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Basin Plan Evaluation 2017 – Social and economic technical overview

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Basin Plan Evaluation

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Murray−Darling Basin Authority pays respect to the Traditional Owners and their Nations of the Murray−Darling Basin. We acknowledge their deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

The guidance and support received from the Murray Lower Darling Rivers Indigenous Nations, the Northern Basin Aboriginal Nations and our many Traditional Owner friends and colleagues is very much valued and appreciated.

Aboriginal people should be aware that this publication may contain images, names or quotations of deceased persons.

Contents

Executive Summary

Implementing the Basin Plan requires the Murray Darling Basin Authority to evaluate the economic, social and environmental outcomes directly attributable to the Basin Plan. This report draws together all the data and modelling used to separate the Basin Plan effects (both positive and negative) from all the other drivers of change at the community scale in the southern Basin. This work built upon the analysis undertaken by the MDBA to support the Northern Basin Review.

The community-level analysis adopted by the MDBA complements the industry and broad Basin-scale summary of social and economic conditions presented in the 2017 Basin Plan Evaluation report. A strong reliance is placed on the community outcomes as this represents the finer scale relationships between the types of irrigated production and local businesses, and between the towns and the surrounding farming communities. Further work is required to align these community-level outcomes with the observed regional, industry and Basin scale changes.

No data sets or modelling capability was readily available to assist the MDBA with assessing how the Basin Plan has contributed to the changes observed in communities. The MDBA developed the key modelling data sets with inputs from a range of organisations and supported the development of a new capability to examine the causes of change. Outputs from this work are the data sets and models. These will be made publicly available, providing a common platform for researchers and organisations to use when addressing research questions in relation to Basin Plan implementation.

For the southern Basin, the community-level analysis was applied to 40 communities with differing degrees of dependence on irrigation. Where possible, the community boundaries were represented by the irrigation district boundaries. For each community, there were considerable variances in the water entitlements owned, water recovered for the environment (in volume terms and through the mix of purchase and irrigation infrastructure investment), mix of crops grown, downstream industries, and in the drivers and timing of change (and scale of change) in the social and economic conditions examined. As such, each community and the economic sectors within each community are modelled separately across the period from 2001 to 2016.

Given limitations with data availability, the MDBA modelling concentrated on water availability, area irrigated by crop type, and changes in employment to describe the immediate effects of water recovery. Additional inputs to support and interpret the modelling results included information on where people lived and worked, the volume, timing and locations for buying and selling temporary water, the challenges facing the irrigation infrastructure operators, and estimates of seasonal worker requirements. Community and industry input was critical to this interpretation process.

In drawing all this information together, it would appear that no community has yet reached a final outcome with respect to the changes arising from the Basin Plan. One of the reasons is the ongoing positive and negative changes from multiple causes which have affected each community as indicated by the trends of social and economic change observed in those communities. It is therefore likely the fully effects of the Basin Plan water recovery will be identifiable in the 2021 census results.

From the information available and used for the 2017 Evaluation, the analysis and interpretation of the modelling results indicate that for the 40 communities assessed in the southern Basin, water recovery has meant:

- 12 communities are likely to have experienced quite small effects;
- 18 communities have experienced modest, yet identifiable effects; and
- 10 communities have experienced quite large changes.

Through the approach employed by the MDBA, it has been possible to describe the relative importance of irrigated production in each community and then consider how a change in water availability led to flow on effects for the social conditions and economic sectors in each community. From this information, it will be possible to build on the existing data sets and modelling capability to inform the 2020 Basin Plan evaluation. In particular, by updating the irrigated production, water ownership and water trade data.

Unfortunately, new information on population, employment by industry sector and the socio-economic indices for areas will not be available until after the 2021 census. However, it is anticipated the MDBA will build on this most recent analysis by considering the social and economic benefits arising from the uses of environmental water. Further insights into the effects of the Basin Plan might be derived by developing a greater understanding of the drivers of temporary water trading and examining whether the combined on and off-farm irrigation infrastructure investment might be promoting a wider array of positive outcomes for production beyond those already observed for the Benerembah and Yanco communities.

Approach to assessing change

Of the 7 key evaluation questions set out in the Basin Plan (section 13.06), the social and economic work informing the 2017 evaluation focussed on one particular question – how has the Basin Plan contributed to the environmental, social and economic conditions in the Murray Darling Basin? This report sets out the approach used to describe the current social and economic conditions in the Basin, changes in economic and social conditions during the Basin Plan implementation (so far) and separating out the Basin Plan contribution to those changes. In seeking to understand the effects of the Basin Plan, it is appropriate to consider the scale at which the changes will be assessed and the methods available for undertaking that assessment. The final part of this report will provide a consideration of the limitations with the analysis and provide some direction for the future social and economic work of the MDBA.

Scales for assessing change

When considering the effects of the Basin Plan, there are multiple scales of relevance. These might be whole of Basin, catchment, industry or local community scale. When attempting to forecast the potential Basin Plan effects, information was drawn together at all these scales. Each provided quite specific evidence regarding change and the consequences of certain causes of change. In the analysis to support the preparation of the Basin Plan, the community scale analysis was prepared for 12 of around 70 council areas within the Basin.

Examples of relevant measures of economic conditions at the Basin and industry scales were provided in the *Basin Plan Evaluation 2017*. At the Basin scale, the maximum gross value of irrigated production (in real terms) was found to have remained constant at around 2000/01 levels, despite the recovery of water for the environment through the Basin Plan and other environmental water recovery processes. By contrast, the real gross value of irrigated production for Australia (including the Basin) has increased by around 11 per cent. The difference is an indicator the environmental water recovery has had an effect on irrigated production in the Basin. These effects were found to differ across the irrigation industries – rice, cotton, milk, vegetables, grape and horticulture.

Determining the most relevant 'community' scale to examine, relied on a number of considerations. At the shire or local council scale, there are numerous examples of where an individual shire might include more than one catchment or there might be irrigation districts which span council boundaries. The council areas also have the potential to be influenced by a broad range of industry changes (with some sectors expanding and others shrinking), making it difficult to separate out the effects of the Basin Plan water recovery. In other cases, where irrigation occurs in multiple parts of the council areas, the Basin Plan water recovery might be more concentrated around particular parts of those areas rather than being spread equally across them.

Further considerations related to the availability of data for the different spatial areas that could be used to represent communities. For example, with the irrigation districts, information is available on entitlements held (by the different classes of entitlement), water use, water trade and in some cases the types of irrigated crops grown each year for the period 1999/2000 to 2015/16. Water recovery can also be aligned to these boundaries. However, the irrigation districts do not align with council boundaries. Relevant industry, government and Australian Bureau of Statistics census social and economic datasets which could be used to identify the effects of the Basin Plan were derived from other data sets to align with the irrigation district boundaries. For example, the census data could be aggregated to the irrigation district scale using postal area data.

The timeframe over which the data was available also influenced the choice of an appropriate ‘community’ scale. Having access to data for the period indicated above would make it possible to consider the extent of various positive and negative influences on communities. These changes might be reflected in the level of economic diversity, employment and demographic changes. The selection of the most appropriate community scale would also be influenced by the method for separating the effects of the Basin Plan from all the other causes of change affecting communities, noting each community has progressed along its own specific pathway of change.

Methods for assessing change

A number of methods could have been used to assess the social and economic effects of the Basin Plan. These range from the use of computable general equilibrium (CGE) modelling, input-output modelling, or a modelling approach which uses key relationships within the social and economic make-up of communities through which it is possible to examine change. Each approach has advantages and is more suitable to particular scales of analysis. They also have their own specific data requirements and as such, face limitations with available data and a reliance on extrapolated data plus the need for extra information to support the interpretation of the modelling results.

To address the primary objective of understanding how the Basin Plan is contributing to change, it was essential the modelling approach represented the influence of water availability on irrigated production and how irrigated production contributed to the changing social and economic conditions at the particular scale being examined. This immediately brings into question the timeframe to be used in the modelling and analysis. From the timeframe employed, there will be differing trajectories of change occurring before and after the Basin Plan water recovery. In this regard, the KPMG review of the social and economic modelling used to prepare the Basin Plan informed the contemplation of modelling approach(es) the MDBA might employ for assessing impacts.

The KPMG review of social and economic modelling for the Basin Plan, noted that although the previous analysis had been fit for purpose, future social and economic impact modelling could be based on a well-specified dynamic CGE model. To do so would require a better reflection of labour and capital mobility (more specifically, immobility) across industries and regions. For labour, there is normally a lag between when people lose their jobs and when they seek employment elsewhere and/or move to a new location. This is partly driven by having their wealth tied to where they live as well as that location being the source of their strong social ties. Similarly, irrigation capital is very rarely mobile. Where a farm sells all their water the irrigation infrastructure will largely become redundant.

As a demonstration of the importance of properly accounting for labour and capital mobility in the CGE modelling specifications, an ABARES modelling run in 2011 (for Marsden Jacob Associates) placed a constraint on labour mobility. The effect of the Basin Plan water recovery scenario applied to the model suggested a decrease in Basin employment of around 0.5 per cent, or 4,600 jobs. Following the KPMG advice, MDBA sought to have more realistic labour and capital mobility functions incorporated into CGE modelling, but in the timeframe available was unable to access meaningful results through that approach. Further work would have been required to transform the outputs of the CGE modelling into a second modelling framework for describing the community-level effects of the Basin Plan.

As an alternative, the MDBA in collaboration with the University of Canberra and KPMG developed a community-level modelling approach to separate out the effects of the Basin Plan from many of the other factors affecting social and economic conditions in Basin communities. It relied on using key relationships to identify the role of irrigation in each community and how production in those industry sectors contributed to the communities' changing economic and social conditions. This approach was first applied to communities of the northern Basin as part of the Northern Basin Review (completed by MDBA in 2016). The independent reviewer for that social and economic modelling recommended options for improving the approach which have been incorporated into the analysis of Basin Plan effects on southern Basin communities.

Although the community-level modelling approach relies on a small number of key relationships, the MDBA is aware that decision-making by farmers and others in the Basin communities are far more complex than these relationships would suggest. However, it would appear through community and industry engagement work undertaken by the MDBA, that the modelling results in the context of detailed social and economic profiling represents a reasonable representation of the overall changes and the contribution from the Basin Plan water recovery.

The processes for separating out the effects of the Basin Plan required the use of actual observations across the period from 1999/2000 to 2015/16 to construct two annual data sets. One data set would reflect what irrigated production and community conditions might have been if there were no Basin Plan water recovery for the whole period. The second data set would estimate the irrigated production and community conditions as if the Basin Plan water recovery up to October 2016 had applied to the whole period. The difference between the two curves would provide an estimate of the effects of the Basin Plan water recovery under the range of climatic conditions experienced in this time period. In particular, how production and community conditions might be affected in the non-drought years (when there was substantial irrigated activity.

Irrigators, local businesses and communities are aware of the likelihood of drought. The businesses are generally designed to endure dry periods, knowing the profits which can be made when water availability improves can provide financial viability over the long-run. Put another way, the effects of the Basin Plan water recovery are hard to observe when there is almost no irrigated activity due to drought. Therefore the modelling does not rely on choosing a single point in time from which to extrapolate potential causes and effects. Rather, it is based on estimating the difference between the two curves over the full sequence of climatic conditions experienced, with particular attention paid to the time of maximum production to provide the best possible insights into the Basin Plan. In this way, it is possible to account for climatic conditions, commodity prices and technology gains (in growing, harvesting, processing) observed over the modelling period, as well as the trajectories of change for the various social and economic factors. While the modelling of the Basin Plan effects provides one piece of information, it should only be used together with other social and economic data to fully describe the effects of the Basin Plan water recovery on each community.

Selection of community scale, communities and data inputs (and sources)

Potential modelling approaches, the timeframe over which the modelling had to extend, data availability and data limitations all influenced the decision on the community 'scale' for the social and economic analysis. The data inputs include the entitlements held by users, the area and/or volume of irrigated production, dryland cropping and grazing production, water use, water trade, data sets relating to output, business profits, employment and measures of social and economic condition.

Water entitlement data was accessible for the irrigation districts and for the reaches of the river systems. Each parcel of water recovered by the Commonwealth included information on where that water had been used, making it possible to assemble the data at any scale being employed. Irrigated area, and in some cases the volumes of irrigation water use, were available at irrigation district level or for specific parts of the rivers where the water was extracted directly by individual irrigation businesses. Estimates of the area irrigated were available at these same levels (or even at the farm scale) from the commodity producers and from other data suppliers (such as Sunrise21). Milk supply data was available at the postcode level. Potential areas of dryland cropping and grazing were available from a 50 metre by 50 metre grid for Australia. With regards to irrigated agricultural production, water availability and water recovery, it was therefore possible to aggregate data at the irrigation district and river reach scales.

With regards to the general parameters that might be used for economic modelling, such as input costs, prices received and profits, there were limited data sources available on either a relevant temporal (annual) or spatial scale. With regards to feed prices (as an input to dairy production) or milk prices, only limited data could be obtained by MDBA. For milk prices, neither the milk price forecasts released in May-June (for the years where that data is available) or annual average estimates of the milk prices received represent suitable explanatory variables for the volume of milk produced. With other commodities, rice prices are forecast by the industry prior to planting but are not received until a significant time after harvesting, wine grape prices are provided after harvesting and a large proportion of the cotton harvest is sold on forward contracts which might be up to 5 year's duration.

During the consultations with irrigators throughout the Basin, a common point was raised in relation to profits. Consideration needed to be given to the short and long-term nature of those businesses. In the short term, it was very difficult to make wholesale changes to the farming enterprises. For example, with cotton, even if there was a significant spike in prices, it was difficult to change the farm layout and rapidly alter the mix of crops grown. Where the land has been developed for cotton production, most producers indicated they would grow that commodity if the price was $400 per bale or higher. There were limits to the proportion of the farms that might be planted in any one year. Even when the international prices have spiked, the area of production increased only by a small amount.

An important component of the cotton rotation (to maintain soil nutrition and therefore, productivity across time) is the harvest of cotton is followed by planting with wheat and then fallowing the land over summer. With dairy, once the dairy herd has been determined for the following year, it is very difficult to change the milk production decisions. Similarly, it is quite difficult for production based on permanent planting such as grapes, nuts or other forms of horticulture to respond to pricing signals within the immediate production year. Where this might occur is in the decisions of which summer or winter crops were planted once the area of summer irrigation had been determined.

With farm profits, there is no consistently produced data set available to represent annual profits. Even if there were such data available, irrigators indicated total profits should only be considered across periods of between 3 and 8 years. In those circumstances, the long-run pricing of commodities and expectations for the future might have implications for the types and locations of irrigated production over very long timeframes of 10 to 20 years, especially where farmers are seeking to establish, build and maintain market access for their goods. Both short and long-run production decisions will therefore be confounding any assessment of the effects from recovering water for the environment on production and profits.

Given the challenges and limitations with accessing and then applying data on input costs, prices received and profits, it was determined there would be a high degree of uncertainty in attempting to estimate how the Basin water recovery may have contributed to changes in the value of farm production and profits at the community scale. Beyond the farm gate, there was further uncertainty around the question of how the gross value of agricultural production and/or farm profits would relate to the local economic activity and social conditions of each community at any one point in time or across time.

Employment, and more specifically the number of jobs and wages, offered some potential as indicators of economic and social conditions. The census offered a consistent collection of data on people in either part-time or full-time employment across 720 job classifications. This data could therefore be used to assess changes in economic diversity and overall economic activity in each community examined. Within the changing structure of local economies, further consideration could be given to shifts in where people live and where people work. In relation to this latter point is the question of if people lose their jobs in response to particular shocks, whether they are likely to leave those locations immediately.

During the consultations, people indicated it may take anywhere between 2 to 8 years to reach a decision on where they will live and work in the longer term. Beyond their social ties to the respective communities, there was also often considerable wealth effects on individuals and families. If a number of people lost their jobs in a particular location at a similar point in time, the immediate negative influence on the local economy could impact on the wealth associated with their homes, businesses and business premises.

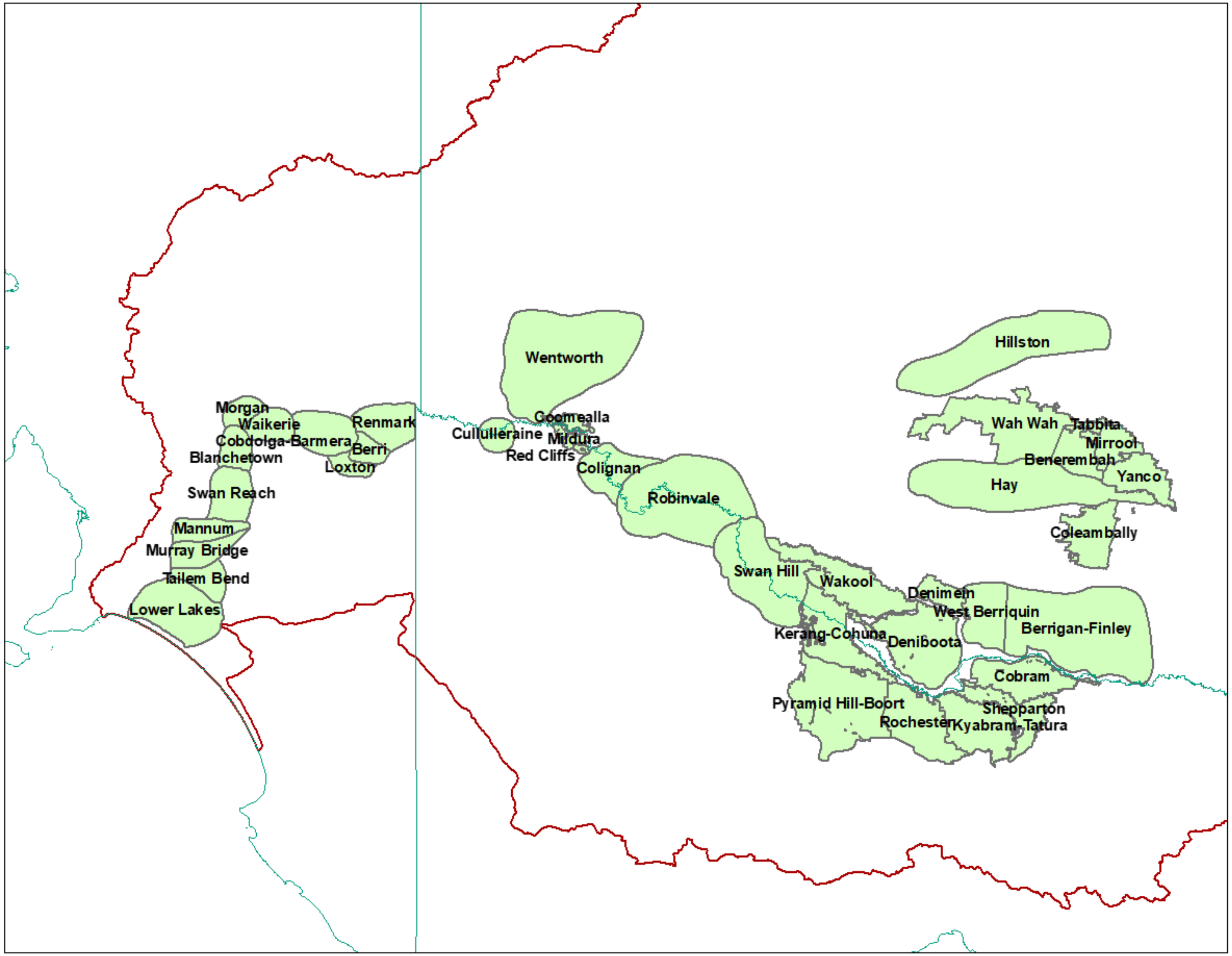
With regards to employment and other data, the Australian Bureau of Statistics census provided suitable information for examining how social and economic conditions in each community had been changing over time. Data was considered for use from the 2001, 2006, 2011 and 2016 census. Employment could be aggregated from full and part-time employment to provide full-time equivalent estimates for 13 industry sectors. Demographic data explained how the farm and town areas within each community were changing and it was the rates of change in the social and economic indicators across time which could be considered alongside data on irrigated production, water availability and water recovery for the environment. A key question remained through all these considerations – would the data and modelling approach be sufficient to separate out the effects of the Basin Plan from all the other drivers of change affecting each community?

