat the 'gap bridging' volume of the Nimmie-Caira entitlement as 132.6 GL [/a]".

No such review has been conducted, and in the absence of an overriding agreement, this agreement has been assumed to represent the status quo and as a result is was necessary to increase the long- term mean diversions of the irrigators by 91.6 GL/a.[2]

### Adjusting the Water Recovery

As there was little time available to do the water recovery adjustment it was decided to speed up the process by only adjusting the Coleambally Irrigation Corporation's and the largest group of river irrigators' (Hay to Maude--RP13) licences and areas. The resulting changes made are summarised in Table 2.

[2] NSW is continuing to pursue this issue with the MDBA

**Table 2 Changes Made for Water Recovery**

| | Before | | | After | | | Change | | |
|---|---|---|---|---|---|---|---|---|---|
| | Entitlement (GL) | Area (Ha) | (ML/Ha) | Entitlement (GL) | Area (Ha) | (ML/Ha) | Entitlement (GL) | Area (Ha) | (ML/Ha) |
| CIA | 150.2 | 35900 | 4.2 | 379 | 85000 | 4.5 | +228.8 | +49100 | +0.3 |
| RP13 | 23.7 | 13000 | 1.8 | 45 | 18000 | 2.5 | +21.3 | +5000 | +0.8 |
| KEA | 908.1 | - | - | 658.1 | - | - | -250 | - | - |

Subsequent discussions with MDBA officers identified that MDBA has automated tools to carry out the required adjustments more broadly and it is expected that MDBA will use their own system when constructing the SDLA package.

### *Adjust the Yanco Creek Calibration*

In 2012 there was a re-calibration of the Yanco-Colombo-Billabong Creeks system carried out by DPI Water. The aim of this re-calibration was to derive a set of loss functions that would produce loss estimates that were similar in terms of rate per unit length between reaches. The re-calibration also created a set of residual inflows that didn't cover the full historic time span (1890-)

These loss parameters were adopted by DHI Water and Environment and a set of residual inflows that would cover the time span required (1895-2009) were derived by Watermation. However during this model update process there were a number of problems with this recalibrated parameter set:

1. Not all of the re-configuration arising from the 2012 re-calibration were carried over to the SDLA models.
2. The time-series residuals for the second reach of the Yanco Creek did not look plausible.

A desktop review of the calibrations was undertaken by Watermation and the changes adopted by DPI water are described below.

### Adding in Missing Effluent Running from Colombo to Yanco Creek

There is an effluent that leaves the Colombo Creek just upstream of the Morundah gauge and enters the Yanco Creek downstream of the Morundah gauge. As a result there is flow in the upper Yanco system that doesn't pass by a gauge until Yanco Bridge and the apparent residual inflow in the second reach (Morundah to Yanco Bridge) is not related to rainfall and is not possible to reproduce with a rainfall runoff model.

To fix this an effluent was added between Colombo and Yanco Creek; the offtake relationship (Figure 2) was based on the HECRAS work done by Tim Morrison. With the addition of this effluent it was found that the second reach could be modelled without the use of a residual inflow. The losses in the second reach were tweaked to work with the new effluent and were found to be more consistent with the pre-2012 loss functions.

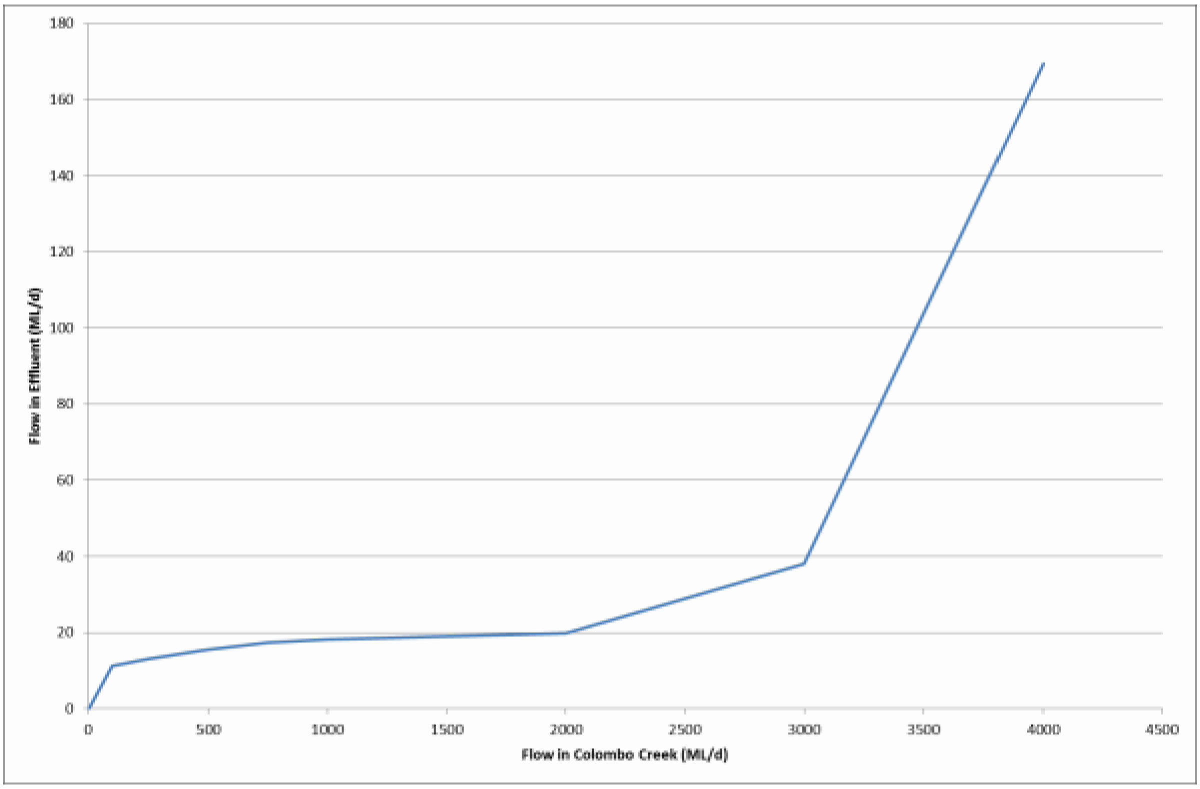


Figure 2 Morundah Effluent

### Adding in Missing Components in the Yanco Reach to Morundah.

As part of the 2012 re-calibration there were a number of additional model components added that subsequently were not brought into the previous SDLA model:

1. Flow routing and a 25% loss on the flow passing down the Washpen Effluent.
2. Two overbank storage nodes representing surface water groundwater interaction.