Beyond water availability, water recovery, irrigated production, employment, and social and economic conditions, additional data would still be required to understand the effects of the Basin Plan. In particular, information on seasonal worker numbers, where people are living and working, what is relevant to understand in relation to temporary and permanent water trade, and how is the recovery of water for the environment affecting individual irrigation companies. The approach to including each of these elements in the social and economic analysis will be presented in this report. However, given the scale at which multiple sources of information could be derived, there was nothing which precluded the community level analysis from being undertaken at the irrigation district and river reach scale.

A total of 45 communities were identified for examining the effects of water recovery in the southern Basin. Five of these communities had little irrigated agricultural production. Across the other 40 communities (boundaries provided in Figure 1), there was considerable variability in the volume of entitlements owned, the level of irrigated production, and the timing, method and volume of water recovery. Given this degree of variability across the communities, any interpretation of the modelling results might need to consider the possibility of bias towards over-estimating the effects of the Basin Plan. However, one reason for focussing on these communities was the expectation of there being insignificant, if any, Basin Plan effects in communities where there has been little irrigation and no water recovery. Further, the modelling is specifically designed to identify the role of irrigation within each of the communities.

Local government area boundaries apply to the 5 communities with little irrigated production – Benalla, Buloke, Lockhart, Temora and Weddin. The purpose of including these communities was not to provide a direct comparison between communities with significant or limited irrigated production, but rather to better describe the range of social and economic changes observed in communities with differing economic make-up, social attributes and drivers of change to the more irrigation-dependent communities.

Figure 1. Community boundaries used for the MDBA social and economic analysisy.



Materials drawn together

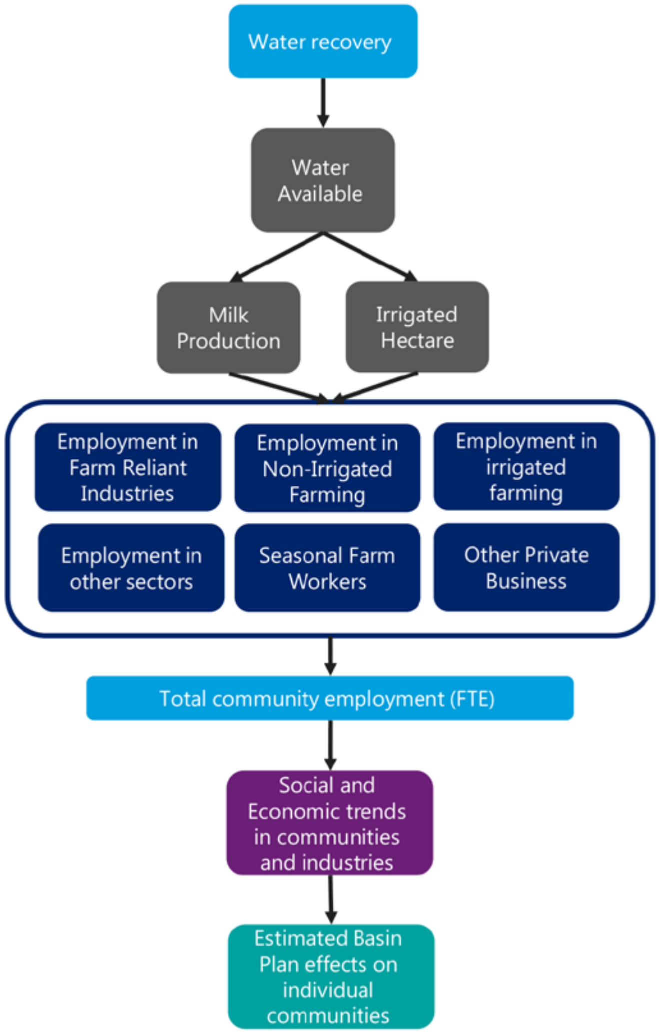
The materials drawn together for the community-level analysis of Basin Plan effects are focussed on drawing out how the Basin Plan might have contributed to the observed changes in social and economic conditions. Central to addressing that question is understanding the role of water and therefore irrigated agriculture in each community, noting the role is itself likely to be changing across time. As such, this impact or effects analysis is not attempting to provide a benefit-cost analysis of water recovery for the environment. Its objective is quite specific given each community is changing in different ways in response to a particular combination of causes of change and have been subject to quite varied means of recovering water for the environment. These varied means of water recovery include the method, timing and relative scale of entitlements recovered.

In general terms, the key relationships underpinning the analysis are those between observed changes in water availability and irrigated production. These relationships were examined across the period from 1999/2000 to 2015/16. This provides a mix of wet and dry years and incorporates the timing of water recovery into the production decisions. Through this approach, it is then possible to consider the effects of recovering water for the environment, taking into account the types of entitlements recovered and the means of the water recovery. For example, whether entitlements were sold directly or provided as consideration in return for on-farm investment in irrigation infrastructure with farmer retention of part of the water savings. Water availability, water recovery and their effects on the area of irrigation by crop type or on milk production form the first part of the modelling framework (Figure 2).

Subsequent relationships examined in actual observations are those between irrigated production and employment in the farm sector and in the farm-reliant sectors, as well as the demands for seasonal workers. In looking at farm sector employment, the jobs data across the period of analysis will have already captured the gains in labour efficiency arising from increasing mechanisation and farm consolidations. Similarly, employment in the farm reliant sectors, which include the services to agriculture and processing of farm outputs, incorporates employment changes over time in various activities such as wholesaling and value-adding. These sectors, along with the non-agricultural manufacturing sector, mining and government services sectors, have an effect on the level of economic activity in the other private business sector. It is the latter sector which supports the whole of the local economy, providing retail, food, accommodation, construction services and the other general requirements of the community.

Through this approach it is possible to follow the changing role of water in the local economy across time and to draw out the effects of water recovery, using employment as a key indicator from the modelling elements. The outputs from the modelling separate out the effects of the Basin Plan water recovery from all other drivers of change across time. This information was then combined with other social and economic information to draw out and interpret the effects of the water recovery in the individual communities. This approach provides additional information, such as the changing level of economic diversity in each community and provides a means for considering how one community is changing relative to others. This data interpretation also relied on the MDBA approach to continuously engaging with industries, governments and communities across the southern Basin. Through that engagement, it was possible to achieve a more comprehensive understanding of what had changed, why those changes had occurred and why the outcomes differed across the communities.

Figure 2. Analytical framework for separatig the effects of water recovery from all other factors affecting Basin communities.



Water recovery through purchase of entitlements and investment in on and off-farm irrigation infrastructure.

Looks at water available relative to hectares of irrigated production or milk supplied, noting use decisions reflect water trade and carrying over. Other factors (input and product prices) are also important considerations.

Employment in farm reliant industries includes agriculture services, fruit, vegetable and wine processing, other agricultural processing and milk processing

Employment in non-irrigated farming includes cropping, grazing and other non-irrigated agriculture

Employment in other sectors includes health and government services, mining and manufacturing

Employment in irrigated farming includes rice (equivalent), grapes, vegetables, fruit, nuts, citrus, and dairy

Other private business includes transport and water supply

Seasonal farm workers

Total community employment with and without the Basin Plan water recovery

Information for towns and farming areas – demographic characteristics, economic diversity, social and economic indices of advantage, disadvantage, wealth and qualifications

Estimate of employment changes combined with other social and economic data to determine the Basin Plan contribution to change.

Collating the data sets

A wide range of data sets were employed by the MDBA to complete the community-level social and economic analysis undertaken for the 2017 evaluation. Key components of those data sets are available in the community profiles (https://www.mdba.gov.au/publications/mdba-reports/southern-basin-community-profiles). For example, information on the volume of entitlements held by irrigators in each community, the water recovery estimates and the net impact on the water available for irrigated production are provided at the start of each profile.

Water entitlements

Estimates of the volume of water entitlements held in each community across time were built from multiple data sources. The data sources include information provided by irrigation companies, state water registers and the hydrologic planning models. Given the nature of the different types of surface water entitlements held across the communities (supplementary, general security, high security, low reliability and high reliability) the estimated volume of entitlements was presented in long-term average available yield equivalents (LTAYE). Data was also collected on some groundwater access entitlements and changes to those entitlements over time.

For the surface water entitlements, irrigation companies were able to provide information on the volume of entitlements held in each entitlement classes. In some cases, those organisations were able to provide additional information on the permanent trade of water between districts. In other cases, the trade data was sourced from the water registers. For sections of the river outside of where the irrigation companies operate, the planning model estimates of water entitlements at the start of 2007/08 (prior to the Basin Plan water recovery) were used for the MDBA analysis. For some communities, irrigated production was dependent on the entitlements held within irrigation districts and for entitlements to extract water directly from the rivers.

Water recovery

Nearly 10,000 parcels of entitlement were recovered for the environment between 2007/08 and October 2016. Some additional water recovery has occurred since that time. However, the recovery up to October 2016 aligns with the timeframe used by the MDBA for its social and economic modelling. The recovered water entitlements have been assigned to the 40 communities examined in the southern Basin, 16 communities in the northern Basin or to the area outside of those community boundaries. The volume of water recovered for the Basin Plan was considered in terms of the change in each entitlement type and the net change in water available for production. Calculating the net change in water available for production required:

- An estimate of water recovery by entitlement type through direct purchase (buyback) or on-farm infrastructure investment being transformed into LTAYE volumes;
- For water recovered through the on-farm infrastructure programs some of the water savings derived from those activities were transferred to the Commonwealth and some of the water savings were retained by the irrigators. While each project might differ in terms of the

proportion of water savings transferred to the Commonwealth or retained by irrigators, the Department of Agriculture and Water Resources examination of the applications for funding found, on average and across the programs, around 70 per cent of the savings for the on-farm programs had been transferred to the Commonwealth;

- The 30 per cent of water savings retained by farmers was recognised as a potential benefit to irrigated production which would not have been available without the investment. As a consequence, where the on-farm infrastructure investment has occurred, the decrease in the volume of water available for production is less than the change in entitlements.

For example, the water recovery estimate for the Murray Bridge community was derived from the following:

- Surface water entitlements held prior to Basin Plan water recovery = 27.4 GL
- Total entitlement recovery = 5.5 GL (approximately 20 per cent of the entitlements)
- Recovery through buyback = 4.4 GL
- Recovery through on-farm infrastructure investment = 1.1 GL
- The 1.1 GL represents water that was not previously being used to support on-farm production and represented realised savings as a consequence of the on-farm infrastructure investment
- Decrease in water available for on-farm production = 4.4 GL minus 0.5 GL (0.5 GL representing the 30 per cent of water savings retained by farmers)
- Net decrease in water available for production = 3.9 GL (14.7 per cent of available water).

The net water savings retained by farmers is likely to represent an under-estimation of the total benefits accruing to landholders. MDBA discussions with irrigators who participated in the on-farm infrastructure programs, indicated the benefits had been largely equal to or greater than they had anticipated. These benefits went beyond the water savings to include the improved management of irrigated production, improved assurance of water delivery to their properties, enhanced speeds of applying irrigation water and greater flexibility in the mix of crops which could be grown.

It is difficult to estimate the total benefits to irrigators arising from these investments. Farmers are still working out how to use them most effectively and it has led many farmers to leverage additional investment into irrigation infrastructure which builds upon investment through the programs (and investment in the infrastructure they had funded by themselves). In some cases, irrigators had pointed to problems encountered with their new irrigation systems (for example, bursting pipes which needed repair). When asked if their experiences with the programs had been overall positive or negative, taking into account those problems, the response was nearly always that they were glad they had participated in the programs and were already considering the next on-farm infrastructure investment possibility.

With regards to the outcomes for communities from the proceeds of selling water through the buyback programs, there are both positive and negative influences to consider. These influences are varied and quite difficult to quantify. Some studies (for example, Wheeler and Cheesman, 2013) reflected on farmers using the proceeds from selling their entitlements to pay down debt or to change their farming enterprise. In some cases, the sellers may have left farming altogether. There are cases with the sale of water entitlement where the proceeds did not return to the affected communities at all. In the case of some large water sales, this had fairly large and rapid flow-on effects to the communities. For others, changing the farming enterprise mix might have been to sell all their water and revert to dryland production while retiring debt. However, given much of the area where water has been recovered is located in 300 to 500 mm average annual rainfall, the new enterprises will largely be lower input and lower output production systems with lesser requirements from local suppliers and other businesses than was the case for the irrigated production. Finally, where farmers have sold part of their entitlements and used the proceeds to re-invest back into the irrigated part of their enterprises, there are likely to be benefits to production.

The MDBA recognises this mix of potential positive and negative effects on production and communities. While it has not been possible to directly include these effects in the current modelling, knowledge regarding the recovery of water through buyback in each community has helped to inform the interpretation of results from the community modelling.

Beyond the recovery of water through buyback and on-farm infrastructure investment, considerable water recovery has occurred and is still being delivered through the off-farm infrastructure programs. Both positive and negative effects for irrigated producers are associated with that investment. Where both on-farm and off-farm infrastructure investment has occurred, the benefits to irrigated production are just starting to be observed. For example, in Benerembah and Yanco communities, the combined benefits from the on and off-farm infrastructure investment appear to have at least offset the net influences of all past water recovery for the environment. A negative effect on irrigators from the off-farm investment is associated with the transfer of part of the conveyance entitlements to the Commonwealth as consideration for that investment. In the New South Wales irrigation districts, for example, this has the potential to reduce the allocation enhancements that may have otherwise been expected to arise from the conveyance water savings generated by the irrigation companies in the way they deliver water across the year in the absence of the infrastructure investment. The allocation enhancements are transferred from the irrigation companies to irrigators as an addition to their general security allocations.

Determinants of irrigated production

The primary determinants of irrigated production by crop type and activity are a function of water availability. For annuals (including rice, cotton, hay, corn and winter and summer cereals and oils) the area planted is determined by a combination of the types of entitlements held and the announced allocations against those entitlements on 1 November each year. With permanent plantings, the volume of entitlements held (by entitlement type) directly correlated with the area of each crop type. For milk production, the volume of milk produced was found to be a function of water availability in each community (based on entitlements and announced allocations on 1 November) as well as milk production the year before and local rainfall. The milk production modelling is provided in a separate report (https://www.mdba.gov.au/sites/default/files/pubs/Technical-Dairy-Report-2018.pdf).

Water availability for production was influenced by water recovery and whether that recovery was through buyback or on-farm infrastructure investment. Where the permanent and temporary trade data had been drawn together, it was used to support the community-level modelling and analysis. For example, in the Robinvale, Renmark, Berri, Cobdogla-Barmera, Loxton and Waikerie communities. For the other communities, preliminary findings in relation to water trade were used to interpret the modelling results. Further work has since been undertaken by the MDBA on trading activity within the temporary water markets of the southern Basin. While water use for irrigation in each community is likely to be influenced by a combination of water availability, temporary trade and carryover (in addition to other factors), a stepwise approach to examine the relationships underpinning the decisions to irrigate. One of the key reasons for this approach is the expected high degree of correlation between availability, trade and carryover.

In the first instance, the modelling sought to build relationships between water availability and irrigated production. This approach drew out very strong correlations with the area of irrigated production, which became the key input to the community modelling. Although the MDBA does not explicitly include variables for water trade and carryover (noting that regulations around carryover have also been changing across the period of the analysis) it is also recognised they are both not insignificant variables. If water availability had not been so highly correlated with the area irrigated, further work would have been undertaken to focus on the influence of the trade and carryover decisions throughout the water year on the area irrigated. It might also be presumed that commodity prices (as well as other factors such as the local climate) would have a significant influence on the area of annual crops produced or decisions around water use, trade and carryover.

As previously mentioned, there is generally a weak correlation between the area of crops planted and the commodity prices. This applies to cotton and rice, as well as to milk production using data for the years where this information has been collected in a consistent manner. As with water trade and carryover, this study does not seek to dismiss those parameters as being unimportant. They will for example, influence profits over time and investment decisions. For summer crops as an example, the individual commodity prices will determine which summer crops are grown. Rather the key finding in this regard, based on consultations with irrigators, is that if the price of commodities is of a reasonable level, crop planting and milk production decisions will be primarily related to water availability. This indicates a likely short-run influence of water availability on production decisions, whereby investments have been made regarding the design of the farming enterprises and that infrastructure is being employed to support production within the current year and across years.

Beyond the scope of this work, but most probably a factor in the background, is the transition of farming enterprises from one long-run structure prior to drought, water recovery and mechanisation, to another long-run structure post these factors, influenced by farm consolidations together with investment in on-farm irrigation infrastructure. This shift in the long-run structure of irrigation enterprises is incremental. It requires considerable investment by landholders at the same time as they are seeking to deal with varying climatic conditions.

The new long-run structure of southern Basin irrigation enterprises has been, and is being, defined by expectations over commodity prices, the advent of new crops suited to the climate and soils, expectations of future temporary and permanent water prices, and the requirements of new water users within the southern Basin. This multitude of factors is not overlooked by the MDBA. Rather it is the knowledge and understanding of what has changed where and by how much, which is captured in the temporal data sets used by the MDBA and assisted the MDBA interpret the modelling results.

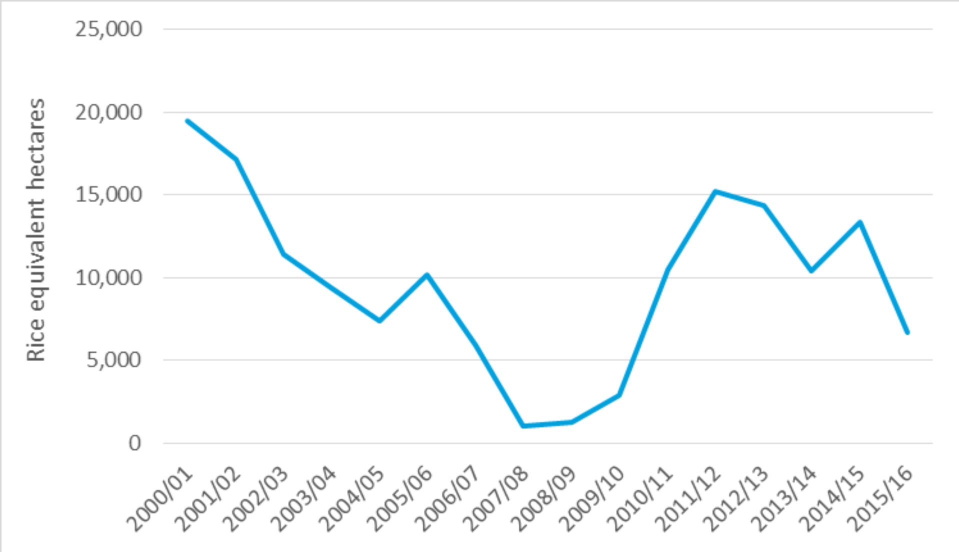
Modelling the area of annuals irrigated

Irrigated annual crops in the southern Basin might include a mix of summer and winter cereals, oils and pasture (the latter for grazing and cutting hay), rice, cotton, corn, chick peas, pulses, fava beans, fodder crops (including Lucerne), vegetables and a range of other crops. The area of these irrigated crops grown in a particular year will depend on multiple factors including the local soil type, local climate and water allocations against entitlements. Variability in the mix of crops grown may also be influenced by the relative prices for the range of summer or winter crops which might be grown or as a consequence of new cropping options. Over the period of this analysis, there has been a considerable degree of substitution in land use between rice and cotton.

The modelling of irrigated annuals in each community considered each of these factors and the limitations on the data available for modelling that production. Advice from irrigators on how they determined the final area of irrigated production was also taken into account. Outside of rice and cotton, decisions regarding the mix of winter and summer annuals grown was influenced by the prevailing commodity prices, noting that water use for each of the crops grown in winter and in summer was not expected to vary significantly. Allocations announced up until 1 November each year were considered to be a key input to decisions on the area to be planted. Those decisions would take into account expectations of potential water use, trade and carryover across the rest of the water year.

For the districts of Murrumbidgee Irrigation, detailed data was available on the area of different crops grown and water use by each crop type. Given the inter-year variability in the area of each crop grown, it was not possible to construct individual production models for each crop. Similarly, cotton started to be grown in the area from 2011/12. This information on the area of annuals irrigated was drawn together to provide an estimate of the rice-equivalent hectares grown in each district. For example, if rice was irrigated with 10 ML per hectare in a particular year and pasture with 2 ML per hectare in the same year, each 5 hectares of pasture was deemed to be equivalent to 1 hectare of rice for the purposes of modelling the area irrigated. An example of the rice-equivalent area of production is provided for the Mirrool irrigation district (Figure 3).

Figure 3. Estimate of non-perennial area irrigated crops in the Mirrool community between 2000/01 and 2015/16 (estimated as rice-equivalent hectares).



The modelling of irrigated production tested sought to include various other inputs such as commodity prices, rainfall and announced water allocations. Announced general security water allocations were used together with the permanent entitlements held by irrigators within each district to estimate the volume of water available for irrigated production on 1 November each water year. For rice-equivalent irrigated production there was an element of managing irrigated production across years, with irrigators seeking to manage their farms through a series of crop rotations which is also directed towards balancing the value of production and improvements in farm soil condition. In modelling the Basin Plan effects in this way, it was possible and necessary to separate out the differing effects of the buyback of entitlements, the benefits to irrigators from the on-farm infrastructure investment and the role of the non-Basin Plan water recovery for the environment.

Similar modelling approaches were applied to the Hillston, Hay and Coleambally communities and for the communities represented as the irrigation districts making up Murray Irrigation plus West Corurgan Private Irrigation District. In each case, while the nature of the primary data varied from location to location, it was possible to develop a consistent modelling approach which represented the aggregate of annuals planted each year at the community scale. Water use relative to the areas and crop types planted would then be a function of a number of other decisions made during the growing season, such as climate expectations for the next year and local climate during the growing season.

For the communities from Swan Hill to the Lower Lakes, the area of irrigated annual cropping was generally estimated as a function of the entitlements held and the 1 November allocations against those entitlements. However, only limited data was available for the area of crops grown each year. Modelling the area of irrigated production in these communities relied on developing relationships for the 4 or 5 years where data was available then using the models developed to estimate the area irrigated across the 16 years examined in this analysis.

For several communities downstream of Swan Hill, there was a long-term increase or decrease in the area of annuals grow which appeared to be unrelated to the entitlements held or water availability.

For those communities, the area of annuals irrigated each year was changed at a specific rate in each community. In those cases, the Basin Plan effects related directly to the area of permanent crops grown. As noted above, for the dairy communities, the relationships between water availability and milk production are presented in a separate report.

Modelling the area of permanent plantings

Across the communities, there is considerable divergence in the types of permanent plantings grown. Each community had some form of specialisation across one or more commodities, identified as table or wine grapes, citrus, stone fruit, apples, pears and nuts. In each community, the total area of permanent plantings was generally determined as a function of the high reliability and/or high security entitlements held by irrigators on 1 July each year. Community-level variations did apply to this general approach.

In the irrigation districts of Murrumbidgee Irrigation for example, less than 5 per cent of the high security water entitlements had been recovered. For these communities, the changes observed (and sometimes increasing across the period examined) were deemed as not being a function of the recovery of water for the environment. With the Robinvale community, the area of permanent plantings was modelled as function of the entitlements held and temporary water trade into that area. Across the Riverland communities in particular, and consistent with the long-term modelling for other communities, the permanent trade of entitlements into and out of the communities was incorporated into the modelling.

Although the modelling of permanent plantings irrigated in total for each community is generally related to the entitlements held, the individual commodities are separately identified in the subsequent modelling of employment. Separating out the effects of the Basin Plan water recovery at the community level therefore depends on the use of the detailed employment data from the census plus the commodity-specific estimates of seasonal worker requirements. Through this approach it is possible to examine the effects of the water recovery across the economic sectors including those value-adding to irrigated production and those sectors which form part of the overall support for the community, such as retail and accommodation.

For the GMID limited industry assistance was provided to help understand how the Basin Plan water recovery has affected production. However, high-level findings for apple, pear, stone fruit and other orchard production indicate the Basin Plan effects on the area irrigated might be limited albeit difficult to distinguish due to the considerable changes made by industry across the period from 2000/01 to 2015/16. These changes include a shift in emphasis from cannery supplies to fresh fruit production, the adoption of new forms of horticulture (moving from orchards to trellised layouts) and the introduction of new plant varieties. Some evidence had been provided by irrigators of the benefits received from the on-farm irrigation infrastructure programs. Further information is required to understand the scale of the productivity benefits to the fruit-growing irrigation businesses and sectors as a whole in that region.

In terms of the volume of production from the orchard-based sectors of the GMID, there are some changes (described in Appendix 1) which required further consideration in the social and economic modelling undertaken by the MDBA and in the interpretation of the modelling results. For apples, production had been in the range of 65,000 to 75,000 tonnes per annum since 2001. The volume of production increased to 89,000 tonnes in 2015/16. With pears, production volumes had been around 120,000 tonnes per annum, falling to 84,500 tonnes per annum up to 2009/10 before increasing back to around 90,000 tonnes in 2015/16. Evidence regarding the potential effects of the Basin Plan water recovery would benefit from an improved understanding of the prices received for these commodities. In the absence of that information, data on employment in fruit growing, processing and wholesaling provide important insights into how that industry has been changing across time.

Census social and economic data

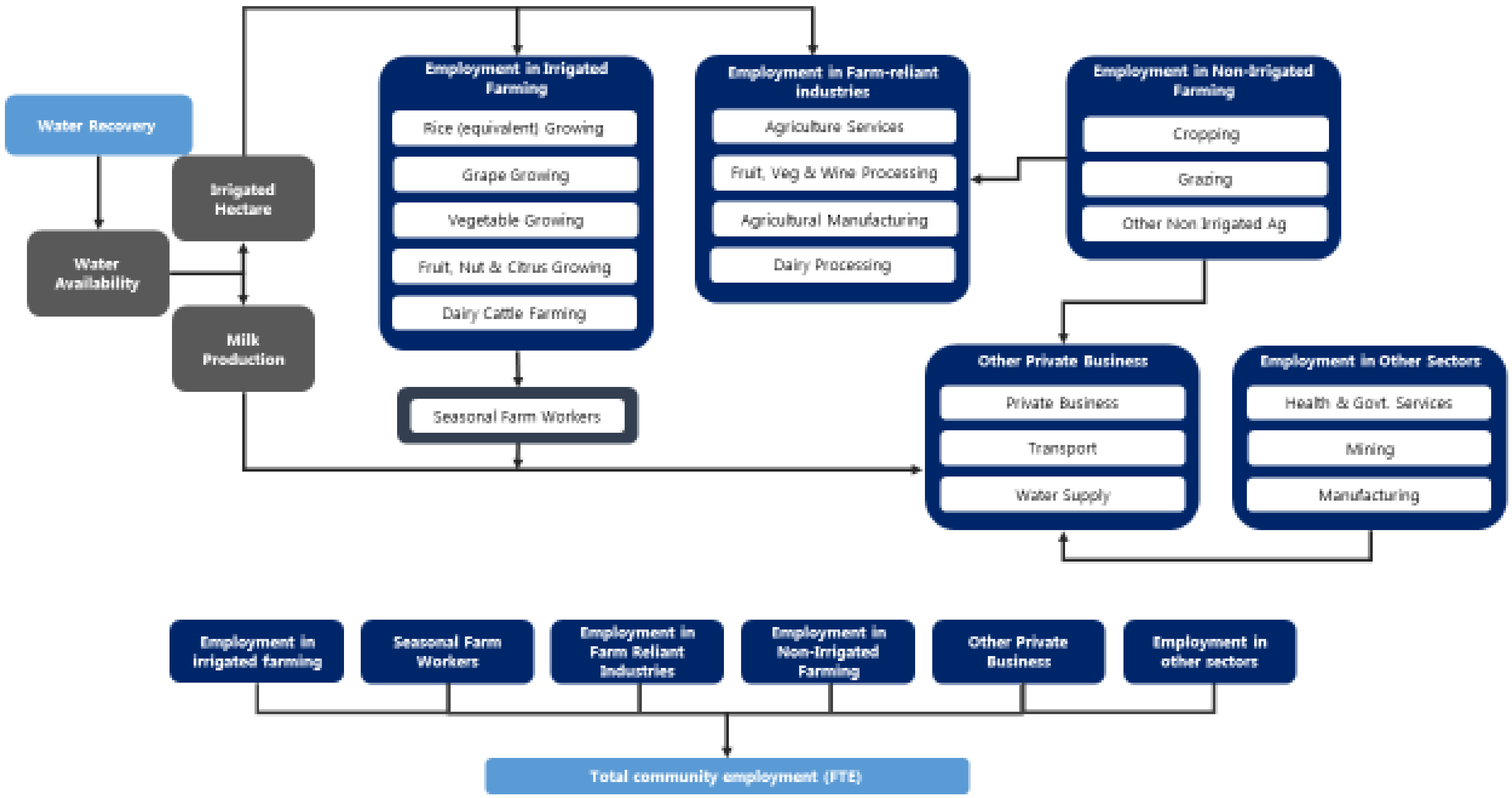
To support the community level modelling and interpretation of the modelling results, datasets were collated from the 2001, 2006, 2011 and 2016 census (https://www.mdba.gov.au/sites/default/files/pubs/2016-Census-Community-Profiles-Report.pdf). One dataset provided the employment estimates as an input to the modelling work. The second provided a range of social and economic data used to describe the changing economic and social conditions in each Basin community.

Both datasets were derived using a concordance between the postal area data collected by the Australian Bureau of Statistics and the community boundaries defined by the MDBA. Where urban centre localities (UCLs) are located within the community boundaries, additional data was extracted for those centres. This information helped to build an understanding of the extent to which the towns and the farming areas of each community might have differed in how they had been changing across time.

The broader social and economic information for the towns and farming areas within each community has been presented in the community profiles (https://www.mdba.gov.au/publications/mdba-reports/southern-basin-community-profiles). Information includes the population and age distribution, the total workforce and employment in key industry sectors, workforce participation, and the socio-economic indices for areas (or SEIFA). A guide to the social and economic profiles (https://www.mdba.gov.au/sites/default/files/pubs/community-profiles-guide-May-2018_0.pdf) explains how to use the information provided in the profiles. The guide provides a point of contrast for comparing the changes identified in any particular community. Essentially, no one piece of information can be used to adequately describe the causes and effects of change at the community scale.

For the 2006, 2011 and 2016 census, people nominated their employment against 720 industry classifications. Employment in the 2001 census was nominated against more than 300 industry classifications. Data collected on full-time and part-time employment was transformed into an estimate of employment as full-time equivalents. The structural modelling linkages between water availability, irrigated production and employment are presented in Figure 4. A report by KPMG describes the different approaches examined in seeking to find the most effective means of modelling these relationships (https://www.mdba.gov.au/sites/default/files/pubs/KPMG-SMDB-Report.pdf).

Figure 4. Economic sectors and relationships between sectors incorporated into MDBA modelling to separate the effects of the Basin Plan from all other sources of change.



Estimating seasonal worker requirements

Estimating seasonal labour requirements and how those requirements change in response to the Basin Plan water recovery are important elements of the community-level social and economic analysis. From discussions with community and industry representatives, and depending on the crop types grown, seasonal workers would appear in relatively large numbers for short periods of timing across the year. It is this concentration of workers and their demands for goods and services which have a flow-on effect in the local economies of the Basin communities.

The National Centre for Social and Economic Modelling (NATSEM) was engaged by the MDBA to assess the options available for estimating the number of seasonal workers employed across the various irrigated enterprises (https://www.mdba.gov.au/sites/default/files/pubs/2016-Census-Community-Profiles-Report.pdf). Methods considered included the potential for using data from the Census of Population and Housing, Labour Force Survey, correlations between rainfall and reported changes in employment, and the number of sub-class 417 (working holiday) second visas granted. As the NATSEM report indicated, the limitations with each of these approaches meant they would not provide suitable information to support the community-level modelling.

NATSEM concluded the most effective means for estimating the seasonal worker requirements for each crop type would be to survey the industry directly. A proforma was set up for collecting the information on seasonal workers required throughout the year. The methods for collecting, analysing and validating the survey data are provided in Appendix 2. Estimates of the seasonal worker requirements used in the social and economic modelling by the MDBA are summarised in Table 1.

Table 1. Estimated seasonal workers required to support irrigated cropping.

Commodity	Area (Ha)	Work days					FTE	FTE/100 ha
		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total		
Grape	573	300	750	0	0	1,050	4.04	0.7 (0.4-2.1)
Citrus	1,184	2,030	11,450	20,040	3,080	36,600	140.77	11.9 (6.2-35.2)
Stonefruit	130	3,465	200	740	3,060	7,465	28.71	22.1 (18.8-39.6)
Pomme fruit	319	3,835	1,100	5,100	1,140	14,135	54.37	17.0 (11.3-31.5)
Almond	8,080	18,420	3,626	9,441	378	31,865	122.56	1.5 (0.9-48.6)
Rice	1,002	250	50	0	0	300	1.15	0.11 (0.08-0.25)

As indicated, there is considerable variation in the seasonal workers required per 100 hectares of each crop type and in the timing throughout the year of when those workers were required. It was assumed changes in water availability would affect the area of irrigation with the demand for seasonal workers in each community being a function of the mix of the area for the crop types grown

Community modelling of employment

The community-level modelling undertaken by KPMG sought to use all the previously described data to differentiate the effects of the Basin Plan from the other causes of change affecting communities (https://www.mdba.gov.au/sites/default/files/pubs/KPMG-SMDB-Report.pdf). However, it is acknowledged that considerable data limitations constrained the types of economic and social relationships which could be specified and quantified at the local level. In particular, the available data did not support the development of a comprehensive economic model which defines and quantifies the demand and supply chains within, and between, communities. To try and address those limitations, any reduced-form econometric model where theoretical relationships between the relevant variables were postulated (such as those between businesses, households and governments) with statistical techniques employed to determine 'robust' associations would be problematic to apply. The uncertainty in such a modelling approach would be too great to draw out reliable conclusions with respect to the effects of the Basin Plan.

In developing the KPMG modelling capability used by the MDBA, it was assumed employment represented a key summary measure of economic conditions at the community scale. This modelling is supported by one of the primary inputs (the census employment data) having both cross-sectional and time series dimensions, having been collected in a consistent way across the last 4 census. This allowed KPMG to use regression techniques which are appropriate for such cross-sectional, pooled data to define the internal economic relationships between the sectors of each community.

As a consequence, and without diminishing the value of their modelling, KMPG stated the MDBA should only interpret their modelling outputs in the context of additional social and economic information which describes the changes affecting each community. That is, the econometric work would have to be 'heavily supplemented' with inputs of theory, other data, judgement and evidence gathered from working with the Basin industries and communities in relation to understand how the individual economies work.

The MDBA recognises the simulation modelling capability developed by KPMG only captures a small fraction of the economic (and social) relationships within each community. But in doing so in a robust way, it provides a means for teasing out the impacts of water recovery on employment as a representation of change which can be subsequently used to describe local economic consequences. In particular, the employment data from the census does contain significant and detailed information of how local economies operate and the internal changes to their economic structure. This has important linkages to the social and economic changes occurring as well as helping to identify the role of water and irrigated production or other economic activities dependent upon water in each community.

For example, farm employment provides a crude approximation for the labour and non-labour income generated by the farm sector. The income generated by the farm sector has a relationship to the upstream demands for goods and services (the agriculture services sector) and on the downstream sectors. A decrease in the labour income of farm workers is presumed to have a negative effect on the non-farm businesses such as retailing and accommodation, noting that those businesses will simultaneously be affected by other positive and negative causes of change.

A further limitation is the inability of the modelling to determine the degree to which productive resources no longer used in support of irrigated agriculture, have been used in alternative activities. However, this is a limitation with other forms of economic modelling which are resolved through an assumed level of mobility for both capital and labour which might not be realistic. Where a job might be lost in one community, workers might travel to other communities for work. While this has not been incorporated into the modelling, the MDBA has examined the extent to which these movements have been occurring to help interpret the modelling outputs.

The view of each local economy provided by the 2001, 2006, 2011 and 2016 census data captures the prevailing economic conditions and the trends (and extent) of change across time. Pooling the cross-sectional and time series data supported the estimation of the KPMG modelling parameters. Multiple options were examined for each of the models being developed and the testing of their statistical significance has been described (https://www.mdba.gov.au/sites/default/files/pubs/KPMG-SMDB-Report.pdf). However, the size of the samples (4 time points for up to 40 communities) meant it was not possible to used standard econometric techniques alone for selecting the preferred models. The selection approach applied for determining the preferred model is described in the KPMG report.

Outside of selecting the preferred model, the limited size of the database meant it was not possible to capture any non-linear responses in the modelling. The non-linearities which do exist suggest some parameters may be influenced by the size, location and nature of the shock or the nature of the lags in changes to employment (and other social and economic conditions). KMPG and the MDBA are aware the linear relationships may not pick up the full influence of other drivers of change or differences in outcomes from say a 10% or a 40% change in irrigated production. Similarly, the models cannot estimate the effects of recovering water for the environment through purchase over 3 years versus the recovery of water over 11 years (as was originally proposed) or from the largest farms versus a mix of farms. This variability in the causes of change at the community level indicate the importance placed on the other datasets required to interpret the KPMG modelling results.

One of the claims around the social and economic analysis of the MDBA is the responses from irrigators to changes in their mix of factor inputs. For example, how a change in one factor (water availability) will lead to changes to the use of other factor inputs. This might also include an increase in the substitution between labour and non-labour factors of production. While these matters are important, they represent the long-run outcomes arising from the recovery of water. For the current analysis, the MDBA is seeking to understand the effects of the Basin Plan as they have been observed and felt. The MDBA is not attempting to estimate the long-run equilibrium outcomes for communities. Not all of the changes have been implemented and producers are still in the processes of changing their farming enterprises in response to the Basin Plan and non-Basin Plan drivers of change. In most cases, there is a significant lag (possibly between 2 and 8 years) associated with the timing of change and being able to observe the full effects of those changes.

Modelling results

The models (and estimated relationships) derived from the four census points, when combined with annual data inputs on irrigated production, were sufficient to generate annual estimates of community-specific employment at the economic sector level. All these data inputs and the annual modelled estimates will be made available by the MDBA. By separating out the effects of the Basin Plan from all the other drivers of change, it was possible to define the role of irrigation water availability in each community and estimate the employment outcomes using up to five scenarios:

1. No Basin Plan water recovery during the period 2001 to 2016 (without Basin Plan)
2. The 2016 level of water recovery had occurred prior to 2001 (with Basin Plan)
3. 2016 Basin Plan water recovery and other environmental water recovery had occurred prior to 2001
4. Scenario 2 plus a consideration of the effects of temporary and permanent water trade
5. Scenario 4 plus a consideration of the productivity gains arising from the combined on and off-farm irrigation infrastructure investment.

The primary inputs to the KPMG modelling were the changes to irrigated agricultural production by crop type (or milk production for dairy) provided by the MDBA. From those inputs, the sectoral models established relationships which provided linkages across the local economic sectors. Through this approach, it was possible to examine the effects of water recovery in multiple sectors by considering how changes in one sector relate to changes in other sectors using a small selection of explanatory variables. For example, employment in the irrigated farm sector was a function of production while for the non-farm sectors reliant on irrigated farming, employment was a function of production in irrigated farming production and the activity in other sectors.