As the loss functions adopted in the SDLA models were calibrated on the basis of the presence of these two components, they were added to the model to reinstate a coherent set of parameters. A code change was made to allow the flow from a 3.1 node to be returned to a 5.0 node (effluent return) so that its functionality could be used to model the loss and routing. There is an issue with the structure of the Murrumbidgee IQQM model that results in an additional 24 hours of lag in the Washpen Effluent but it was decided that this was acceptable in light of being able to represent the 25% loss and the impacts would not be material to the proposed SDLA scenarios.

### *Adjusting Snowy Inflows for the Water for Rivers Entitlements*

The previous SDLA scenario used a fictional demand point to represent the reduction in water availability resulting from the Water for Rivers project. It was identified that the effects on water allocations was representative of a reduction in Snowy inflows, however the artificial demand continued to compete for release capacity from Blowering Dam and that this was distorting the results. It was originally intended to adjust the time series of Snowy inflows to Blowering Dam to represent the water owned by Water for Rivers that will be used elsewhere. Given the short time frame available for this and the fact that the entitlement remained tied to the Murrumbidgee resource assessment it was decided to take an alternative approach. The IQQM was modified to add the facility to allow regulated irrigators (8.0) and bulk-access licence nodes (3.4) to pump directly from a storage. The SDLA models were then modified to have the two WfR nodes pump directly from Blowering and free up the access to the outlet capacity of that dam for other water users.

#### *Enhanced Nimmie-Caira Watering Proposal*

A scenario for the enhanced Nimmie-Caira watering proposal was prepared. The without rehabilitation option was modelled as the rehabilitation will be dealt with as a separate activity.

Creating the scenario for the enhance watering proposal require re-calibrating the access functions at the Nimmie-Caira and Redbank offtakes such that the water diverted in to Lowbidgee would be sufficient to meet the Alluvium targets.

#### Representing Yanga in the IQQM Setup

The Murrumbidgee IQQM represents the Redbank area as a single overbank storage. Based on the inundation extent it was estimated that the Yanga (southern bank of the Murrumbidgee) component is half of this based on the relative area of Redbank and Yanga. In the revised SDLA benchmark model the Redbank diversions are 109 GL/a so the Yanga component was estimated as 55 GL/a.

1. Based on an estimate of the increase in diversions required to meet the Alluvium enhanced watering it was initially estimated that the Yanga component would become 75% of the total Redbank diversion and the flow requirements were judged on this basis. After calibration it was found that the Yanga component was 65% which was close enough to the initial estimate that it was decided to not adjust this. The overall take figure for both sites is consistent with the previous estimate of joint consumption added to the additional alluvium Yanga demands.

A more detailed representation of water balances between Redbank and Yanga requires a full hydraulic model of the area between Maude and Balranald and this is outside the scope of the SDLA projects

#### Interpreting the Alluvium Watering Requirements

While attempting to configure the offtakes into Nimmie-Caira and Redbank it was found that meeting more of the highest flow class targets resulted in a reduction in the number of lower flow class targets being met. As a result it was decided to use a configuration that resulted in missing 4 high flow events but meeting 6 more medium flow class events.

No attempt was made to determine the relative environmental value of the events and the highest event count was chosen for consistency with the SDLA ecological elements equivalence scoring mechanism.

### Net Effect of Changes

Table 4 shows a summary of the statistics obtained from the original BDL and SDL, and the revised benchmark and project proposals.

### Caveats

As there is a large change in the flows going into Lowbidgee and the purpose of those flows there is a high degree of uncertainty in the prediction of return flows from Lowbidgee.

The fundamental difficulty of modelling Lowbidgee is that the only reliable flow data available is at Hay and Balranald Weirs; the intermediate stream gauges do not necessarily measure all of the flow and only the regulated flow into Nimmie-Caira is directly measured. As a result of the distance between the measuring points and the flat topography in the area there is little constraint on the paths that water takes from Hay to Balranald as it could be passing through Nimmie-Caira or passing down the Murrumbidgee but overbank. The Lowbidgee model was calibrated so as to replicate the observed regulated diversions into Lowbidgee and the flow passing Balranald.

The cessation of irrigation in the Nimmie-Caira area will result in a major change in the behaviour of the water once it is inside Lowbidgee. Previously the water would be deliberately managed to maximise infiltration but this may not be the long term management aim for future environmental managers. The storage characteristics adopted for this Nimmie-Caira representation represent the best available understanding of the future environmental operations for Nimmie-Caira but these should be reconsidered as long term environmental watering plans are developed and experience is gained in how best to manage an environmental Nimmie-Caira.

Ongoing monitoring of the water behaviour within Lowbidgee will be an essential requirement to improve the understanding of where the water will go.

**Table 3 Enhance Nimmie-Caira Watering Requirements**

| Event occurrence (proportion of successful years) | Event duration months | Min Flow | Max Flow | Event Timing | Volume required from offtakes (GL) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Maude Weir | Waugorah creek | 1AS/ 1ES | Overbank flows | TOTAL |
| 95% | 1 | 0 | 15,000 | July to Sep | 3 | | 23 | | 26 |
| 50% | 1 | 0 | 15,000 | July to October | 46 | | | | 46 |
| 40% | 3 | 0 | 15,000 | July to October | 180 | 12 | 56 | | 248 |
| 14% | 3 | 15,000 | | May to February | 230 | 72 | 72 | 290 | 664 |