The KPMG modelling was informed by examining changes to the relationships between employment and the area of crops irrigated or milk production across the last 4 census. With dairy, a linear relationship was evident for milk production and employment in that activity for each of the census years. Across the dairy communities, they were observed to change in a consistent manner across time, with most of the employment changes having occurred prior to 2011 (link to p.35 of the KPMG report). With the modelling of employment in rice, productivity improvements over time appeared to be evident in the data. While further analysis is required to determine the causes of those changes, it is reasonable to expect some of the more recent productivity gains might be associated with investment in on and off-farm irrigation infrastructure.

The modelling capability developed by KPMG provided the MDBA with the capability to examine the influences of water recovery on the changed economic (and social) conditions of Basin communities. In developing those models, it was also possible to identify potential areas for improvement. For example, with grape production in Mirrool, the area irrigated-employment relationship is substantially different (a much smaller FTE/hectare) relative to all other communities where grapes are grown. Understanding why this was the case would be quite valuable, noting that the grape area-jobs relationship follows a similar decline over time as found in all other grape-growing communities. With fruit, nuts and citrus, there might be benefits or improvements from modelling these 3 activities separately. Similarly, for dryland farming, further investigation is required to improve the modelling relationships between employment and cropping and grazing production in those sectors of the southern Basin communities.

Modelling options were developed as part of the KPMG work, including linear and log models for each sector in each community. While noting the limitations indicated above, a key output from that modelling were the employment elasticities from the log models (Table 2).

Table 2. Elasticities of employment by sector, presented as a percentage change in employment associated with a 1 per cent change in the independent variable (the area irrigated).

Employment sector	Percent change
Irrigated agriculture employment	
Milk production	0.36
Rice equivalent (broadacre) irrigation	0.44
Grape growing	0.24
Vegetable growing	0.10
Fruit, nut growing	0.15
Agricultural services sector employment	
Milk production	0.18
Rice equivalent (broadacre) irrigation	0.35
Other irrigated production	0.05
Non-irrigated agriculture employment	0.29
Fruit, nut, citrus, grape, vegetable processing employment	
Fruit, nut, citrus, grape, vegetable production	0.41
Dairy processing employment	
Milk production	0.33
Other agriculture manufacturing employment	
Irrigated and non-irrigated agriculture employment	0.23
Other private business sector employment	
Fruit, nut, citrus, grape, vegetable processing employment	0.03
Non-irrigated agriculture employment	0.15
Irrigated agriculture employment	0.20
Health and government services employment	0.57
Non-agriculture manufacturing employment	0.06

The elasticities in Table 2 indicate the percentage change in employment from a 1 per cent change in the dependent variables. For example, a 1 per cent change in milk production (where the estimate of milk production related to water availability) was estimated to lead to an average 0.36 per cent change in dairy farming employment and a 0.18 per cent change in agricultural services sector employment. This general elasticity was derived for all the milk producing communities and modified up or down based on community-specific changes to employment in that sector across time.

In going beyond the modelling of on-farm employment, the total employment in agricultural services was a function of the different mixes of irrigated agricultural production found in each community. That is, for each type of agricultural production, separate elasticities (ranging between 0.05 and 0.35) were identified for relating production in the different crops to employment in agricultural services.

For the manufacturing (value-adding) of milk and fruit/vegetables/wine, employment was found to be a function of employment in agricultural production for those sectors (with elasticities of 0.33 and 0.41, respectively). In the other private business sector (retail, food, beverage, accommodation, building services, professional non-agriculture services, and part of the transport sector) employment was demonstrated to be a function of employment in the farm and farm-related sectors (elasticities between 0.03 and 0.2), government services sector (elasticity of 0.57) and non-agriculture manufacturing (0.06). For the other private business sector, the model did not include agricultural services or the agriculture processing sectors as explanatory variables because employment in those sectors is highly correlated with other employment variables that had already been included.

By using a panel data set in this way, the modelling approach made it possible to draw out the common influence of one sector on the local economies and the relative importance of the economic sectors in each local economy. Beyond these relationships, the modelling development process highlighted other key changes within particular communities. For example, changes in non-agriculture manufacturing, mining and government services/health are also important; there was a big decline in manufacturing across the communities between 2011 and 2016; health and government services generally increased up to 2011 then decreased (with some exceptions in larger services communities such as Mirrool and Murray Bridge); and mining was a relatively small sector of the southern Basin economies.

The KPMG report (https://www.mdba.gov.au/sites/default/files/pubs/KPMG-SMDB-Report.pdf) provides some regional representation of effects from recovering water for the environment effects. Communities were aggregated for the Murrumbidgee, GMID, New South Wales Murray and Victoria Murray without GMID, Sunraysia plus Riverland, and lower South Australia. The average changes for these locations provide some additional insights noting there is considerable variability in effect across the individual communities of each region. Other important outputs from the KMPG modelling were a consideration of the effects from non-Basin Plan environmental water recovery, the effects of water recovery plus permanent and temporary water trade where it was possible to do so, and the initial productivity gains arising from the on and off-farm irrigation infrastructure investment in the Murrumbidgee Irrigation Area. A demonstration of model performance (comparing actual and modelled employment) is provided in Appendix 3 to the KPMG report.

Communities with limited irrigated agriculture

In considering the effects of the Basin Plan on communities, it was also necessary to reflect upon the changing social and economic conditions in communities where there is limited irrigated agriculture. The data for these communities was derived using local government area boundaries. Across the five non-irrigation dependent communities, there was a high degree of divergence in how their social and economic circumstances changed between 2001 and 2016 (Table 3).

Table 3. Comparative changes in economic and social conditions in five communities with limited irrigated production relative to changes in the average social and economic conditions across the 40 communities examined by the MDBA.

	Average 40 irrigation communities	Benalla	Buloke	Lockhart	Temora	Weddin
Community population (percent change 2001-16)	4	3	-11	-8	2	0
Community full-time jobs (percent change 2001-16)	-9	20	-8	-5	16	65
Workforce participation (percent change 2001-16)	-5	6	1	1	4	13
Agricultural jobs (percent change 2001-16)	-37	7	-33	-23	-12	31
Non-agriculture private jobs (percent change 2001-16)	-14	21	-2	-27	10	64
Government services jobs (percent change 2001-16)	33	32	42	81	76	143
Main employment sector (2016)	NFP	NFP	Farm	Farm	NFP	Farm
Town population (percent change 2001-16)	11	8	0	-3	-2	2
Population over 45 (percent of population in 2016)	47	55	62	56	54	60
Population under 45 (percent change 2001-16)	8	17	21	26	21	19
Town full-time jobs (percent change 2001-16)	22	21	20	23	22	21
SEIFA decile average (2016)	3.5	4.5	4.8	5.2	4.6	3.8

Note: NFP is the non-farm private sector; Farm represents employment in the farming sector

The population of some communities had grown while declining in others. Similarly, there is considerable variability with respect to the changes in total employment (measured as FTE), the number of farm jobs, non-farm private sector jobs and the town population of these communities. While some variables are similar across the five non-irrigation communities (such as the change in the proportion of the population which is under and over 45) the changes differ considerably when compared to the average for the 40 irrigation-dependent communities.

The degree of variability in social and economic conditions across all the communities demonstrates one of the benefits from examining the effects of the Basin Plan water recovery at the community scale. Given the high degree of divergence in water recovery volumes, timing and method, and the complexity of change in social and economic circumstances, it was necessary to employ a method which could most reasonably take account of the changes experienced by communities.

Independent review

The independent review of the social and economic modelling undertaken to inform the 2017 Evaluation of the Basin Plan (https://www.mdba.gov.au/sites/default/files/pubs/UNE-model-independent-review-report.pdf) considered the data used, the modelling methods employed and provided commentary on further work which could be undertaken to enhance the current modelling capability. An important part of the independent reviewer's role was to provide guidance on the adequacy and suitability of the modelling as it developed, rather than just respond to a final report and examination of the models developed by KPMG. There were benefits to the independent reviewer, the MDBA, KPMG and NATSEM from this approach. Each of the participants developed a strong, mutual understanding of each other's role, with the learning and the exchange of knowledge contributing to the final modelling capability. By example, this approach informed the data extraction process, the modelling design and the statistical testing of the model parameters.

In preparing their final report, the independent reviewer also reflected upon the findings from their literature review to elicit specific findings and recommendations. Table 4 outlines the findings and recommendations of the independent review, and the MDBA responses to those matters.

Table 4. MDBA responses to matters raised by the independent reviewer for the social and economic modelling,

Independent review finding/recommendation	MDBA response
How is the epistemic and stochastic uncertainty being addressed in the modelling and the outcomes communicated?	Clear articulation of the assumptions employed, recognition of data limitations and use of multiple data sources to draw conclusions
Provision of evidence for not including worker mobility in the community modelling	Addressed in this report; worker mobility was considered when interpreting the modelling outputs
Need to take account of farm and community adaptability	Given data limitations, modelling interpretation required the use of multiple social and economic parameters which provide insights to adaptive capacity
Indicate the extent to which private benefits from infrastructure investment translate into community employment	Taken into account where possible; only just starting to observe the potential benefits of on-farm and off-farm irrigation infrastructure investment
Address the issue of whether investment in health and education has greater effects on employment than irrigation infrastructure investment	Further analysis would be required to distinguish the effects of different forms of government investment on employment, given the considerable increases, and in many communities, decreases to government services employment between 2001 and 2016
Explain why the economic modelling for irrigated production isn't based on revenue	Data limitations preventing the use of revenue and profits are described elsewhere in this report; revenue (and profits) would need to be considered over multiple years to be useful as an indicator of social and economic condition

Independent review finding/recommendation	MDBA response
Explain why long-term influences of irrigated production (commodity prices, terms of trade, technology) have not been taken into account	The modelling does explicitly capture technology gains across time. Weak correlations between production and commodity prices limit the potential for improving the modelling capability by including those parameters
Explain how the issue of sample selection bias has been addressed	The social and economic analysis and modelling has been specifically designed to understand the effects of water recovery on irrigation communities. This is assisted by considering the nature and scale of changes in non-irrigation communities and by including communities which have had very little water recovery through to those with considerable recovery
Explain how the paradox of irrigation efficiency and the rebound effect has been addressed (views raised in the literature review in relation to the Jevons effect associated with technology improvements and natural resource use)	The cap on water diverted for consumptive use in the Basin limits the potential for an increase in water use above the prescribed levels
Statistical tests should be undertaken for endogeneity, collinearity, heteroskedacity and serial correlation or other relevant statistical tests for each of the models developed	The relevant tests have been undertaken and are provided in the reports and/or with the models
Given the inclusion of milk production the year before in the dairy model, full regression analysis and relevant test statistics should be provided	Relevant information has been included in the dairy production modelling report
Provide reasons why the MDBA feels the dairy model is capable of explaining much of the causes of change to milk production	This has been addressed in the dairy production modelling report
Can additional effort be placed on gathering milk price data so this variable can be included in the dairy production model?	The MDBA placed considerable effort into attempting to gather milk price data using buyer forecasts in the previous year and milk prices paid in the year of production. Insufficient information was available to build a time series data set for this parameter.
Can the MDBA emphasise the level of investment made in community consultation to inform the social and economic modelling and evaluation?	Across 2010 to 2018, the MDBA consulted with farmers, industry groups, irrigation companies, local governments, community groups and others to build an understanding of the changing social and economic conditions for southern Basin communities. This knowledge was critical to developing the community models and interpreting the modelling results

In finalising the independent review of the social and economic modelling for the Basin Plan evaluation, it was determined the modelling of water recovery impacts in southern Basin communities:

- Had been undertaken carefully, iteratively and in a comprehensive fashion,
- Contextualised using various relevant qualitative and quantitative data sources including extensive in situ visits to towns and regions, and
- Could be improved by addressing the findings and recommendations outlined in their report.

As Table K indicates, the process of engaging the independent reviewer throughout the data extraction and modelling development stages provided the means for helping to address many technical issues and challenges as they occurred. Matters which couldn't be addressed at the time they were raised provide guidance on how the future social and economic analysis undertaken by the MDBA might evolve.

Other important considerations

While the modelling of irrigated production and employment provide insights into the relative importance of some drivers of change affecting Basin communities and industries, they are unable to capture and describe all the factors influencing the changes observed across time. Additional information was therefore necessary for interpreting the modelled outputs and to complement the social and economic data sets. Interpretive inputs to separate the effects of the Basin Plan water recovery from other drivers of change relied on specific pieces of analysis and/or social and economic reports prepared for other purposes. For the 2017 evaluation, the additional information included an examination of where people work and live (a description of labour mobility), the changes affecting irrigation infrastructure operators (IIOs), temporary and permanent water trade, and the estimated volume of water taken for consumptive uses relative to water available. Recent industry changes (post 2016) provides additional context for helping to understand how the observed changes in Basin communities might be a consequence of the Basin Plan water recovery and other causes of change. The latter includes a consideration of where irrigated crops are grown and the changing mix of irrigated crops.

Worker mobility (where people work and live)

The MDBA analysis of community change has focussed on the marginal changes to employment which arise from the recovery of water. For each community, these changes have been considered within the broader changes to employment. Across the communities examined, the long-term employment trends vary considerably. For some there has been employment growth while for most, there has been a decline in employment since 2001. As there are many causes of change associated with these trends, the MDBA has sought to capture the effects on employment related specifically to changes in water availability.

In those locations where employment has been increasing, it is reasonable to expect the new employment opportunities would have occurred without the Basin Plan and employment may have been even higher than has been observed if there were no water recovery. Conversely, where employment has been falling, that trend would most likely be exacerbated by the Basin Plan water recovery. It would therefore be unrealistic to simply consider a loss of employment in one location associated with water recovery to be offset by those same people finding employment in neighbouring communities (where those opportunities exist). It is for these reasons the MDBA analysis has concentrated on the marginal changes to employment and why the elasticities described previously are so relevant to separating out the effects of water recovery.

Beyond the direct effects on employment associated with the Basin Plan water recovery, there are flow-on effects which require further investigation. If those losing employment in one location do gain employment elsewhere, the potential effects on the respective communities are likely to be influenced by a number of factors including:

- whether these people move to take up the new employment or stay in the original community
- any relative difference in the wages received from the lost job and new job, and
- the proportion of income spent in the community of work and the community of residence.

Each of these matters could manifest in different ways, such as the demand for goods and services (including housing) in the respective communities. The scale and timing of the changes may further influence the extent to which these demands change and the timeframe over which the changes are likely to be observed. Taking into account these matters could indicate whether the modelled estimates of employment change might be reasonable or may need to be modified up or down.

Considering each of these (and possibly other) flow-on effects for communities would require further detailed analysis. It is questionable as to whether the data and knowledge exists to capture these complex changes for individual communities using total employment measures. As reasoned above, the approach is based on modelling the marginal effects of one factor – water recovery (reflected as water availability in the models) and using other information to interpret the results of that analysis.

As recommended by the independent reviewer, the MDBA sought to consider worker mobility and changes in worker mobility over time. Estimates of worker mobility rely on census data for where people live and their place of work. While the place of work information was not available for the community areas used by the MDBA, it was possible to derive indicative evidence of worker mobility using data based on local government areas (LGA). While the MDBA has examined the place of work and place of usual residence for all local government areas, indicative results for the Murrumbidgee (including Griffith, Leeton, Hay, Narrandera) and the GMID are provided in this report.

Data extracted by the MDBA from the census results (Tables 5 and 6) were used to help explain the extent of worker mobility. The data groupings used were:

- Resident working – the number of residents living in a specified LGA who are also working;
- Resident work in next LGA – residents who live in one shire and work in an adjacent shire;

- Resident work other LGA – residents who live in the specified shire but work elsewhere beyond the shire of residence and the adjacent shires;
- No work address – residents living in a shire who provided no work location;
- Resident work, live in LGA – residents who work and live in the same LGA;
- Worker from other LGA – people who work in the specified LGA but live beyond that shire and the adjacent shires;
- Worker from next LGA – people who work in the specified LGA but live in an adjacent LGA;
- Jobs in LGA – the total number of jobs within a specified LGA.

For the Murrumbidgee and GMID LGAs using the 2016 census data (Tables 5 and 6, respectively) similar patterns of worker mobility are apparent, albeit at different scales. While the majority of residents in 2016 lived and worked in the one shire, around 96 to 98 per cent of residents either live and work in the same shire or at most, travel to work in an adjacent shire. For the GMID area, this is an increase relative to 2001 where around 94 per cent of residents lived and worked in the same or neighbouring shire (Table 7). That is, since 2001 the number of workers who travel from outside the GMID region to work within it has fallen at the same time as the number of jobs within the GMID has increased. The within region worker mobility and inter-regional worker mobility estimates therefore provide important insights to be used when interpreting the effects of water recovery on employment.

In the Murrumbidgee region the number of people with a job (Resident working = 22,955) is quite similar to the number of jobs held in the area (Jobs in LGA = 22,524). Of these, 19,764 jobs are held by people who live and work in the same locality and while 2,052 people travel from their shire of residence to a neighbouring shire for work, almost the same number of people (1,994) travel from adjacent shires into these shires for work. With regards to residents moving to outside the region for work (456 people in 2016) or those living outside the region and coming into the area to work (866 people in 2016), as a proportion of the workforce they are relatively small (2 per cent and 4 per cent, respectively). That is, there is likely to be only a limited leakage of wages to outside the area and for wages being bought back into the area from places further away than the adjacent shires.

Table 5. Worker mobility in 2016 derived from place of work and place of residence for shires associated with the Murrumbidgee Irrigation Area.

	Resident working	Resident work in next LGA	Resident work other LGA	No work address	Resident work, live in LGA	Worker from other LGA	Worker from next LGA	Jobs in LGA
Carrathool	1,371	261	42	41	1,027	39	185	1,251
Griffith	11,649	448	102	295	10,804	312	824	11,940
Hay	1,274	35	27	68	1,143	43	51	1,237
Leeton	4,678	513	108	143	3,914	85	510	4,509
Murrum-bidgee	1,683	305	128	53	1,197	127	229	1,553
Narrandera	2,300	490	49	82	1,679	160	195	2,034
Total	22,955	2,052	456	682	19,764	866	1,994	22,524

Note: Resident working – (resident work in next LGA + resident work other LGA + no work address) = residents work, live in LGA; Jobs in LGA = residents work, live in LGA + worker from other LGA + worker from next LGA.

The difference between Resident working and Jobs in LGA are large made up of those who have not specified a place of work (No work address).

For the smaller communities (Carrathool, Hay, Murrumbidgee and Narrandera) a relatively large proportion of the residents work in an adjacent shire. While no quantitative evidence is available to suggest otherwise, and given the range of goods and services available in their place of residence, it would appear reasonable to assume workers might spend a significant proportion of their income in the locations where they work. This is supported from anecdotal evidence gathered by the MDBA during discussions with people and businesses in these communities, which indicate people have a preference to spend their income in the locations where they work if those locations provide a broader range of goods and services than their local communities.

A loss of jobs within these smaller communities might also be expected to have a stronger and direct negative effect on those localities than where a greater proportion of people live and work in the same location. These direct (and indirect) effects expected to be a consequence of the social and economic conditions (and trends in those conditions) at the time of the water recovery and the scale of the subsequent employment changes. Indirect effects on employment in the smaller LGAs might lead to significant flow-on effects for other businesses and the wealth people hold (mostly reflected in the value of their houses) than might be experienced for a similar level of employment change in larger communities. The overall effects of these changes could also take a long-time to be fully realized. It might be reasonable to assume the long-term effects arising from the water recovery will not be apparent for up to 5 years (or even longer) from the time of the water recovery.