**Table 4 Summary Statistics**

| Mean Annual (GL/a) | MDBA BDL | MDBA SDL | Revised SDLA Benchmark | SDLA Proposals | | |
|---|---|---|---|---|---|---|
| | | | | Tripartite | Yanco Regulator | Enhanced NC Watering |
| Regulated Diversions (excluding TWS &IVT) | 1841 | 1331 | 1423 | 1469 | 1432 | 1422 |
| Lowbidgee Diversion | 292 | 204 | 290 | 284 | 286 | 400 |
| Supplementary Diversions | 243 | 156 | 153 | 148 | 155 | 155 |
| Balranald Flow | 1233 | 1718 | 1590 | 1578 | 1634 | 1567 |
| Darlot Flow | 324 | 301 | 283 | 265 | 248 | 283 |
| | | | | | | |
| Redbank Diversion | 105 | 58 | 109 | 107 | 106 | 155 |
| Total Inflow to Nimmie-Caira (Diversion + Flood) | 230 | 195 | 265 | 262 | 269 | 330 |
| Outflow from Nimmie-Caira | 34 | 29 | 93 | 92 | 96 | 150 |
| Nimmie-Caira Return | 15% | 15% | 35% | 35% | 36% | 46% |

# Yanco Offtake and Effluents Modelling – February 2017 update

28 February 2017

Craig Mackay

## Overview

This memo summarises the revision of the Yanco Offtake project modelling previously discussed with DPI (email Andrew Brown to Dan Berry 10 November 2016), and further discussions on the Yanco Effluents project modelling in February 2017. It alters the post-project models to more directly represent environmental flow requirements, and operations to achieve them, so that the model is less susceptible to changes in the future as other projects are added in.

A series of minimum flow nodes, seasonal event flags and high flow triggers have been added into the model to do this. Much of this memo outlines these changes in detail so they can be understood by others and adapted further if required.

This updated modelling also includes changes to the benchmark model, provided by DPI Water in February 2017.

The adapted model produced results in line with expectations. It was able to be manipulated to achieve the Yanco Creek system environmental targets to a similar level to that seen in the Adapted Benchmark model. When the results from the model were compared against the Adapted Benchmark model, there was generally an improvement in the SFI scores on the river, particularly for high flow events. The post-project model increased allocations relative to the Adapted Benchmark model, leading to an increase in irrigation diversions.

## Background

The proposed Yanco Offtake structure will control inflows into Yanco Creek for river flows up to 45,000ML/d. For river flows less than this, operators will be able to specify the flow rate through the offtake gates.

This is a significant change from the existing situation, where Yanco Creek inflows can only be partially controlled by operation of Yanco Weir on the main river channel. Furthermore the river weir is only effective as a control at lower flows, and cannot prevent inflows into the creek when river levels are high.

The current flow regime in the Yanco, Colombo and Billabong creeks (and the regime reflected in the Basin Plan Benchmark model) reflects this relatively low level of control. Consequently the creeks receive large inflows whenever the river is high. The proposed regulator potentially allows all inflows to be halted for river flows up to 45,000ML/d, potentially producing a significant change in the creek flow regime.

An environmental flow study was carried out for the creeks in 2013 by Alluvium Consulting. That study identified a number of baseflow, freshes, bankfull flow and overbank flow targets for reaches in the creek system. It subdivides the system into six reaches:

- Reach 1: Yanco Creek from the Offtake to Colombo Creek
- Reach 2: Yanco Creek from Colombo Creek to Billabong Creek confluence

- Reach 3: Colombo Creek
- Reach 4a: Billabong Creek from the Colombo Creek confluence to Jerilderie
- Reach 4b: Billabong Creek from Jerilderie to the Yanco Creek confluence
- Reach 5: Billabong Creek downstream of the Yanco Creek confluence
- Reach 6: Forest Creek

Previous IQQM project modelling has estimated the potential benefits of the proposed regulator, whilst aiming to preserve the same level of compliance with the environmental flow measures given in the Alluvium report. The previous modelling was set up to avoid decreasing the environmental flow measures compared to the Basin Plan Benchmark model. This was done by using pre-processed timeseries:

- to maintain Benchmark model flows through the regulator when river flows are less than 15,000ML/d
- to divert larger inflows for short periods at specific times when flows are between 10,000ML/d and 24,000ML/d

When the proposed Yanco Offtake project was put into a combined model with other projects, changes to the river flow regime meant that the pre-processed time series needed to be updated to ensure Yanco environmental flow regime targets were still meet, and that there were not impacts on the SFI on the Murrumbidgee River at the sites at Maude and Balranald. As a result it has been decided to revisit the modelling, and change the approach used in the model to manage inflows into the Yanco Creek system. This memo summarises how this has been done, and summarises results when compared against the Benchmark model.

In addition to producing an updated version of the Yanco Offtake project model, a combined Yanco Offtake and Yanco Effluents post-project model has also been produced. The Yanco Effluent project includes a number of re-regulation structures on Yanco, Colombo and Billabong Creeks, some works to existing block banks on mid-Yanco Creek and Billabong Creek at Algudgerie, enlargement of the capacity of the DC800 drain in Coleambally Irrigation Area to 100 ML/d, and use of Berrigan Escape for supply of up to 100 ML/d from Murray Irrigation into Billabong Creek near Jerilderie.

## Changes to the Benchmark Model to add in Yanco Offtake project

This section summarises a revision of the modelling approach to representing the Yanco Offtake project, and in how environmental flow requirements are targeted. The model files developed are summarised in the table below.

| Model | Description | Based on |
|---|---|---|
| BIDGB009 | Adapted Benchmark model | - |
| BIDGY004 | Benchmark model with new Yanco Offtake regulator and associated flow rules to manage environmental flows in Yanco Creek system | BIDGB009 |
| BIDW001 | Benchmark model with new Yanco Offtake regulator and associated flow rules to manage environmental flows in Yanco Creek system, and with Yanco Effluents project | BIDGY004 |

*Yanco Offtake structure*

Yanco Offtake is modelled by Node 361 (Type 4.1). This was updated to represent the new gate control. The maximum capacity of the new gate is compared against the existing offtake maximum capacity in Figure 1 below.

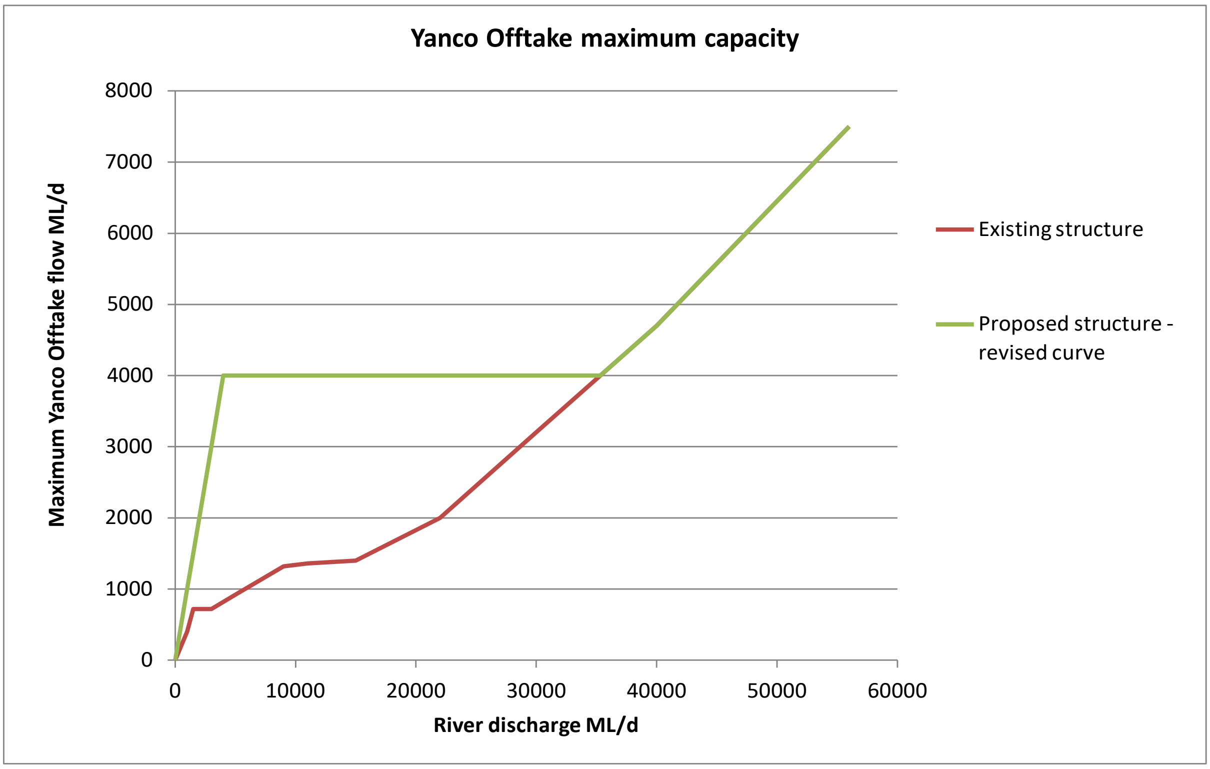


**Figure 1 Yanco Offtake existing and post-project maximum capacity rating**

*Yanco surplus diversion node*

Additional flows can be diverted through Yanco Offtake in addition to orders if they are available in the river (Node 548, Type 3.1).

In the Benchmark model, additional diversions are made when there is a surplus at Wagga Wagga; when there is a surplus and it falls within October – February period, the structure diverts 6% of the Wagga surplus. The additional diversion is limited so that the total flow through Yanco Offtake (including Node 361) doesn't exceed the maximum capacity rating.

In the post-project model, the surplus node is changed to work as follows:

- check to see if Reach 1 (Yanco Offtake to Morundah) fresh event is needed and can be produced
    - Calculate total amount potentially available through Yanco Offtake (Yanco orders+surplus at Narrandera)
    - Multiply three 0/1 factors together: 1 if time of year is right (Sep-Dec); 1 if a successful event hasn't already been done this year; 1 if Narrandera surplus is large enough to be useful; if any of these aren't true (i.e. 0) the overall result is zero and a surplus diversion for Reach 1 freshes won't be tried this timestep
    - If criteria are meet and surplus available, cap freshes potential diversion including orders at 2600Ml/d (**A**)

- Check to see if Reach 4a (Billabong from Colombo junction to Jerilderie) fresh event is needed and can be produced
    - Multiply two 0/1 factors by a large number flag: 10,000 if the is large Narrandera flow at the moment; 1 if right time of year (Sep-Dec); 1 if a successful event hasn't already been done this year; if any of these aren't true (i.e. 0) the overall result is zero and a surplus diversion for Reach 4a freshes won't be tried this timestep
    - Product of these is 0 if conditions are wrong, 10,000 if conditions are right (**B**)
- The maximum of **A** and **B** is taken (i.e. if either event is on use that, or if both take the Reach 4a large capacity 10,000 value)
- Cap the result of max(**A**, **B**) at the offtake capacity (this is the total to go through Nodes 361 and 548 into Yanco Creek) ('**C**)
- Work out the amount to go through 548 by subtracting the amount going through 361 from ('**C**)

***Recording whether Fresh >2500Ml/d has occurred in Reach 1***

A dummy offline storage (Node 826, Type 6.0 and Node 827, Type 7.0) has been added. This is allowed to fill in Sep-Dec, and the inflow is throttled so that it fills when there are >3 days of flows exceeding 2600Ml/d in the creek. It then remains full until 1 January on the following year, when a large dummy evaporation series empties it prior to the next Sep-Dec period (**evap added to NEWBIDGE.idx/out to be NW2BIDGE.idx/out – the dummy evap is series 18**).

This dummy storage is a flag to say whether Reach 1 has already had a successful fresh this year. It is referenced by the Yanco Offtake surplus Node 548 (see above), when it deciding whether to let surplus flow into the creek or not.

***Minimum flow – Reach 1 (Yanco upstream of Colombo Creek)***

There is a target minimum flow in Reach 1 of 250ML/d in the Environmental Flow Study. This is implemented by changing Node 149 (Type 9.0) to give a minimum order of 250ML/d.