Across the shires of the GMID, around 82.5 per cent of jobs (53,956 of 65,505 jobs) in 2016 were held by people who lived and worked in the same LGA (Table 6). 3 per cent of jobs were held by people who resided outside the GMID shires and adjacent shires, with a similar proportion of people travelling to beyond their place of residence and the adjacent shires for work. The remaining 14.5 per cent of jobs were held by people who travel from their LGA of residence to work in an adjacent shire of the GMID.

Table 6. Worker mobility in 2016 derived from place of work and place of residence for shires associated with the Murrumbidgee Irrigation Area.

	Resident working	Resident work in next LGA	Resident work other LGA	No work address	Resident work, live in LGA	Worker from other LGA	Worker from next LGA	Jobs in LGA
Benalla	5,612	995	240	259	4,118	187	769	5,074
Campaspe	15,899	2,611	423	654	12,211	357	2,718	15,286
Gannawarra	4,354	660	68	172	3,454	108	375	3,937
Greater Shepparton	26,928	1,418	759	864	23,887	796	3,343	28,026
Loddon	2,817	595	204	100	1,918	196	535	2,649
Moira	11,763	2,565	411	419	8,368	281	1,884	10,533
Total	67,373	8,844	2,105	2,468	53,956	1,925	9,624	65,505

Important variations were observed across the LGA of the GMID. For the two western most shires (Gannawarra and Loddon) there is a substantive difference between the residents with a job and the proportion of those residents who work in the shire where they live (both have around 800 people travelling from the shire where they reside for work). For Campaspe, Greater Shepparton and Moira residents, over 3,000 people from each location work in a different shire. Most of these are working in a neighbouring shire to where they live. This is significantly different to the observed worker mobility for the shires of the Murrumbidgee examined in Table 5. It is anticipated these regional variations of where people lived and worked influenced how the scale and timing of water recovery affected the community-level employment changes.

A comparison of where people lived and worked in 2001 and 2016 provided further information for interpreting the employment modelling results. Across the five shires of the GMID the total number of people who worked within them increased by 9.1 per cent (from 55,400 to 60,431 people) (Table 7). Over the same period, the number of residents holding a job increased by 5 per cent (from 58,851 to 61,761). An increasing number and proportion of residents within the region were therefore able to take advantage of the growing local jobs marked.

At the LGA level, the outcomes differed from those described for the whole GMID region. In Gannawarra and Loddon shires there was a significant decrease in both the number of residents with a job and the number of people working within those shires. With worker mobility largely associated with employment in the place of residence or the neighbouring shire, it is reasonable to assume the effects of water recovery would be felt more strongly in those communities than where there is increasing employment. That is, in Campaspe, Greater Shepparton and Moira (making up the eastern part of the GMID) based on both the number of jobs and the number of residents with a job.

Table 7. Changes in Place of Usual Residence (PUR) and Place of Work (POW) for the shires of the GMID between 2001 and 2016.

	PUR 2001	PoW 2001	PUR 2016	PoW 2016
Campaspe	15,127	14,413	15,899	15,286
Gannawarra	5,052	4,870	4,354	3,937
Greater Shepparton	24,478	24,083	26,928	28,026
Loddon	3,300	2,918	2,817	2,649
Moira	10,894	9,156	11,763	10,553
Total	**58,851**	**55,440**	**61,761**	**60,431**

Note: no comparable data was available for Benalla in 2001 and 2016

The effects of water recovery need to be considered within the context of growing or declining labour market trends which are further nuanced when considering the community-scale of water recovery and employment. While at the regional scale there has been a growth in employment and in the proportion of local residents working within the GMID as a whole. It would be reasonable to presume total employment in 2016 would have been greater in the absence of water recovery. At the shire scale, the increasing and decreasing employment trends became quite apparent and more so when employment changes were examined at the community scale.

Given the data on where people live and work over time, it would appear that while labour mobility might be significant in some communities, for the irrigation-dependent communities there was only a small proportion of the workforce who lived in substantially different locations (relative to the place of work). Worker mobility levels would therefore be expected to have a lesser effect on community changes than the underlying trend of growth or decline in the local labour markets This matter also requires consideration when attempting to determine whether people losing their jobs as a consequence of water recovery (such as in the Gannawarra or Rochester communities) could readily find alternative employment, noting there is an additional wealth effect on those people directly (and indirectly for others in the community where they live).

Changes affecting irrigation infrastructure operators

Irrigation infrastructure operators (IIOs) hold particular obligations for supplying water to many of the water entitlement holders in the southern Basin. The MDBA has sought to understand the degree to which the Basin Plan has contributed (and may in future contribute) to the changes experienced by these companies. Their challenges extend beyond the effects of permanent and temporary transferring of water out of and into the areas they manage.

While the IIOs are required to achieve rigid operational performance targets with respect to water delivery, the environment they operate in is dynamic, difficult to predict and subject to the demands of various market forces including the vagaries of markets for agricultural outputs (being the end products of water deliveries in the irrigation districts). Further uncertainty regarding the demands for water delivery arises from climate variability, changes to the area and mix of irrigated crops grown, changes to the structure of farming enterprises (including the aggregation of farms), and long-term, on-going changes in government policy settings.

Fulfilling the water delivery obligations to IIO customers therefore necessitates significant planning and investment in the maintenance and up-grading of the infrastructure they each manage. This has become increasingly apparent as the IIOs seek to provide services which complement the pace of innovation in on-farm practices and the application of new technologies. At the same time, the IIOs are operating in a business environment where there may be an increasing reliance on farm revenue from the temporary trading of water. The potential variability in demand for water deliveries within and across irrigation seasons occur alongside the expectations placed on IIOs to maximise the efficiency of their operations and to share the benefits of those improvements with their respective stakeholders.

In addressing these matters, IIOs need to account for the expanding risks and obligations on their projected cost and revenue streams. The revenue streams are comprised of varying mixes of fixed and variable fees. Beyond the potential variable revenue streams associated with the volume of water delivered, the fixed income stream for each irrigation company might have been affected by a decline in the volume of water delivery rights or shares (WDR) retained by their customers. Although the termination of a water delivery right or share might lead to an IIO receiving an immediate payment of up to 10-times the annual fixed charges, there might be some future financial uncertainty associated with an increasing volume of WDR being terminated. In undertaking this analysis, the MDBA was advised of the challenges the IIOs faced with respect to recovering annual fixed charges from some irrigators who had sold water entitlements and were no longer irrigating. In their words, the annual fees remaining unpaid to date were significant and are costly to recoup.

Each IIO has taken different approaches to how they operate their business. This has been influenced by how they meet their particular challenges (which is a function of their business structure), making it difficult to separate out and understand the effects of the Basin Plan water recovery. For example, in relation to reducing the risks of potential future decreases in income associated with a decline in fixed annual charges, Coleambally Irrigation sought to re-issue the terminated delivery rights through a Delivery Entitlement Incentive Scheme. As a consequence, only around 1 per cent of the initial volume of delivery rights remain terminated, providing greater certainty to both Coleambally Irrigation and the irrigators within that irrigation district with respect to the income stream for managing and maintaining the water delivery assets.

While it may be difficult to decipher the effects of the Basin Plan from all other causes of changes, it is necessary to try and understand how the Basin Plan water recovery has been contributing to the changing business circumstances of IIOs. This is particularly relevant, given irrigator confidence within the irrigation scheme areas seems to be closely aligned with their perceptions of the extent to which the respective IIOs might meet their current and future water delivery service obligations.

Part of the difficulty with undertaking this analysis is a recognition most of the IIOs are still in a process of transition as they respond to the multiple drivers of change they each face. For example, Commonwealth investment in upgrading the off-farm irrigation infrastructure (in return for mostly conveyance entitlements) is not yet complete. It is anticipated this investment will have a positive influence on the irrigation enterprises and in many cases the irrigation sectors and the wider communities in which they operate. Perceptions regarding the expected benefits to IIO businesses is anticipated to be of direct consequence to long-term community outcomes. In particular, the confidence of irrigators to utilise the water available to them. Some additional analysis undertaken by the MDBA (described below) provides support for this assertion.

Changes within the areas managed by IIOs

Publicly-available data was collated for 6 IIOs – Murrumbidgee Irrigation, Coleambally Irrigation, Murray Irrigation Limited, Goulburn Murray Water, Central Irrigation Trust and Renmark Irrigation Trust (Appendix 3). The key variables examined were the annual volume of water delivered, the changes to water access entitlements held by irrigators within the areas managed by the IIOs, and the volume of WDR held by irrigators.

Focusing on these particular elements of water ownership and use provides some indication of what has happened to date (Table 8). While the volume of water access entitlements has fallen by between 17.2 per cent and 35 per cent, the volume of water delivery rights (or shares) has fallen by a much smaller proportion of between 1 per cent and 12.6 per cent. There is no significant correlation between the decrease in the water access entitlements and the WDR. Similarly, there have been varying differences to the maximum water delivery volume when comparing water use before and after the Basin Plan. While the maximum volume delivered by Coleambally Irrigation has increased, it is lower for Renmark Irrigation Trust and Goulburn Murray Water, and has remained similar for the other 3 IIOs.

Table 8. Changes to the acess entitlements, water delivery shares and maximum water delivery volumes for 6 of the irrigation infrastructure operators (IIOs) between 2016 and prior to the Basin Plan water recovery.

IIO	Decrease in access entitlements (%)	Decrease in WDR/shares (%)	Change to maximum water delivery volume
Murrumbidgee	17.2	3.3	Similar
Coleambally	18.6	1.0*	Higher
Central Irrigation Trust	35.0	12.6	Similar
Murray Irrigation	23.5	9.8	Similar
Renmark Irrigation Trust	20.5	6.2	Lower
Goulburn-Murray Water	19.1	4.0	Lower

Note: for Coleambally Irrigation, the decrease of around 1 per cent is associated with that IIO re-issuing most of the WDR which had been terminated.

This information provides a starting point to help identify what data might be most useful for identifying the effects of the Basin Plan water recovery on IIOs. These changes have occurred within the context of each IIO having their own mix of fixed and variable charges, and alternative sources of income in addition to the variable revenue received from the delivery of irrigation water.

As with the community level analysis, it is difficult to draw out generalisations of Basin Plan effects which apply to all IIOs. Each organisation started with different volumes of entitlements and entitlement types, irrigation infrastructure, Commonwealth investment in upgrading the off-farm infrastructure and water recovery from irrigators within the areas they service. An examination of the annual cost and revenue streams for these IIOs did not provide any clear means for separating out the effects of the Basin Plan from all the other causes of change affecting those organisations.

This is not to say Basin Plan effects do not exist. But rather, given the information that is publicly available and the changing nature of those businesses (as described in Appendix 3), a considerable amount of additional information would be required in order to undertake an analysis for determining the extent to which this is the case. For example, IIO discussions with MDBA indicate each organisation has made multiple changes to their 'business as usual' approach due to the implementation of the Basin Plan. This alone makes it difficult to develop a baseline from which it might be possible to identify the positive and negative Basin Plan effects.

With little change in the WDR held by irrigators within the areas managed by the IIOs, the companies indicated one of their major challenges was to maintain the capacity for meeting peak demand from all their members who might seek to irrigate at some future point in time. These organisations further indicated to MDBA they might have to do so while having greater potential variability in water demands with the possibility of there being reduced total water use (deliveries) across time. Unfortunately, these organisations were not able to indicate to MDBA which financial variables would be most appropriate to examine in order to define the Basin Plan effects. From their perspectives, the challenges for the IIOs arising from the Basin Plan water recovery were not yet fully evident. While the IIOs have sought to change their business models to accommodate these demands and pressures, they held concerns the full effects of the Basin Plan water recovery might only be evident with the next 2-3 year drought.

Another matter which may require further consideration was a comparison of the volume of water used within the areas managed by the IIOs and the volume of water available for production within each year. For Coleambally, Murrumbidgee and Murray Irrigation, a comparison of water use and water available was undertaken for the period before and after the Basin Plan water recovery (Appendix 3). In Coleambally and Murrumbidgee IIO, the volume of water deliveries relative to water available for use on 1 November each year increased post the water recovery when compared to the years prior to water recovery. The converse was the case for Murray Irrigation where the volume of water use relative to water available for determining irrigator production decisions was markedly reduced in the period from 2010/11 to 2015/16 relative to the irrigation water use prior to the recovery.

Discussions with irrigators and the IIO suggest there was a considerable lack of confidence in the area where Murray Irrigation delivers water. The lack of confidence was attributed to a number of factors including the Basin Plan water recovery. This observation might require further consideration in relation to the comparison of water available for use more generally within the Basin SDL areas and the volume of water taken for consumptive purposes. If it does provide a temporal indication of confidence to invest in irrigated production, this would also be consistent with a perceived improvement in confidence in 2016/17 and 2017/18, which saw a considerable increase in the volume of water use relative to the volume of water potentially available for use.

Temporary and permanent water trade

Permanent and temporary water trade represent one set of influences on irrigated production and social and economic change at the community scale. What is apparent from the analysis undertaken to date by the MDBA is the scale, direction and timing of water trade differs from community to community. In this analysis, the direction of trade refers to whether there has been permanent and/or temporary water trade into and out of the communities. Any generalised claims regarding the water market activities, and the influence of the Basin Plan on those activities, should therefore be contextualised with respect to the individual communities.

The observed activities of the permanent and temporary water markets to date appear to be consistent with the Basin Plan objectives. Objective 5 seeks to ensure water markets are efficient and effective in facilitating the transfer of water to its most productive use. However, observations with respect to the water market activities are taking place as industries and communities adjust to multiple sources of change, including the Basin Plan water recovery.

As previously observed for the community-level modelling (in communities such as Renmark, Berri and Loxton), the effects of the Basin Plan water recovery purchases have been offset to varying degrees by the volume of water access entitlements purchased from other communities. Essentially, this has transferred the effects of the Basin Plan water recovery from say Renmark back to those communities selling the permanent water entitlements. In this community, the water recovery had been largely from the irrigation district while water purchased back into the area has been used to support production by irrigation enterprises pumping water directly from the river onto their farms.

For the Robinvale community, the sale of permanent water entitlements to the Commonwealth has largely been offset by irrigators procuring water through the temporary water market. In the dairy communities of northern Victoria and the rice-producing communities around Deniliquin, the buying and selling of water through the temporary water markets has provided one mechanism to facilitate the adjustment to the reduced availability of water for irrigation. Other adjustment mechanisms employed by the Commonwealth have included investment in on and off-farm irrigation infrastructure improvements, with the former having the potential to influence the volumes and locations of temporary water trading.

Since the Basin Plan water recovery commenced in 2007/08, the volume of water entitlements sold between irrigation enterprises has been relatively small in volume terms, even though the price of permanent water entitlements has risen substantially over the past 10 years. At the same time, there has been considerable level of trade occurring in the temporary water market. As such, the remainder of this section will focus on particular aspects of temporary water trade in the southern Basin, including:

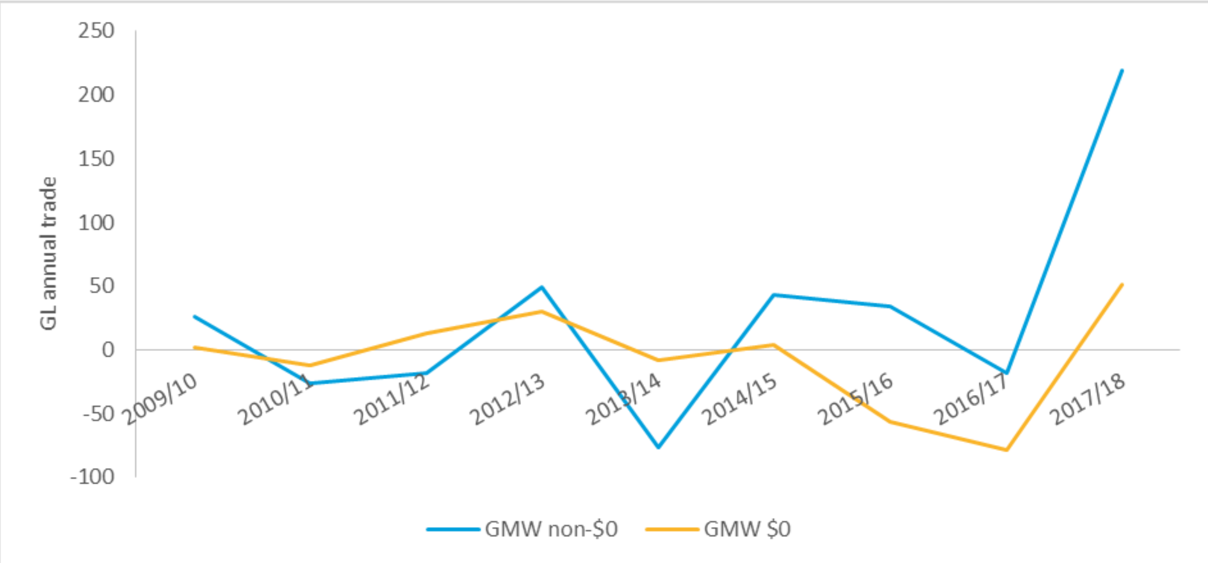
- Which locations have been buying and/or selling water;
- Whether the annual volume of that trade has increased over time, taking into account the effects of climate on water availability and the timing of the water recovery;
- The relative importance of commercial trades (those with a price) and non-commercial ($0) trades to total water trade;
- Findings with respect to the direction and spatial scales (State, valley, district, sub-district) of temporary water trading; and
- The variability with respect to the timing, volume and price of water trades within each water year.

At the present time, there is insufficient data to analyse temporary water trading activities for all the irrigation communities in the southern Basin. However, the use of multiple sources of data can be used to inform a consideration of the influences of water trade on community outcomes. For example, by using data from the State water registers and from the IIOs (where temporary water trade within the irrigation districts is not disclosed to the authorities regulating water trade). Some of this analysis has then be broken down into water trades with a price, water trades without a price, the sale of water from irrigators to the environment and from the environment to irrigators, or from the water corporations to the private sector. Each of these types of trade can influence production outcomes, noting that irrigators will be using temporary water trade for multiple reasons, which are likely to differ throughout the year. Those reasons, beyond buying water to immediately put onto crops, included procuring water to support their production across an irrigation season (that is, to manage their perceived risks of potential water demands and water availability in summer), to carryover water into the next irrigation season, or to balance their accounts at the end of the water year.

Considering the spatial and temporal elements of temporary trade

Data on commercial trades (those with a price greater than $0) and non-commercial trades (price of $0) between private entitlement holders in norther Victoria identified several key spatial and temporal elements of the temporary water trading activities. Annual trade flows into and out of the GMID region were available the last 9 years (Figure 5). A positive volume indicates water was sold out of the district; a negative volume arose where water was bought into the district. There is a very weak correlation between the commercial and non-commercial annual trade into and out of the district across the first 8 years of available register data, indicating decisions in relation to the commercial and non-commercial trading of temporary water are likely to be driven by very different factors.

Figure 5. Annual net commercial trade of temporary water into and out of the GMID (identified in the trade data as GMW) between 2009/10 and 2017/18.



Source: Data accessed from the Victorian water register (http://waterregister.vic.gov.au/water-trading/allocation-trading). Positive value represents net water trade out of the GMID.

Year on year, it is highly variable as to whether GMID irrigators were net acquirers of water or had been trading water away from the district. Across the first 8 years of register data, the net commercial trade of water out of the district is around 12 GL in total (or around 1.5 GL per annum). This can be compared to there being around 1,400 GL of high reliability Victorian water entitlements being held by irrigators after the Basin Plan water recovery up to October 2016. The sum of commercial and non-commercial trades for the GMID across the same period was a net acquisition of around 95 GL (or a net trade into the district of around 12.3 GL per annum). This tends to indicate irrigators have adapted (and continue to adapt) their farming production across the years by managing irrigated production and trade to the variability in irrigation water availability.

The net trade of temporary water out of the GMID in 2017/18 appears anomalous when compared to the previous 8 years of data. The volume of water traded out of the district largely occurred between February and April 2018. At the time, the commercial trading of water was at prices ranging between $70 and $175 per ML. Net commercial trade out of the GMID for 2017/18 ended up being close to 220 GL, with a further 50 GL of net trade out of the district through non-commercial transactions.

Anecdotal information collected from irrigators within the GMID suggest these net trade outcomes were a consequence of production decisions influenced by multiple and quite specific factors. Low hay prices at the time and a need to generate additional cashflow through the temporary sale of water were two of these factors. The requirement for generating that cashflow is proposed to be a consequence of the challenges with milk prices in 2016/17 and the financial effects of the 2016 floods on milk production. This sale of water out of the GMID is consistent with a significant decrease in the area of irrigated pasture being grown (MDBA observations during community visits) through the autumn of 2018. Further analysis is required to understand the reasons why the net trade of water out of the area during 2017/18 was so much higher than in previous years. These decisions are expected to have flow-on effects for milk production in 2018/19.

The sources of traded water

One of the challenges with using information in relation to the temporary trade of water has been to account for the different sources of that water. For example, the Victorian Water Trading 2016/17 annual report (http://waterregister.vic.gov.au/images/documents/Victorian%20Water%20Trading%20Annual%20Report_2016-17_Web.pdf) refers to the net trade of water into the GMID in 2017/18 being 183 GL. However, this estimate of net trade into the region includes part of the 359 GL of water which had been transferred from private accounts without water use to private accounts with use in northern Victoria. In some cases, irrigators hold both these types of accounts and the trade would reflect their transfer of water between the accounts. Further investigation indicates much of the trade of water between the use and non-use accounts is within the GMID area. As such, when examined as the net trade of water, the GMID was actually a net exporter of water from private accounts of nearly 200 GL as indicated in Figure 5, not a net importer of water.

Other elements of temporary water trade which may have influenced production decisions include the trade of water to the private entitlement holders from what are defined as ‘water corporations’ in the Victorian water register data and from the environment (Table 9). Information on temporary water trade from the water corporations was available from the register since 2011/12. As indicated, the volume of water sold into the temporary water market by the water corporations is quite significant and varied between 45 GL up to 162 GL per annum. That is, between 6 per cent and 18 per cent of the total volume of water traded between private water accounts. In relative terms, the sale of water from the environment has also been important yet quite small in volume terms, ranging between 0 GL and 22 GL per annum).

Table 9. Sources of temporary water trade in northern Victoria, 2010/11 to 2017/18.

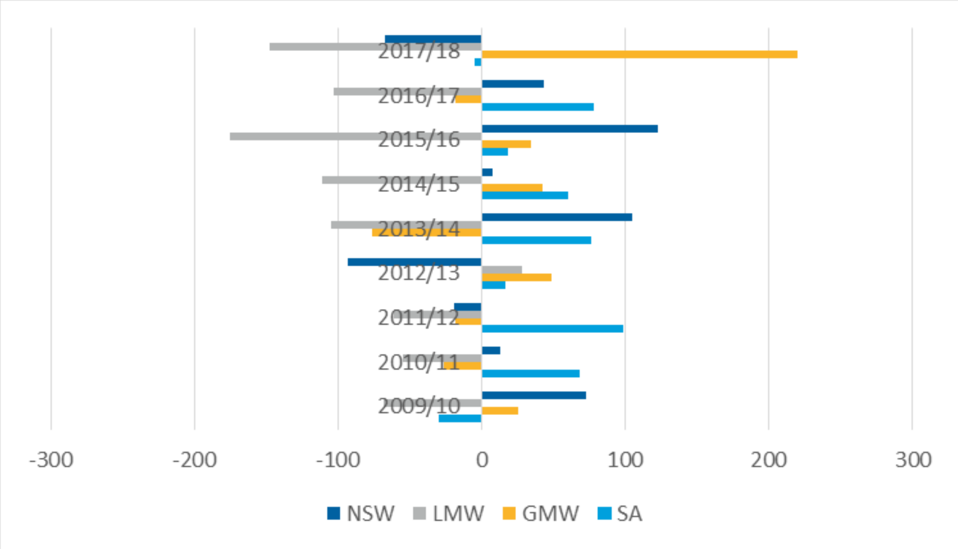
	Water corporation to private buyers	Environment to private buyers	Total commercial private trade volume	Total non-commercial private trade volume
2011/12	45	8	660	412
2012/13	157	13	855	354
2013/14	162	0	740	362
2014/15	112	13	718	403
2015/16	69	22	703	483
2016/17	121	20	786	643
2017/18	112	16	887	617

The source(s) of water traded to private accounts from the 'water corporations' has not been identified nor any reason provided as to why the volume traded to private entitlement holders is so variable. It is unknown as to whether similar volumes of water will continue to be made available to the private sector in future. This may lead to uncertainty over the total volume of water which might be available through temporary trade and therefore to support irrigated production in future years. A further element of the overall water trade is the tagged water use. In 2017/18, 94.6 GL was transferred for use through this mechanism. This is significantly larger than the previous highest level of tagged water use (40 GL, of which most was from the Murrumbidgee to Victoria). It is unknown whether this increase is part of an emerging trend of increasing volumes of tagged water use or a consequence of the prevailing climate and economic conditions at that time.

Commercial and non-commercial temporary trades

The spatial and temporal dimensions of temporary water trade further highlight both the significance of the temporary water market and the potential role for the market to assist irrigators adjust to the recovery of water for the environment (and other challenges, including climate variability). As indicated with Figure 5, this requires a consideration of the commercial and non-commercial trade data. For the commercial trades (those with a recorded price), net trades are described for the GMID, the area managed as Lower Murray Water, South Australia and New South Wales (Figure 6). While Lower Murray Water is mostly a net importer of water, the other 3 regions are sometimes net buyers and in other years are net sellers of water.

Figure 6. Net commercial trading of temporary water into and out of the GMID, Lower Murray Water, South Australia and New South Wales, 2009/10 to 2017/18.

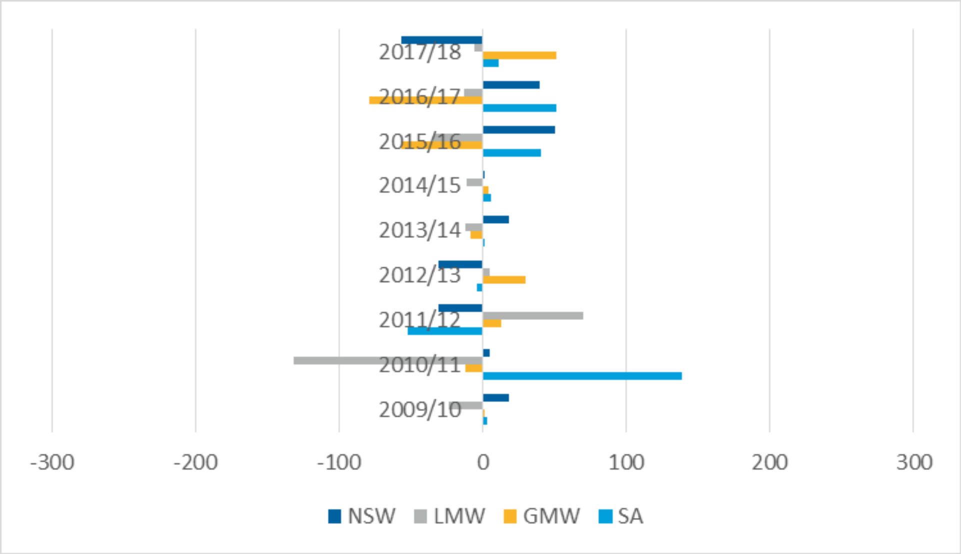


Note: a positive value = net trade out of an area; a negative value = net trade into an area.

While there may be concerns GMID allocation holders might be trading an increasing volume of water out of that district, it should be noted that between 49 per cent and 60 per cent of all the commercial trades occurring in northern Victoria are between the private accounts of those within the GMID. This includes 2015/16 where the water price was above $200 per ML until the very end of the water season, with 56 per cent of farmers indicating water prices above $220 per ML were not viable for their businesses (file:///C:/Users/61448/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/RILWUM_DairyEvaluation2017%20(3).pdf).

With the non-commercial (zero price) trades a more variable spatial pattern was observed for the period since 2009/10 (Figure 7) than was observed with the commercial temporary trades. For example, the volume of temporary water transferred as non-commercial trades into the Lower Murray Water region is generally much smaller than was the case for the commercial trades into that area. As a consequence, the annual net volume of non-commercial trades between private account holders within the GMID represented between 49 per cent and 89 per cent of all the non-commercial trades in northern Victoria.

Figure 7. Net non-commercial trading of temporary water into and out of the GMID, Lower Murray Water, South Australia and New South Wales, 2009/10 to 2017/18.

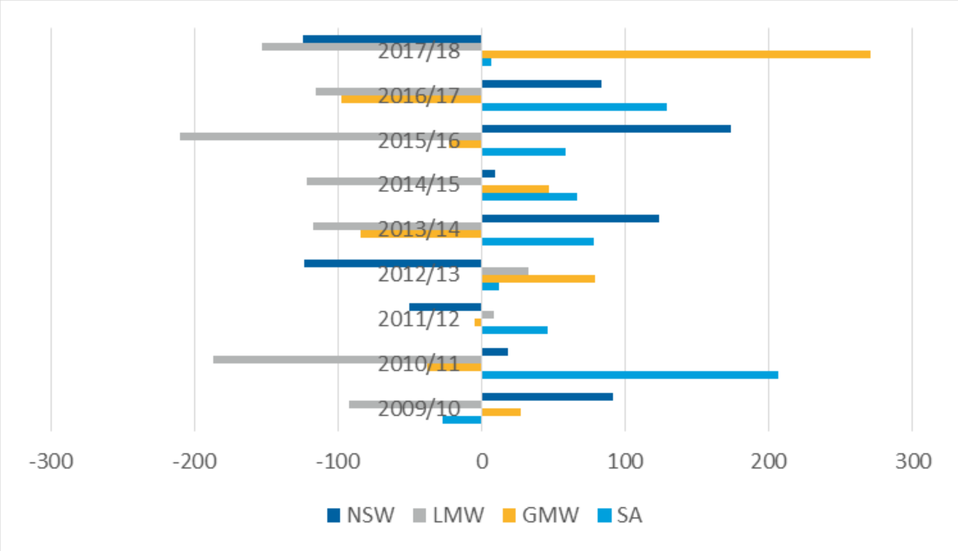


Note: a positive value = net trade out of an area; a negative value = net trade into an area.

South Australia was largely a net supplier of water through non-commercial trades into Victoria (as was the case with the commercial trades). However, year-on-year, there are differing levels of net trade into and out of these regions. Further analysis is required to determine whether there are consistent, identifiable determinants of trade (possibly related to climate and water availability or the timing of allocation announcements) which are underpinning these observations.

The combined commercial and non-commercial trades involving Victoria's private account holders (noting the data excludes the tagged water use and trade from both water corporations and the environment to the private account holders) indicates the degree of variation in net trade for each region (Figure 8). For example, while there is generally a net trade of water from South Australia to Victoria, the annual amount varies between 27 GL being purchased by South Australia from Victoria in 2009/10 to 207 GL being acquired by Victorian irrigators from South Australian irrigators in 2010/11. For New South Wales-Victoria, the net annual trade volume varied between 124 GL traded from Victoria to New South Wales (2017/18) up to 174 GL traded from New South Wales to Victoria (2015/16). Future temporary trade analysis might consider how production decision-making and the risk management approaches of farmers might be influencing the aggregate net trade volumes and the direction of that trade.

Figure 8. Net commercial plus non-commercial trading of temporary water into and out of the GMID, Lower Murray Water, South Australia and New South Wales, 2009/10 to 2017/18.



Note: a positive value = net trade out of an area; a negative value = net trade into an area.

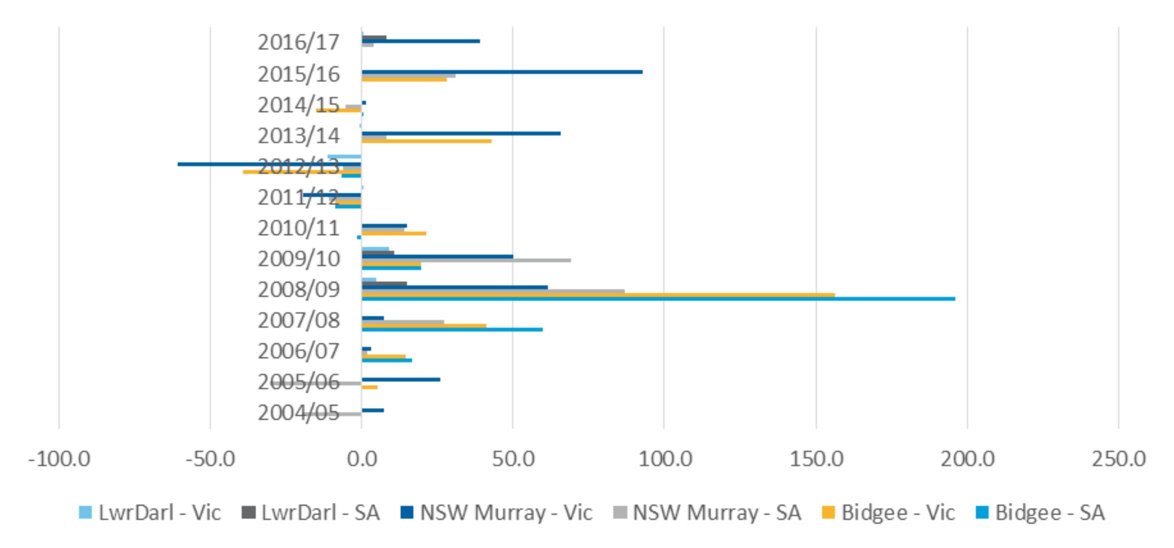
The analysis of the temporary (and permanent) trade data requires an extraction of information from multiple water registers. Data from the New South Wales water register goes back to 2004/05 and provides additional information with respect to the temporary water trade between the New South Wales sustainable diversion limit areas and the trade into (and out of) South Australia. Some useful insights can be gathered in relation to temporary trade by examining the aggregated temporary trade for New South Wales. For example, between 2004/05 and 2015/16:

- There were 5,037 GL of temporary trade involving New South Wales buyers and sellers in the Lower Darling, Murrumbidgee, New South Wales Murray with a price greater than $0;
- 28 per cent of all those trades were from Murrumbidgee sellers to Murrumbidgee buyers;
- 18 per cent of the trades were between New South Wales Murray buyers and sellers;
- The net trade from New South Wales to Victoria was around 560 GL (with 287 GL sold from Victoria to New South Wales and 847 GL sold from New South Wales to Victoria);
- The net trade from New South Wales to South Australia was around 480 GL (with 129 GL sold from South Australia to New South Wales and 608 GL sold from New South Wales to South Australia).

This aggregated analysis indicates the main trading activities occur within the catchments where the water is owned (representing nearly half the total volume of temporary trades with the buyer and/or seller being from New South Wales. With respect to interstate trade, New South Wales has, in aggregated, been a net seller of water to both Victoria and South Australia.

As observed with the temporary water trades involving private account holders in Victoria, the net volume and the direction of the trades with a price is highly variable from year to year (Figure 9). The New South Wales data also includes the net trade volumes to Victoria and South Australia when the water sharing plans were suspended during 2008/09. Additional information within the New South Wales trade includes the trade between the New South Wales' sustainable diversion limit areas.

Figure 9. Net commercial temporary water trading between New South Wales sustainable diversion limit areas and South Australia and Victoria, 2004/05 to 2016/17.



Note: a positive value = net trade out of an area; a negative value = net trade into an area. LwrDarl = Lower Darling, Vic = Victoria, SA = South Australia, Bidgee = Murrumbidgee.

The commercial temporary trade volumes from the New South Wales and Victoria trade registers are largely consistent. However, the commercial temporary trade data for South Australia-New South Wales (and for South Australia-Victoria trades) are not as easy to reconcile. The South Australian trade data (where South Australia is either the seller and/or buyer) are spatially identified using postcodes. It is possible to reconcile the locations of the interstate commercial trades involving South Australia with the trade register data from New South Wales and Victoria for around two-thirds to three quarters of the volume traded. For the remaining commercial temporary trades, the postcode locations provided do not represent locations where the water might have been used for irrigation (data not shown).

Analysing temporary trade data at finer scales

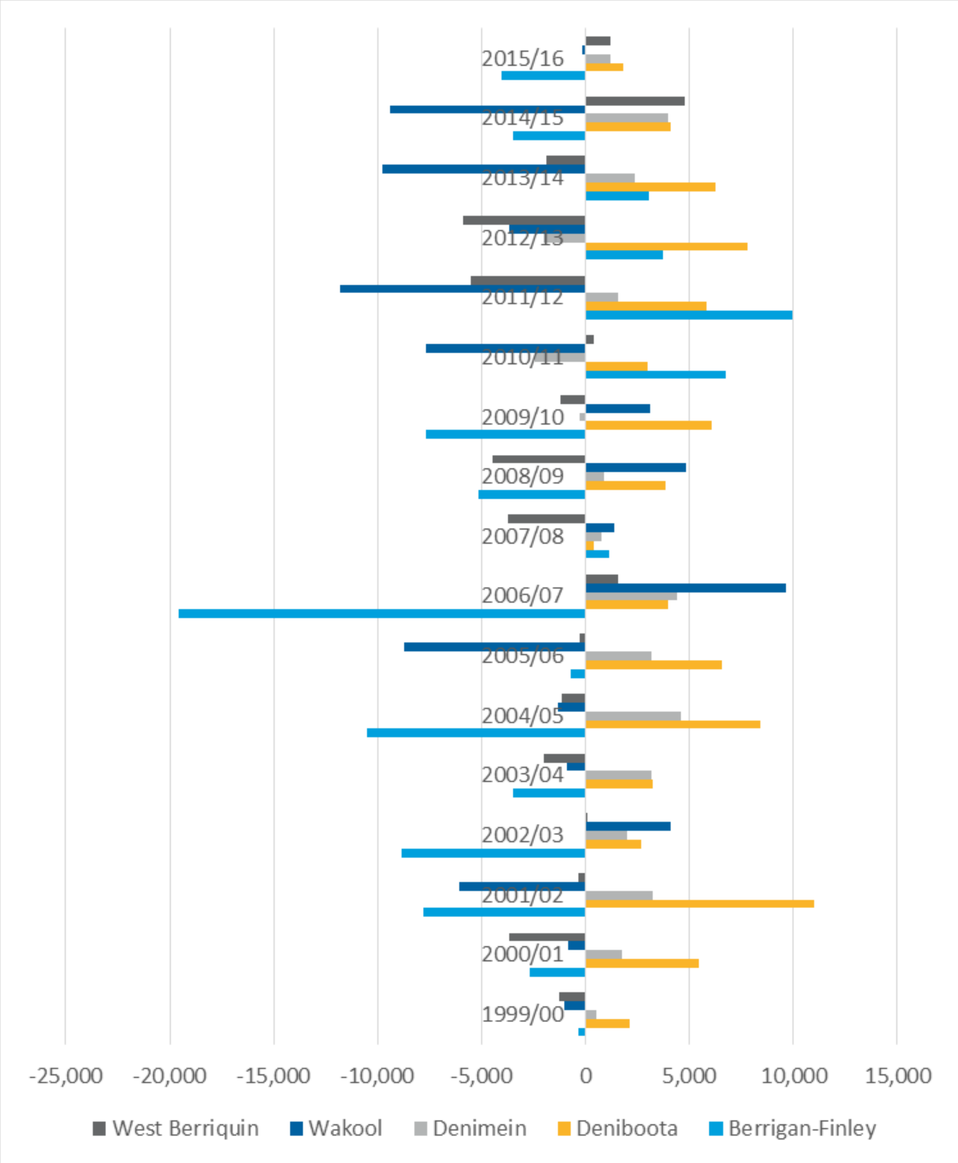
To support the community level analysis, the MDBA sought to understand (and to take into account where possible) the influences of temporary trade on irrigated production within South Australia and within the irrigation districts. For example, the MDBA was provided with access to the temporary trade data within the Murray Irrigation and Murrumbidgee Irrigation areas. This data includes a mix of commercial (price greater than $0 per ML) and non-commercial ($0 per ML) trade data.