***Minimum flow – Reach 2 (Yanco between Colombo Creek and Billabong confluence)***

The unused MDBA minimum node is replaced to give a minimum flow that varies by season and by valley allocation (Node 219, Type 9.0). This aims to supply 200Ml/d throughout the year when allocations are high, but only 100ML/d when allocations are low. The Node IDT works as follows:

- Take a minimum flow varying through the year, which will be applied if allocations on 1 September are low
- A low / high allocation flag is multiplied by an additional flow amount, that is added if allocations are high

In addition, this node is used to produce short freshes events in Reaches 1 and 2 of Yanco Creek. This is done with:

- two short periods of 350ML/d independent of allocation that are added to the minimum flow to produce short freshes in this reach in September / October each year;
- two short periods of minimum flow lowered to 150ML/d, with two short 320ML/d peaks to produce short freshes events, in April and May of each year.

The timing of these short freshes is indicative of how the regulator might be operated to fulfil flow targets in the creek system, rather than specific dates on which these would necessarily be carried out.

***Yanco Creek adjustment for Coleambally orders***

Node 609 (Type 9.0) redistributes Yanco Creek orders onto the CCD and DC800 drains. This node is changed relative to the post-CARM model and the Benchmark models. This is because CARM assumes a minimum flow of 50ML/d in this reach. However the environmental flow study requires 200Ml/d. This makes it necessary to redistribute this minimum back off the Yanco Drains and into Yanco Creek, relative to CARM and the Benchmark.

This affects Node 609, as well as Node 257 (Type 3.1, CCD orders), and Node 264 (Type 3.1, DC800 orders).

***Minimum flow – Reach 3 (Colombo Creek)***

A minimum flow requirement has added to Node 589 (Type 9.0) at the top of Colombo Creek.

This applies a minimum of 105ML/d between September and May each year, in line with the environmental flow study.

***Recording whether Fresh >2500Ml/d has occurred in Reach 4a***

A dummy offline storage (Node 829, Type 6.0 and Node 830, Type 7.0) has been added. This is allowed to fill in Sep-Dec, and the inflow is throttled so that it fills when there are >3 days of flows exceeding 2600Ml/d in the creek (including from upper Billabong unregulated tributary flows). It then remains full until 1 January on the following year, when a large dummy evaporation series empties it prior to the next Sep-Dec period (series 18 in NW2BIDG.idx/out).

This dummy storage is a flag to say whether Reach 4a has already had a successful fresh this year from either Yanco Offtake or the Upper Billabong. It is referenced by the Yanco Offtake surplus Node 548 (see above), when it deciding whether to let high river flows into the creek or not.

Note that this differs from the flag used for Reach 1. The Reach 1 flag is used to reference small Narrandera surpluses, whereas this Reach 4a flag is used for larger Narrandera flows (<20,000Ml/d as set in Node 548). This is because larger sustained volumes are needed to produce freshes in Reach 4a than in Reach 1, where smaller inflows may be sufficient.

***Minimum flow – Reach 4a (Billabong upstream of Jerilderie)***

There is a seasonally varying baseflow target in Reach 4a in the environmental flow study (50Ml/d in spring – autumn, 250ML/d in winter). Node 820 (Type 9.0). The 200Ml/d is reduced to 70ML/d when allocations are low.

In addition to the baseflow, a short periods of 350ML/d independent of allocation are also added to produce short freshes in this reach in September each year.

The Node IDT works as follows:

- Take a minimum flow varying through the year, which will be applied if allocations on 1 September are low

- A low / high allocation flag is multiplied by an additional flow amount, that is added if allocations are high

***Minimum flow – Reach 4b (Billabong between Jerilderie and Yanco confluence)***

There is a target minimum flow in Reach 4b of 70ML/d over spring – autumn in the Environmental Flow Study. This is implemented by Node 821 (Type 9.0). It is not allocation dependent.

***Minimum flow – Reach 5 (Lower Billabong)***

There is a target minimum flow in Reach 5 of 50Ml/d in January – April and 200Ml/d in May-December. This is implemented in Node 822 (Type 9.0).

This works as follows:

- Assign a minimum flow depending on the time of year, based on a high allocation
- If allocation is low, the 200Ml/d applied between May and December is reduced to 50Ml/d

***Minimum flow – Reach 6 (Forest Creek)***

There is a target minimum flow in Reach 6 of 10Ml/d throughout the year. This is implemented in Node 448 (Type 9.0) as a fixed value demand.

## Future manipulation of the model to change outcomes

The additions to the model identified above can be used to change how the model behaves. This may be useful when adding the project into other combined models, and the statistics for achieving specific environmental flows in the reaches changes. Suggestions on ways this can be done include:

***Achieving baseflow targets***

This is most directly controlled by changing the 9.0 minimum flow nodes in the Yanco Creek system. Most contain FCT's that specify an annual pattern of minimum flow, and this can be adapted to increase or decrease the flows achieved.

In addition, baseflow will be sensitive to the allocation level at which baseflow is constrained in low allocation years (Reaches 2, 4a and 5). Increasing or decreasing the allocation level (currently 0.4) will directly change the statistics for achieving baseflows.

***Achieving freshes and higher flow targets***

Performance on smaller freshes targets can be improved by changing the 9.0 minimum flow nodes, to include additional short periods of elevated (or lowered) flows (this is already done on Reach 2 and Reach 4a).

It can also be achieved by changing the relative inflow threshold and size (days filling) of the dummy storages on Reach 1 and Reach 4a, and the associated thresholds in Node 548, which control the operation of the surplus node on the main river. This is a less precise control than changing the 9.0 nodes but less likely to increase the use of regulated water.

The thresholds in the FCTs in Node 548 (which controls river inflows) can also be changed. Specifically, the Narrandera large flow threshold at which water starts to be diverted (currently 20,000ML/d), and the smaller Narrandera surplus threshold (currently 3,000ML/d).

## Impacts of project on modelling outcomes

Tabulated results are provided below for:

- Environmental Flow Study targets (level of achieving targets, compared to Benchmark)
- SFI indicator scoring
- Valley licence allocation

***Environmental flow study targets***

Modelled flows for each reach were evaluated against the targets in the Environmental Flows Study (see spreadsheets Reach1_E1_A.xls, Reach2_E1_A.xls,…,Reach6_E1_A.xls). The results from this are summarised in Tables 1 (Yanco Offtake project) and 2 (Yanco Offtake and Yanco Effluents projects combined). The environmental flow target spreadsheets evaluate model outputs to determine whether they meet baseflow, freshes, bankfull flow or overbank flow targets.

In some cases the flow target is for multiple events in a season or year. These are generally smaller freshes events, with targets of the form: *2 events for 1 day duration between November and May*. It is assumed that two consecutive events are independent if there is a period between them with flows below the threshold for at least 14 days. The evaluation spreadsheets assume the following when determining how many events occur for each case:

- An event is initiated if it goes above the flow threshold during the period, or it starts the period above the threshold (e.g. on 1 November in a Nov-May period)
- The event duration must be at least as long as the target duration
- An event is counted towards the total for the year if it is followed by 14 days of flows below the target flow, or if the flow is still above the threshold at the end of the period (e.g. on 1 June in a Nov-May period)

These assumptions apply to both the benchmark and post-project models. Note that for some small freshes events, the target is only achieved rarely either because the offtake is uncontrolled (in the benchmark) or because the minimum flow required to supply downstream reaches environmental baseflow requirements means flows are consistently higher than the threshold (in the post-project case).

For 15 of the 34 indicators, the Yanco Offtake project indicator achievement exceeds benchmark levels. However some indicators decrease slightly in 3 cases for this project.  As the indicators will need to be retuned after the proposals are integrated into the package, this scenario sufficiently demonstrates that adequate water will continue to be available to meet future environmental flow needs, and that operational rules can be configured to satisfy these indicators.

## Table 1 Yanco Offtake project flow target outcomes (Reaches 1, 2, 3 and 4a)

| Flow Component | Period | Magnitude (ML/d) | Frequency and Duration | Adapted Benchmark BIDGB009 | Benchmark + Yanco Offtake Project BIDY004 |
|---|---|---|---|---|---|
| | | | | | |
| **Reach 1: Yanco Creek from Offtake to Morundah, Colombo Ck upstream Sheepwash Weir Pool** | | | | | |
| Base flow | All year | 250 | % of days above base flow | 100% | 100% |
| Freshes | Nov-May | 450 | % of years that have 2 events for 1 day duration | 55% | 57% |
| | Aug-Dec | 600 | % of years that have 2 events for 14 days duration | 23% | 25% |
| Bank full | Sept-Dec | 1500 | % of years that have 1 event for 1 day duration | 75% | 91% |
| Overbank | Sept-Dec | 2500 | Number of years that have 1 event for 2 day duration (percent achievement over 2 years) | 71% | 98% |
| | | | | | |
| **Reach 2: Yanco d/s Colombo Offtake to junction with Billabong Ck** | | | | | |
| Base flow | All year | 200 | % of days above base flow | 71% | 75% |
| Freshes | Dec-Feb | 250 | % of years that have 3 events for 1 day duration | 1% | 2% |
| | Aug-Dec | 350 | % of years that have 2 events for 14 days duration | 8% | 20% |
| Bank full | Sept-Dec | 800 | % of years that have 1 event for 2 days duration | 59% | 78% |
| Overbank | Sept-Dec | 1000 | Number of years that have 1 event for 1 day duration (percent achievement over 3 years) | 61% | 75% |
| | | | | | |
| **Reach 3: Colombo Creek Sheepwash Weir pool to d/s Cocketdegong Weir** | | | | | |
| Base flow | All year | Maintain weir pools | % of days above base flow | | |
| | Sep-May | 105 | % of days above base flow | 100% | 100% |
| Overbank | Sept-Dec | 1600 | Number of years that have 1 event for 4 day duration (percent achievement over 10 years) | 85% | 79% |
| | | | | | |
| **Reach 4a: Billabong Creek frpm Cocketdegong Weir to Yanco Junction (u/s Jerilderie)** | | | | | |
| Base flow | Sep-Apr | 50 | % of days above base flow | 100% | 100% |
| | May-Aug | 250 | % of days above base flow | 14% | 18% |
| Freshes | Sep-Apr | 250 | % of years that have 4 events for 2 day duration | 6% | 7% |
| | Sep-Dec | 300 | % of years that have 2 events for 28 day duration | 2% | 0% |
| | Any | 700 | % of years that have 1 event for 1 day duration | 86% | 86% |
| Bank full | Sept-Dec | 2500 | Number of years that have 1 event for 2 day duration (percent achievement over 2 years) | 37% | 41% |
| Overbank | Sept-Dec | 3000 | Number of years that have 1 event for 10 day duration (percent achievement over 3 years) | 7% | 7% |

**Table 1 ctd. Yanco Offtake project flow target outcomes (Reaches 4a, 5 and 6)**

| | | | | | |
|---|---|---|---|---|---|
| **Reach 4b: Billabong Creek frpm Cocketdegong Weir to Yanco Junction (d/s Jerilderie)** | | | | | |
| Base flow | All year | Maintain weir pools | % of days above base flow | | |
| | Sep-May | 70 | % of days above base flow | 100% | 100% |
| Overbank | Sept-Dec | 1600 | Number of years that have 1 event for 1 day duration (percent achievement over 10 years) | 96% | 96% |
| | | | | | |
| **Reach 5: Lower Billabong** | | | | | |
| Base flow | Jan-Apr | 50 | % of days above base flow | 100% | 100% |
| | May-Dec | 200 | % of days above base flow | 79% | 92% |
| Freshes | Jan-Apr | 200 | % of years that have 4 events for 7 day duration | 0% | 0% |
| | Aug-Dec | 700 | % of years that have 1 event for 5 day duration | 92% | 93% |
| | Jan-Apr | 1200 | % of years that have 1 event for 2 day duration | 18% | 20% |
| | Oct | 1200 | % of years that have 1 event for 2 day duration | 54% | 54% |
| Bank full | Sept-Dec | 1500 | % of years that have 1 event for 2 day duration | 61% | 68% |
| Overbank | Sept-Dec | 3000 | Number of years that have 1 event for 1 day duration (percent achievement over 3 years) | 48% | 50% |
| | | | | | |
| **Reach 6: Forest Creek** | | | | | |
| Base flow | Any | 10 | % of days above base flow | 30% | 61% |
| Freshes | Sep-Jan | 100 | % of years that have 1 event for 14 day duration | 20% | 22% |
| | Sep-Nov | 800 | % of years that have 1 event for 14 day duration | 0% | 0% |
| | Any | 500 | % of years that have 1 event for 5 day duration | 9% | 6% |
| Overbank | Sept-Dec | 1500 | Number of years that have 1 event for 1 day duration (percent achievement over 10 years) | 0% | 0% |