Examining the effects of temporary water trading on production within South Australia is difficult. While some consideration was given in the production and employment modelling to the volume of trade into and out of the upper 5 communities in South Australia (Renmark, Berri, Loxton, Cobdogla-Barmera, Waikerie) and the lower 4 communities (Lower Lakes, Tailem Bend, Murray Bridge, Mannum) a significant proportion of the within-state trades are associated with postcodes outside the Murray Darling Basin. Further work would be required to determine how temporary trade between South Australian buyers and sellers is influencing irrigated production in these communities.

Within the area operated by Murray Irrigation, the MDBA assessed the effects of water recovery using the boundaries for the districts as the community boundaries. This provided information on production, water use, entitlements owned and water trade (permanent and temporary trade) for Deniboota, Denimein, Wakool, West Berriquin and that part of the Berrigan-Finley community within the Murray Irrigation footprint. The remainder of that community includes the Corurgan (check spelling) irrigation area. Temporary trading between the Murray Irrigation districts covers a longer period than can be analysed using the trade register data. The data presented here is for the period 1999/2000 to 2015/16 (Figure 10). Some general trends arise when using this data which were relevant to the community-level analysis:

- Deniboota and Denimein had consistently been net exporters of temporary water to the other districts;
- Berrigan-Finley was mostly a net importer of water from the other districts prior to the water recovery but since that time, appears to have increased the net trade of water out to the other districts;
- Wakool appears to be more regularly purchasing water from other districts since the recovery of water for the environment commenced;
- West Berriquin had mostly been a small net importer of temporary water prior to the water recovery; since the water recovery, the volume of water bought in and transferred each year has increased.

Figure 10. Net temporary trading of water between the irrigation districts of Murray Irrigation Limited, 1999/2000 to 2015/16.



Note: a positive value = net trade out of an area; a negative value = net trade into an area.

When considering the net volume of trade into and out of communities, the previous data indicates the insights which can be obtained by examining temporary trade at the state, larger regional level and at the community scale. This is particularly relevant for understanding there are particular trading patterns and, if so, how they might be influencing production and outcomes at the community scale.

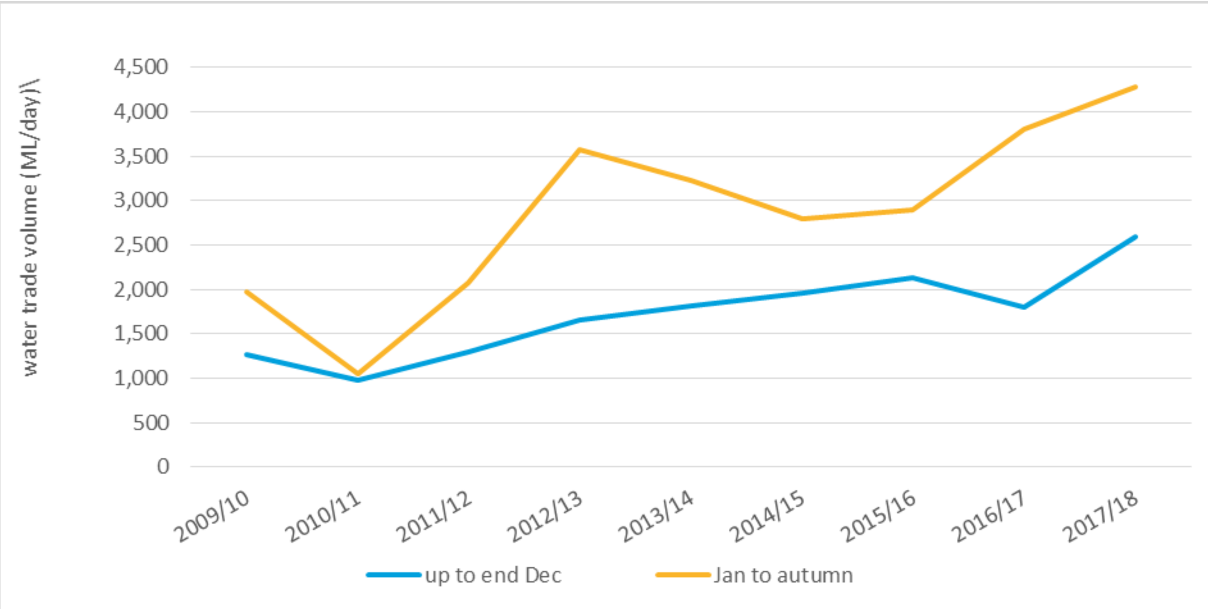
The timing of trade within the water year

Further insights can be provided by going beyond the net trade between locations to examine the volumes of water traded and the prices of temporary water trading within each water year. Annual averages for water pricing do not provide a reflection of the considerable within-year variations in water price. It seems the within-year variations reflect water availability, seasonal conditions (and expectations), and how irrigators are seeking to manage the risks to their production systems. For the latter, once the production decisions are made to grow particular crops, risks arise in relation to perceived water demands (and availability) through the summer months in particular.

While considering the water demands for irrigated crops already in the ground and the crops to be planted, irrigators have been simultaneously making decisions in relation to the volume of water they will be seeking to carryover into the following water year. The MDBA has sought to use some of the insights into the variability in trading volumes and prices within each water year to examine the potential effects of the Basin Plan water recovery in terms of how it might influence the temporary water market activities and irrigated production.

When examining the trade register available from Victoria, distinctive elements of the commercial trading behaviour became apparent. In the first instance, the daily commercial trade volume for northern Victoria after the new year period mostly increased (Figure11). Further analysis is required to understand why there is a significant difference in daily trade volume around this point in the water season. The second key observation was the volumes of daily water trade in both the pre and post-New Year periods have increasing trends. Questions remain in terms of what might be the drivers underpinning these increasing trends, such as the influence of recovering water for the environment or the improved production and water trading decisions of irrigators.

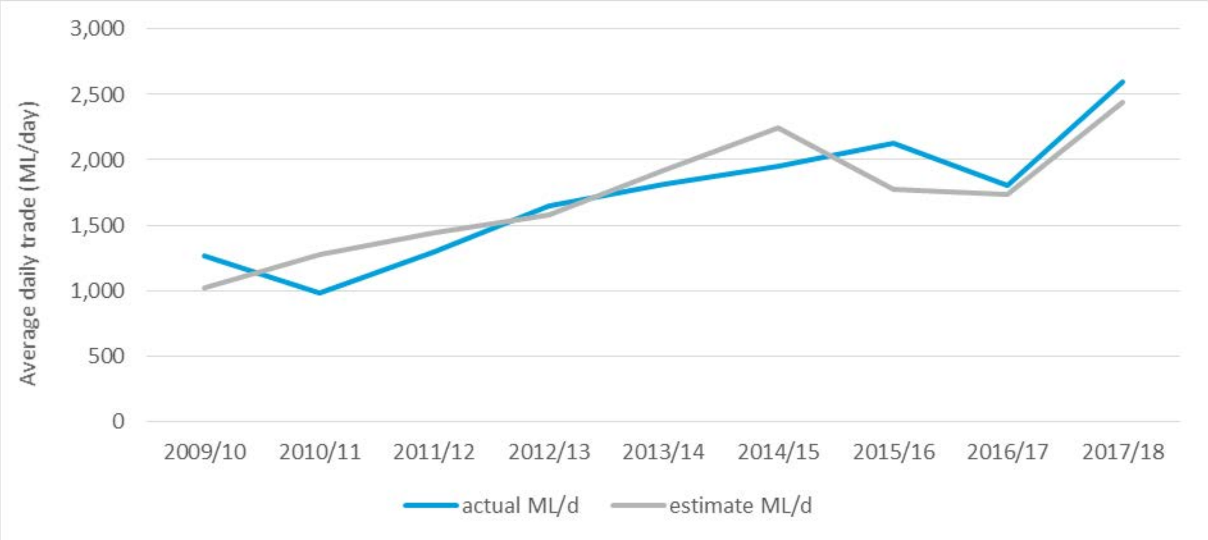
Figure 11. Average daily commercial trade volume for northern Victoria from July to December and from January to Autumn across the period 2009/10 to 2017/18.



Note: the yellow line represents the volume of trade from the start of January to autumn; different time points for examining the trade volume were used due to the highly variable climatic conditions experienced during autumn the substantive variability in prices at that time. This will be discussed in further detail in the subsequent text.

For the period from July to December, the daily volume traded was found to be well-correlated (around 75 per cent) with the starting allocations against high reliability water entitlements for the Victoria Murray and for the Goulburn systems. Further modelling indicates the average daily volume of temporary trading in northern Victoria correlates with a combination of the starting allocations in the Victoria Murray, use of dummy variable to account for 3 years of zero or 1 per cent starting allocations and the proportion of water entitlements which have been recovered for the environment. The estimated average volumes of daily water trading (based on these parameters) and actual daily trade volume for commercial temporary water trades in northern Victoria are provided in Figure 12.

Figure 12. Estimated and actuall average daily temporary trade volume for northern Victoria between July and December across the period 2009/10 to 2017/18.

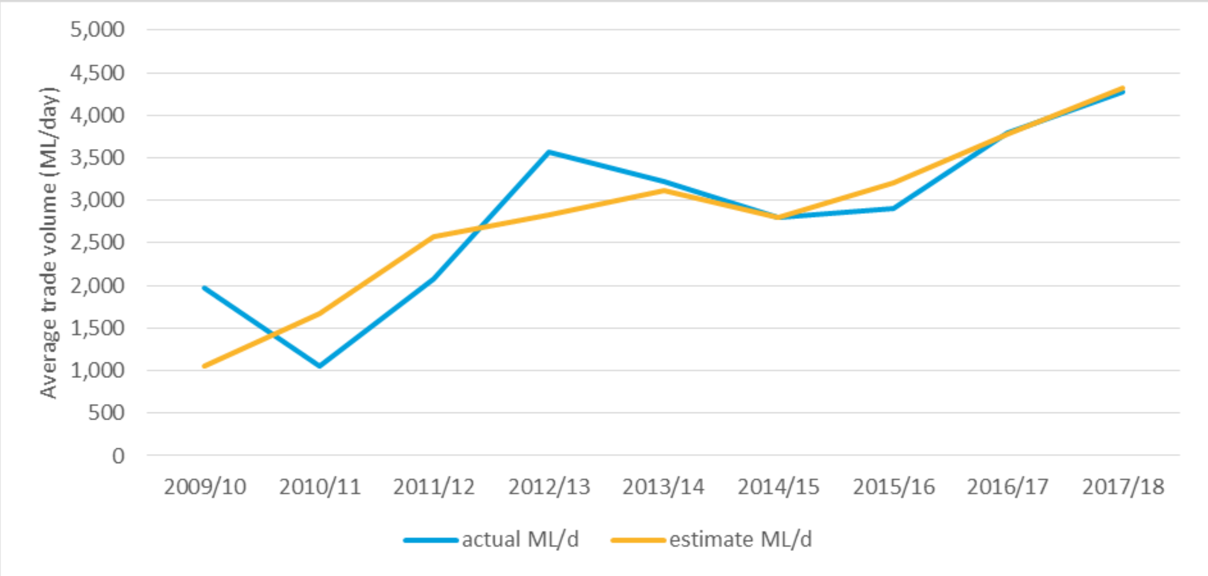


Equation

Other parameters examined by the MDBA included a combination of the starting allocation percentage for the Victoria Murray high reliability entitlements and the 1 August allocation percentage for general security entitlements in the New South Wales Murray. That equation provided estimates of the average daily trade volume which were more variable relative to the actual volume of trade than for the estimates presented in Figure 12. Further work is required to better understand the key drivers in the determinants of the daily trade volume beyond the correlations tested to date.

For the period from the start of January through to autumn, the MDBA similarly stated to examine the factors which correlate with the larger average daily water trade volumes, as described in Figure 11. In this case, the average daily water trade volume correlated most strongly with the timing of the period for reaching 100 per cent allocation on the high reliability entitlements in the Victoria Murray and the timing of the water recovery. With respect to the timing of reaching 100 per cent allocation against the high reliability entitlements, the daily trade volume was higher the later in the water season the 100 per cent allocation was announced. The modelled relationship and the observed data are presented in Figure 13. This suggests the later announcements on high allocations might correlate with decisions to reduce irrigated production in summer and to trade a larger volume of water during the second half of summer and into early autumn. Further analysis is required to better define this relationship. Other factors being considered include the timing of reaching threshold allocation percentages against general security entitlements in the New South Wales Murray. For example, the timing of 50 per cent or 60 per cent allocation announcements in the water year.

Figure 13. Estimated and actuall average daily temporary trade volume for northern Victoria between July and December across the period 2009/10 to 2017/18.



Temporary water prices across the water year

Multiple approaches could be used to examine temporary water prices and the influence of water recovery (through either purchase or infrastructure investment) on those prices. For example, the average price each year might be used for some purposes. However, it represents a fairly simplistic approach to examining water trading activities without providing details of the degree of change within the year. When using an average price it would also be necessary to focus on the standard deviations for the temporary water prices in each water year.

Alternatively, it may be more appropriate to examine other factors influencing the within-water year temporary water prices, such as:

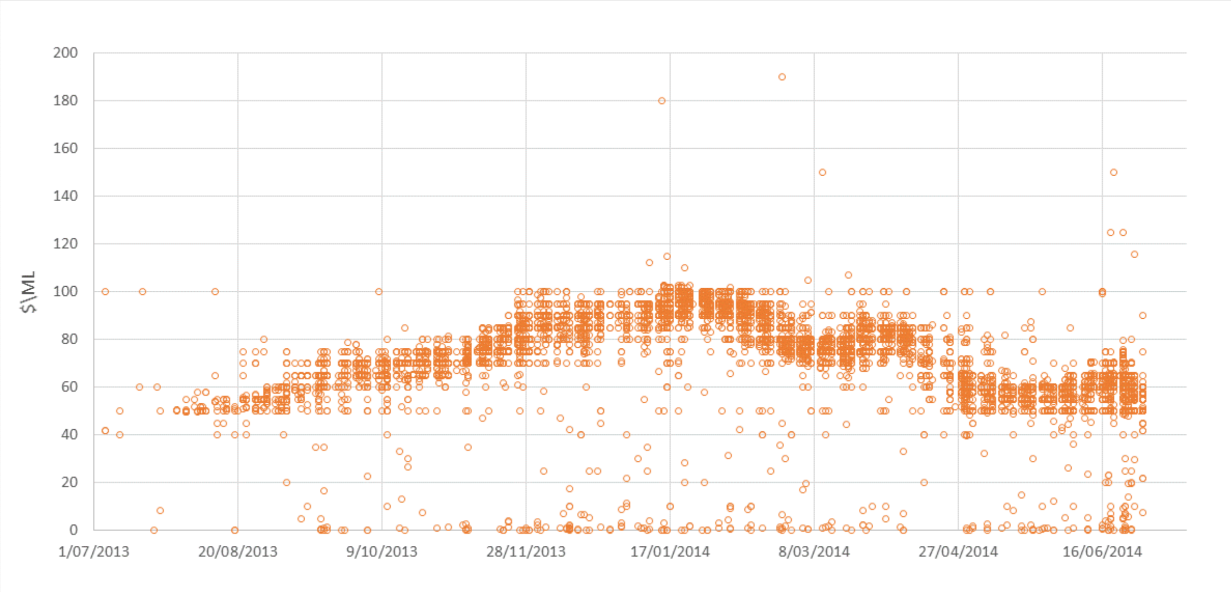
- the prevailing climate
- the perceived risks of being able to obtain water throughout the irrigation season (especially if conditions turn hotter than expected)
- irrigator adaptations in their farming production decisions, and
- an improving irrigator capability to utilise the water market to support their on-farm decision-making.

While the average annual price might be useful in some broad contexts, it is important to note the variation in price across each of the last 9 irrigation seasons has been within a range of between 2 and 4-fold. It indicates there may be benefits to understanding the reasons behind the peaks and troughs in the market price. This might depend further on the extent to which irrigators intend to purchase from, or sell into, the temporary water market.

For each of the last 9 years, the temporary water price changes across the year demonstrate distinctive elements, noting the prices recorded represent the intersection of the supply and demand curves at those point in time. While further work is required to adequately describe those supply and demand curves and to define the variables causing them to move around, some general characteristics of the market activity are frequently observed. Figure 14 presents the prices for commercial trades in northern Victoria during 2013/14 as an example. The characteristics to note include:

- Temporary water prices generally increasing between 1 July and 1 November (the demand curve for water is shifting up and to the right relative to the supply curve during this period). Exceptions to this include 2009/10 and 2016/17 where water prices had finished quite high in the previous year and fell across the period from July to November due to high levels of rainfall;
- Temporary prices are reasonably stable between the start of November and late January to early February, noting the daily volume traded increases from 1 January (the demand and supply curves are moving to the right at approximately the same pace). Exceptions to this are 2012/13 where the hot dry spell during January caused the demand curve to shift up and to the right quite abruptly with irrigators searching for additional water to apply to their crops. At the same time, the supply curve shifts up and to the left as irrigators had relatively less water to sell at each price, given the extra water they needed to apply to their own crops;
- For a six-week period around February to mid-March, temporary water prices fall (supply of water to the market increases relative to demand as irrigators seek to reduce the volume they held to ensure sufficient was available to meet the potential risks of extreme summer demands);
- Temporary water prices generally increasing again around mid-March to April (where the demand curve is shifting up and to the right relative to the supply curve, which is further reflected in the variability of the average daily trade volumes during this period);
- Observed prices in April and May appear to be influenced by the climate in autumn, expectations of rainfall in winter and potential for managing water availability risks in the next water year through the use of carryover (possibly increasing carryover volumes in some years by acquiring water through the temporary water market or having supply outstrip the demand for water through April as was the case in 2013/14).

Figure 14. Prices for commercial, temporary water trades in northern Victoria during 2013/14.



The observations of prices and volumes traded in the temporary water market indicate how the supply and demand curves are continually shifting during the water year. When the volume of trade is considered against the total volume of water available for use and the volume of water used, it should be noted that not all temporary trade is for purchasing water to immediately use on crops. Rather, it would appear large volumes of water are traded relative to the water available in some areas and communities suggesting a significant proportion of this trade is to manage the perceived risks of meeting the possible irrigation production requirements across summer. This is evidenced by certain aspects of the trading activity such as prices generally falling across February to mid-March. The water market observations and irrigator approaches to managing the risks of water availability to meet their potential demands also requires consideration in the context of the volume of water taken for use relative to the total available to irrigators each year and across years.

Estimating surface water permitted and actual take

In seeking to understand how the Basin Plan water recovery has affected the respective industries and communities, consideration may need to be given to the volume of water taken by consumptive users relative to the volume of take made available to users by the States (water lawfully accessible for take). For example, a question which may need to be addressed is whether the effect of the Basin Plan water recovery has been partly absorbed by consumptive users taking a larger proportion of the water available to them each year than was the case before that water recovery occurred. At this time, it is not possible to provide a definitive answer to this question.

SDL water accounting and compliance under the *Water Act 2007* and Basin Plan puts in place clear limits on permitted water take for States. Permitted take limits are determined at the end of the water year and are therefore retrospective, allowing them to take into account the prevailing climatic conditions. This policy framework establishes a foundation for enforcement to ensure that over the long term, the annual actual take of Basin water resources for consumptive use does not exceed the SDLs. In preparing to meet these compliance requirements, the MDBA and Basin states have been trialling the types of water reporting, accounting and compliance methods and processes that will need to be in place from 1 July 2019.