## Table 2 Yanco Offtake and Yanco Effluent projects flow target outcomes (Reaches 1, 2, 3 and 4a)

| Flow Component | Period | Magnitude (ML/d) | Frequency and Duration | Adapted Benchmark BIDGB009 | Benchmark + Yanco Offtake + Yanco Effluents Project BIDW001 |
|---|---|---|---|---|---|
| | | | | | |
| **Reach 1: Yanco Creek from Offtake to Morundah, Colombo Ck upstream Sheepwash Weir Pool** | | | | | |
| Base flow | All year | 250 | % of days above base flow | 100% | 100% |
| Freshes | Nov-May | 450 | % of years that have 2 events for 1 day duration | 55% | 63% |
| | Aug-Dec | 600 | % of years that have 2 events for 14 days duration | 23% | 25% |
| Bank full | Sept-Dec | 1500 | % of years that have 1 event for 1 day duration | 75% | 92% |
| Overbank | Sept-Dec | 2500 | Number of years that have 1 event for 2 day duration (percent achievement over 2 years) | 71% | 98% |
| | | | | | |
| **Reach 2: Yanco d/s Colombo Offtake to junction with Billabong Ck** | | | | | |
| Base flow | All year | 200 | % of days above base flow | 74% | 75% |
| Freshes | Dec-Feb | 250 | % of years that have 3 events for 1 day duration | 1% | 3% |
| | Aug-Dec | 350 | % of years that have 2 events for 14 days duration | 8% | 20% |
| Bank full | Sept-Dec | 800 | % of years that have 1 event for 2 days duration | 59% | 78% |
| Overbank | Sept-Dec | 1000 | Number of years that have 1 event for 1 day duration (percent achievement over 3 years) | 61% | 74% |
| | | | | | |
| **Reach 3: Colombo Creek Sheepwash Weir pool to d/s Cocketdegong Weir** | | | | | |
| Base flow | All year | Maintain weir pools | % of days above base flow | | |
| | Sep-May | 105 | % of days above base flow | 100% | 100% |
| Overbank | Sept-Dec | 1600 | Number of years that have 1 event for 4 day duration (percent achievement over 10 years) | 85% | 79% |
| | | | | | |
| **Reach 4a: Billabong Creek frpm Cocketdegong Weir to Yanco Junction (u/s Jerilderie)** | | | | | |
| Base flow | Sep-Apr | 50 | % of days above base flow | 100% | 100% |
| | May-Aug | 250 | % of days above base flow | 14% | 39% |
| Freshes | Sep-Apr | 250 | % of years that have 4 events for 2 day duration | 6% | 5% |
| | Sep-Dec | 300 | % of years that have 2 events for 28 day duration | 2% | 1% |
| | Any | 700 | % of years that have 1 event for 1 day duration | 86% | 86% |
| Bank full | Sept-Dec | 2500 | Number of years that have 1 event for 2 day duration (percent achievement over 2 years) | 37% | 40% |
| Overbank | Sept-Dec | 3000 | Number of years that have 1 event for 10 day duration (percent achievement over 3 years) | 7% | 7% |

## Table 2 ctd. Yanco Offtake and Yanco Effluent projects flow target outcomes (Reaches 4a, 5 and 6)

| | | | | | |
|---|---|---|---|---|---|
| **Reach 4b: Billabong Creek frpm Cocketdegong Weir to Yanco Junction (d/s Jerilderie)** | | | | | |
| Base flow | All year | Maintain weir pools | % of days above base flow | | |
| | Sep-May | 70 | % of days above base flow | 100% | 99% |
| Overbank | Sept-Dec | 1600 | Number of years that have 1 event for 1 day duration (percent achievement over 10 years) | 96% | 96% |
| | | | | | |
| **Reach 5: Lower Billabong** | | | | | |
| Base flow | Jan-Apr | 50 | % of days above base flow | 100% | 100% |
| | May-Dec | 200 | % of days above base flow | 79% | 78% |
| Freshes | Jan-Apr | 200 | % of years that have 4 events for 7 day duration | 0% | 0% |
| | Aug-Dec | 700 | % of years that have 1 event for 5 day duration | 92% | 92% |
| | Jan-Apr | 1200 | % of years that have 1 event for 2 day duration | 18% | 21% |
| | Oct | 1200 | % of years that have 1 event for 2 day duration | 54% | 54% |
| Bank full | Sept-Dec | 1500 | % of years that have 1 event for 2 day duration | 61% | 65% |
| Overbank | Sept-Dec | 3000 | Number of years that have 1 event for 1 day duration (percent achievement over 3 years) | 48% | 46% |
| | | | | | |
| **Reach 6: Forest Creek** | | | | | |
| Base flow | Any | 10 | % of days above base flow | 30% | 61% |
| Freshes | Sep-Jan | 100 | % of years that have 1 event for 14 day duration | 20% | 22% |
| | Sep-Nov | 800 | % of years that have 1 event for 14 day duration | 0% | 0% |
| | Any | 500 | % of years that have 1 event for 5 day duration | 9% | 6% |
| Overbank | Sept-Dec | 1500 | Number of years that have 1 event for 1 day duration (percent achievement over 10 years) | 0% | 0% |

***SFI outcomes***

The model outputs were run through the MDBA "Sledgehammer" tool to assess their impact on the SFI scores relative to the Adapted Benchmark. This was done for the Adapted Benchmark, model Y004 (Adapted Benchmark + Yanco Offtake regulator) and W001 (Yanco Offtake regulator and Yanco Effluent project). These are summarised below in Table 3a (Mid Murrumbidgee), 3b (Lowbidgee) and 3c (Murrumbidgee Freshes).

Note that the SFIs for Murrumbidgee at Narrandera were adapted to take into account the effect of the Yanco Offtake project on flows downstream of Yanco Offtake. By keeping additional flow in the river relative to the Benchmark, the project increases the effective inundation area downstream of Yanco of a specific Narrandera flow (see Page 63 of the Yanco Creek Offtake Business Case, August 2015). The equivalent flows in the post-project model relative to the Benchmark model are shown in Table 2.

**Table 2 Equivalent flows in the Murrumbidgee River at Narrandera to achieve the equivalent inundation of Mid Murrumbidgee Floodplains Wetlands as the benchmark for each SFI** (from table 7 of the Yanco Offtake Business Case)

| Yanco Creek regulator operated as per benchmark | Yanco Creek regulator operated as per proposal | Change in Murrumbidgee River flow to achieve equivalent inundation |
|---|---|---|
| 26,850 ML/d | 24,621 ML/d | - 8.3% |
| 34,650 ML/d | 31,522 ML/d | - 9.0% |
| 44,000 ML/d | 39,912 ML/d | - 9.3% |

## Table 3a SFI results for Mid Murrumbidgee

| Flow Indicator | | | Adapted Benchmark B009 | | Y004 | | | W001 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Flow Event - threshold, duration, season (as gauged on the Murrumbidgee River at Narrandera) | | Target Proportion of years with a successful event | Proportion of years with a successful event | Number of years with a successful event | Proportion of years with a successful environmental event | Number of years with a successful environmental event * | Limts of Change (Result) | Proportion of years with a successful environmental event | Number of years with a successful environmental event * | Limts of Change (Result) |
| 1 | 26,850 ML/d for a total duration of 45 days (with min duration of 1 day) between Jul & Nov | 20 - 25 % | 12% | 14 | 14% | 16 | passed | 14% | 16 | passed |
| 2 | 26,850 ML/d for 5 consecutive days between Jun & Nov | 50 - 60 % | 58% | 66 | 63% | 72 | passed | 63% | 72 | passed |
| 3 | 34,650 ML/d for 5 consecutive days between Jun & Nov | 35 - 40 % | 43% | 49 | 52% | 59 | passed | 52% | 59 | passed |
| 4 | 44,000 ML/d for 3 consecutive days between Jun & Nov | 30 - 35 % | 32% | 37 | 35% | 40 | passed | 35% | 40 | passed |
| 5 | 63,250 ML/d for 3 consecutive days between Jun & Nov | 11 - 15 % | 8% | 9 | 8% | 9 | failed (benchmark also fails) | 8% | 9 | failed (benchmark also fails) |

## Table 3b SFI results for Lowbidgee

| Flow Indicator | | | Adapted Benchmark B009 | | Y004 | | | Y004 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Flow Event - threshold, duration, season (as gauged on the Murrumbidgee River at Maude Weir) | | Target Proportion of years with a successful event | Proportion of years with a successful event | Number of years with a successful event | Proportion of years with a successful environmental event * | Number of years with a successful environmental event * | Limts of Change (Result) | Proportion of years with a successful environmental event * | Number of years with a successful environmental event * | Limts of Change (Result) |
| 1 | Total volume of 175 GL (flow > 5,000 ML/d) between Jul & Sep | 70 - 75 % | 89% | 101 | 89% | 101 | passed | 89% | 101 | passed |
| 2 | Total volume of 270 GL (flow > 5,000 ML/d) between Jul & Sep | 60 - 70 % | 81% | 92 | 81% | 92 | passed | 81% | 92 | passed |
| 3 | Total volume of 400 GL (flow > 5,000 ML/d) between Jul & Oct | 55 - 60 % | 76% | 87 | 77% | 88 | passed | 77% | 89 | passed |
| 4 | Total volume of 800 GL (flow > 5,000 ML/d) between Jul & Oct | 40 - 50 % | 55% | 63 | 55% | 63 | passed | 55% | 63 | passed |
| 5 | Total volume of 1,700 GL (flow > 5,000 ML/d) between Jul & Nov | 20 - 25 % | 27% | 31 | 28% | 32 | passed | 28% | 32 | passed |
| 6 | Total volume of 2,700 GL (flow > 5,000 ML/d) between May & Feb | 10 - 15 % | 13% | 15 | 14% | 16 | passed | 14% | 16 | passed |

## Table 3c SFI results for Murrumbidgee Freshes (Balranald)

| | | | Adapted Benchmark B009 | | Y004 | | | Y004 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Flow Indicator | | | | | | | | | | |
| Flow Event - threshold, duration, season (as gauged on the Murrumbidgee River at Balranald Weir) | | Target Proportion of years with a successful event | Proportion of years with a successful event | Number of years with a successful event | Proportion of years with a successful environmental event * | Number of years with a successful environmental event * | Limts of Change (Result) | Proportion of years with a successful environmental event * | Number of years with a successful environmental event * | Limts of Change (Result) |
| 1 | 1,100 ML/d for 25 consecutive days between Dec & May | 58 - 77 % | 45% | 51 | 43% | 50 | failed (benchmark also fails) | 43% | 50 | failed (benchmark also fails) |
| 2 | 4,500 ML/d for 20 consecutive days between Oct & Dec | 54 - 72 % | 57% | 65 | 58% | 66 | passed | 58% | 66 | passed |
| 3 | 3,100 ML/d for 30 consecutive days between Oct & Mar | 55 - 73 % | 49% | 56 | 48% | 55 | failed (benchmark also fails) | 48% | 55 | failed (benchmark also fails) |

*General security allocation and diversions*

The changes to the Yanco Regulator and adding Yanco Creek system minimum flow requirements will affect the licence allocation within the broader valley. The long-term average allocations from the model are summarised below in Table 4, for three specific dates over the water year.

**Table 4 Comparison of average annual general security allocation (%)**

| | **1 October** | | **1 January** | | **1 June** | |
|---|---|---|---|---|---|---|
| | **Effective** | **Actual** | **Effective** | **Announced** | **Effective** | **Announced** |
| **Adapted benchmark B009** | 65.12 | 48.14 | 75.74 | 61.43 | 84.84 | 76.23 |
| **Offtake Y004** | 65.70 | 48.47 | 76.30 | 62.26 | 85.21 | 76.86 |
| **Offtake and Effluents W001** | 66.04 | 49.25 | 76.63 | 62.66 | 85.42 | 77.19 |