These changes are necessary given the shift from States having to demonstrate compliance with the Cap on water diversions to compliance with the SDLs. One of the reasons for not being able to address the question raised above (at this time) is a consequence of how some forms of actual take (floodplain harvesting and interception) are estimated and not yet measured. In 2016/17, approximately 26% of combined total actual surface water take was reported using long-term estimates.

While noting these limitations, available data across the last five years suggest actual take has been virtually equal to or below the permitted volume of take. For the southern Basin (including the Lachlan SDL region), the permitted volume of take (excluding interception) for the period 2012/13 to 2016/17 varied between 5,415 GL and 9,652 GL (Table 10). In the same period, the volume of take was estimated as being between 5,387 GL and 8,336 GL. That is, water take was estimated to be between 83 per cent and 99 per cent of the permissible take.

Table 10. Southern Basin surface water (excluding interception) permitted take and actual take estimates (including the Lachlan SDL region).

	2012/13	2013/14	2014/15	2015/16	2016/17
Water lawfully accessible for take (GL)	11,709	9,138	6,369	7,509	8,482
Permitted take (GL)	9,652	8,160	6,593	5,415	6,563
Actual take (GL)	8,336	6,739	6,327	5,387	5,664
Annual balance (GL)	1,316	1,421	265	29	899

Extracted from *Transition Period Water Take Report 2016/17*, Table 7.4 (MDBA, June 2018)

The data in Table 10 is consistent with the estimates of water available for consumptive water use and water deliveries in the area supplied by Murray Irrigation (as described above, where water available for use was significantly greater than the volume of water taken and used). Further work being undertaken by the MDBA and Basin states is expected to improve the methods for estimating the annual volumes of permitted and actual take. This will rely on significantly increasing the proportion of actual take which is measured. Improvements to the reporting of permitted and actual take might then provide future inputs to help improve the MDBA understanding of the effects of the Basin Plan on industries and communities.

Developments since 2016

The 5-year evaluation of the effects from the Basin Plan sought to separate the effects of the water recovery from all the other sources of change affecting communities up to that time. Those changes had been occurring within the dynamic economic and social environment of Basin communities which were simultaneously being affected by a range of factors, contributing to positive and negative trends of change. However, it is unlikely there would be any community where the Basin Plan effects had been finalised at the time of undertaking that analysis. That is, no new equilibrium of Basin Plan outcomes would have been reached in 2016. Many changes were still being felt – directly for irrigation businesses adjusting to change, for town businesses who provide goods and services to the farm enterprises and the other town and non-farm businesses. From MDBA discussions across the Basin communities, these effects take a long time to be realised. In addition, there are the broader social and community changes associated with the non-Basin Plan causes.

From the changes identified up to 2016, it is highly likely there will be further positive or negative changes in the Basin communities. It is anticipated the identified trends of the change in the population, population structure, employment and social conditions in 2016 will be added to by the time of this report being released. This is anticipated to be the case given the particular changes to various parameters such as the mix of irrigated production and the role of the IIOs in those communities where water is supplied from off-river irrigation networks. In undertaking any future analysis, the changes observed since 2016 could be used to expand upon the findings of the social and economic work undertaken by the MDBA in support of the 2017 Basin Plan evaluation. Some of these include:

- General changes in the Basin such as the expansion of perennial plantings (table grapes, almonds, olives, fresh fruit, dried fruit) and improvements in markets for citrus and wine grapes. Improvements to the markets for citrus and wine grapes have partly arisen as a consequence of the bilateral trade agreements entered into by Australia).
- Water recovery through infrastructure investment (on and off-farm) still being delivered through the previous long-term programs administered by the Commonwealth and future recovery through programs such as the 450 GL recovery from efficiency measures. In the South Australia Riverland area, the expansion of horticulture has been partly supported by activities undertaken through the SARMS (South Australia River Murray Sustainability) program.
- Changes to the locations where crops are grown. For example, some replacement of rice with cotton in southern New South Wales and a considerable increase in additional cotton production in areas developed for irrigation since 2016 (for example, along the Murrumbidgee River between Gogeldrie Weir and Maude Weir, and to the west of Griffith within the Murrumbidgee Irrigation Area); increase in table grapes around Euston and further expansion of almonds around Robinvale; where crops are considered to have diminished in terms of the area irrigated (such as rice) further investigation will be warranted to determine if this is a function of increased variability in production (smaller areas in drier years than without the Basin Plan, larger areas in average to above average years, no change in wet years); on-going improvements in technology supporting further changes to the mix of crops grown and the locations where irrigated crops are grown.
- Understanding how the mix of on and off-farm irrigation infrastructure investment is facilitating and supporting the changes in irrigated agriculture production, which will also have some relationship with the challenges for IIOs and their processes for meeting those challenges (which are also still evolving).
- For the GMID milk production area, considerations would most likely include the increasing variability in feed sources to support milk supply (with a change to the mix of on-farm pasture

and non-pasture feed options) and the on-going investment in milk processing facilities within the area (while noting the Rochester plant has been identified for closure).

Many of the changes observed since 2016 have been community specific. In addition to those identified above, there are new almond processing and fruit wholesaling businesses. For Merbein, there has been a re-invigoration of dried fruit production. Other changes across communities are expected to be influenced by the growth in production outside of the historical scheme areas. That is, to locations where water is being increasingly accessed directly from the Basin rivers, such as in the Renmark, Colignan, Robinvale and Hay communities.

Other social and economic reports

A number of studies seeking to contribute to the understanding of social and economic change arising from the Basin Plan water recovery have been released since 2011. Some of these studies focus on potential outcomes for particular industries and/or localities (Connell and Associates, 2014; RMCG, 2016; TC&A and Frontier Economics, 2017). Other studies concentrate more on changes in the water market and how observations regarding water trade might relate to changes in production as an indirect consequence of the Basin Plan water recovery and other causes of change (Aither, 2017; Australian Bureau of Agricultural and Resource Economics and Sciences, 2017).

Further analysis has sought to understand the effects on industries and communities which have been the beneficiaries of on and off-farm infrastructure investment (Department of Agriculture and Water Resources, 2017; Ernst and Young, 2018). The literature review for the independent review of the social and economic modelling approach provides further details on relevant studies undertaken to examine the effects of water recovery and water policy in general (https://www.mdba.gov.au/sites/default/files/pubs/UNE-model-independent-review-report.pdf). That review highlighted some of the issues raised both within particular studies and in submissions to parliamentary inquiries which had presumably been based on supplementary studies.

The MDBA considered and examined each of these studies as a basis for developing its approach to modelling the social and economic effects of the Basin Plan. Importantly, the MDBA recognised the consequences of the Basin Plan had not yet reached a new equilibrium and that the changes arising from the water recovery (both positive and negative) were still occurring at the time of this analysis. Furthermore, the changes from the Basin Plan arose at a time when the Basin economy was responding to multiple drivers of change. This made it necessary to examine the nature and source of change at a community level, requiring the MDBA include a temporal dimension to its analysis. That is, to recognise change and the responses to change continue over multiple years, meaning there is little value from seeking to understand the effects of change in wet, dry or other specific types of climatic condition.

An important element of the temporal relationships are the social and economic trends of change (what trends are positive or negative) and the relative scale of change within those observed trends. Without that information, it was difficult to draw conclusions out of other studies or to compare the results from the different pieces of analysis. In each case, it was essential to recognise the key assumptions made and the modelling approaches employed in the analysis when considering the conclusions reached.

One important area the independent reviewer requested the MDBA consider was the claims regarding the Jevons effect arising from investment in irrigation infrastructure (https://www.mdba.gov.au/sites/default/files/pubs/UNE-model-independent-review-report.pdf). The Jevons effect proposes an increasing use of a natural resource where there have been technology gains and improvements in economic efficiency associated with the use of such a resource. This theory was developed in relation to the use of coal for energy production in the 1800s. However, the Jevons effect is not likely to apply to water use in the Murray Darling Basin as the total volume of water available for consumptive purposes has been set in legislation.

In 1995, the Murray–Darling Basin Ministerial Council introduced the Murray–Darling Basin Cap on diversions (the Cap) to protect and enhance the riverine environment and to protect the rights of water users. The Cap introduced long-term limits on how much surface water could be taken from rivers in 24 designated river valleys. In most cases, the long-term Cap limit was determined with reference to the 1993–94 level of development in each valley. That is, the diversions for consumptive use through the water infrastructure and rules in place at that time. The annual accounts of use against the Cap limits have been recorded in the Cap Register maintained and published by the MDBA.

Subsequently, the Basin Plan set new limits on the volume of water which could be diverted for consumptive uses (the SDLs). SDLs represent the maximum long-term average annual volumes of water that can be taken for these purposes. Compliance with the surface water SDLs, requires the baseline diversion limit (BDL) be reduced by a long-term average annual volume of 2,207 GL per year. As such it is highly unlikely the Jevons effect could apply to the Basin's surface water resources as a consequence of investment into on and off-farm irrigation infrastructure.

However, results for IIOs indicate in Murrumbidgee and Coleambally Irrigation areas that the investment in on and off-farm irrigation infrastructure is coincidental to within-scheme water use increasing relative to that observed with the pre-Basin Plan relationship between historical use and water available for consumptive uses. That is, there is an observed increase in water use at the locations where it is owned and both on and off-farm infrastructure investment have occurred.

While there can't be an increasing volume of water used within the Murrumbidgee SDL region, there appears to be changes to the locations of where water is used within that catchment. Further analysis would be needed to determine the extent to which this might be a consequence of the government and non-government irrigation infrastructure investment or a function of changing irrigation enterprises (and the crop mixes grown). Further insights from the IIO analysis described previously also indicates the importance of other determinants of water use. For example, relatively low irrigator confidence to use the available water within the area supplied by Murray Irrigation between 2011/12 and 2015/16.

Overall findings

The modelling approach employed by the MDBA to separate the effects of the Basin Plan from all the other factors leading to change in the Basin irrigation industries and in the social and economic conditions of the individual communities relied on irrigated production and employment as the key indicators. Considerable data limitations helped define this modelling approach and the appropriate scale to employ. However, the modelled findings alone were insufficient to describe how the Basin Plan water recovery affected those communities.

As indicated through this report, the final evaluation results relied upon an interpretation of the modelling outputs. This interpretation required considerable information which could not be included in the landuse and employment models. It included details on worker mobility (where people live and work), temporary water trading and the challenges for the irrigation infrastructure operators. For each of these, the observed changes were influenced by the Basin Plan and non-Basin Plan factors.

Other information employed to interpret the modelled results included the mix of landuses (grazing, cropping irrigation), population, age structure, economic structure and the socioeconomic indices for area. For the population, relevant information includes the pace and timing of the changes for both the town and the farming areas of each community. Within the population, changes to the age groupings of below and above 45 years of age were taken into account. With respect to employment, consideration was similarly given to changes within the town and farming areas, the participation rates (proportion of people within the population who were employed), changes across broad economic categories (farm sector, government sector and non-agriculture private sector) and unemployment rates.

A unique output of this approach was the ability to define the relative importance of water and irrigation in each community, and to follow a change in water through to changes in different sectors of each community. New information generated by the modelling itself included the employment elasticities (that is, the change in employment at the sectoral level arising from a change in water availability). With respect to the employment elasticities, some community responses to water recovery were determined by multiple elasticities, depending on the range of irrigation sectors present in the individual communities.

The approach taken by the MDBA deliberately focussed on the irrigation-dependent communities and sought to limit any potential bias in the results by developing individual models for the economic sectors within those communities. This ensured for each community it was possible to recognise their differing dependence on irrigated agriculture, their individual social and economic makeup, the different changes they experienced, the differing scales of water owned and recovered through purchase and in exchange for infrastructure investment, and the timing of that water recovery. The social and economic makeup incorporated details on the relative size and economic diversity of communities, and whether employment (and other social and economic trends) had been increasing or decreasing over time.

Changes to the social conditions provided additional information regarding each community's ability to adapt to change. Including non-irrigation dependent communities in the analysis provided evidence in relation to the variances in the scale and drivers of change for individual rural communities affected by a range of other factors, but not water recovery.

In drawing all this information together for 40 communities with varying dependence on irrigation agriculture and communities with little irrigated production (and no water recovery), the MDBA further relied on the insights and understandings it had gained through its extensive consultation and within-community data gathering. From this comprehensive set of data and knowledge, it was possible to conclude (as spatially represented in Figure 15) that:

- 12 communities were likely to have experienced quite small effects from the Basin Plan water recovery. For Benerembah, Berrigan-Finley, Blanchetown, Coleambally, Hillston, Mirrool, Morgan, Renmark, Robinvale, Tabbita, Wah Wah and Yanco, water recovery was estimated to have reduced total employment by less than 2.7%. This level of variation makes it difficult to distinguish the impact of the Plan from the other processes of change affecting these communities. For Benerembah and Yanco it was found the Basin Plan water recovery had a positive effect on employment and production;
- For 18 communities, the effects of water recovery were modest, yet identifiable. For these communities, changes in total employment arising from Basin Plan water recovery were generally found to be in the range around 3 per cent to 5 per cent. Those communities were Cobram, Coomealla, Cullulleraine, Deniboota, Denimein, Hay, Kerang-Cohuna, Kyabram-Tatura, Mannum, Mildura, Murray Bridge, Pyramid Hill-Boort, Shepparton Irrigation Area, Swan Hill, Tailem Bend, Waikerie, Wentworth and West Berriquin;
- 10 communities were identified as experiencing large changes arising from the Basin Plan water recovery. In general, the Basin Plan effects on total employment were around 6 per cent or greater. These communities (Berri, Cobdogla-Barmera, Colignan, Lower Lakes, Loxton, Merbein, Red Cliffs, Rochester, Swan Reach and Wakool) have also been strongly influenced by non-Basin Plan drivers of change.

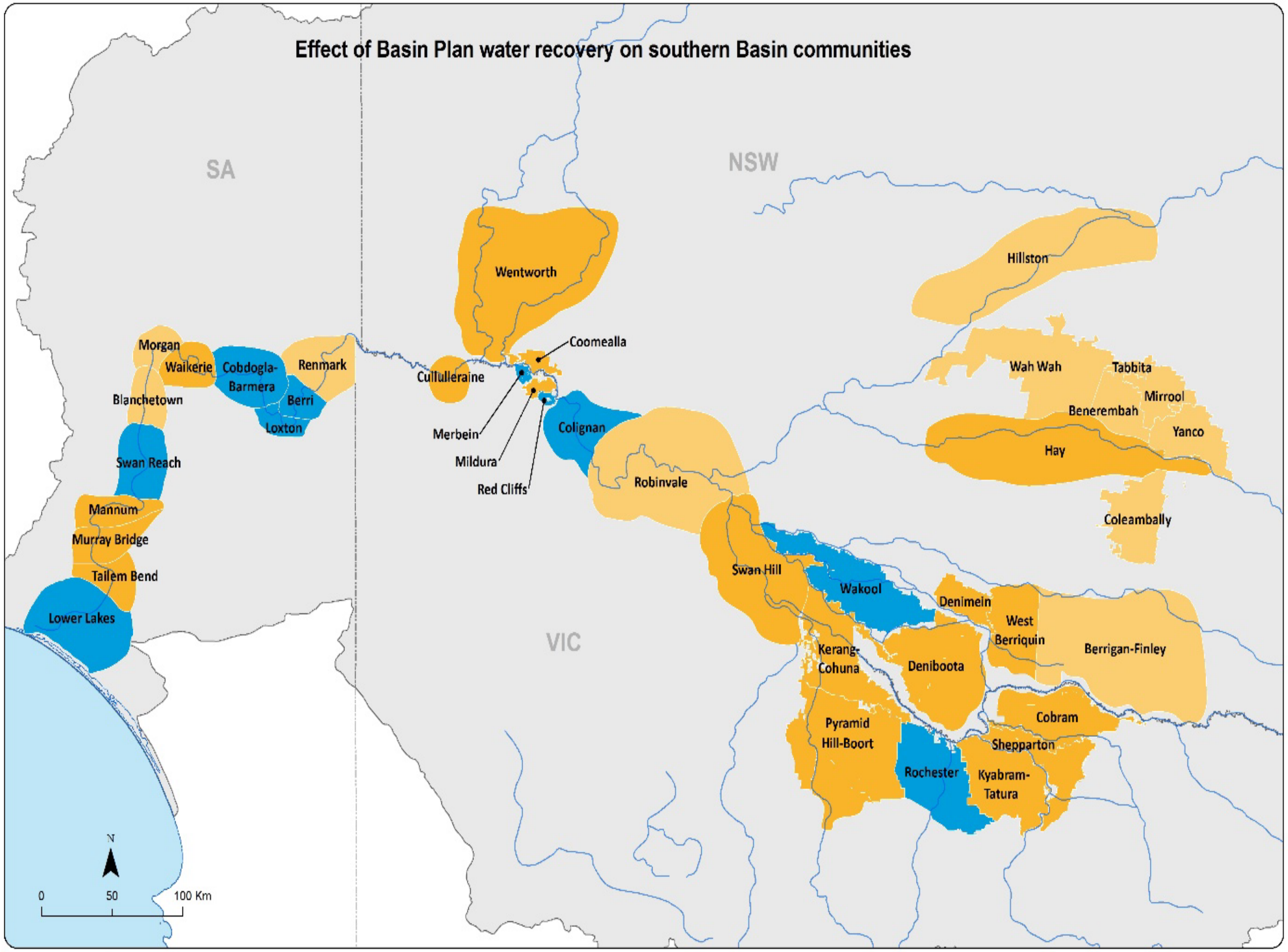
For 13 of the 18 communities with modest yet identifiable change to total employment from the Basin Plan was around 5 per cent or lower. In Cullulleraine, Mildura and Murray Bridge, the Basin Plan effects were estimated to be greater than 5 per cent of total employment. However, those changes had occurred in local communities which were growing across the period from 2001 to 2016.

With Hay and Waikerie, information in addition to the employment effects was relevant to distinguishing the Basin Plan effects as being modest rather than large. Conversely, the Lower Lakes community had a similar level of total employment change associated with the Basin Plan water recovery as observed for Hay and Waikerie, yet it is identified as having a large effect associated with the Basin Plan. The rationale for these distinctions are:

- Hay – in this community, the timing of changes are quite relevant to assessing the effects of the Basin Plan. With the water recovery, a considerable volume of water was sold to the Commonwealth. Coming out of the millennium drought, irrigated production shifted focus from rice to cotton. Permanent water entitlements were purchased back into the Hay community to support the rapid expansions of cotton, particularly from Coleambally. In more recent times, the Hay community has benefited from a further expansion of potential irrigated cotton production.

- Waikerie – beyond the water permanently traded back into this community after the Basin Plan water recovery with other forms of irrigation replacing the decrease in centre-pivot production, the community has had an increasing population, a relatively small decrease in employment for the non-agricultural sector and a relatively large increase in government services. It is expected that for this community, the modelled effect on total employment of 6.5 per cent is an over-estimation as the effect on the area irrigated is of a similar percentage change.
- Lower Lakes – the loss of irrigated production following the Basin Plan water recovery and drought, loss of confidence in irrigation (including to invest in irrigated land rehabilitation following the millennium drought) and the more recent permanent and temporary trade of water out of the area compounded the effects of the Basin Plan. The relatively small proportion of the population in employment and the large decrease in total employment (particularly contributed to by the decline in the non-agricultural private sector) across this community were deemed to have amplified the effects of the Basin Plan water recovery.

Figure 15. Estimated effects of the Basin Plan water recovery on communities (blue-shaded area = large effects; darker orange-shaded area = modest effects; light orange shaded areas = small effects).



Implications for further work

The information collated for the 2017 Evaluation provides an initial data set and modelling capability which could be extended to support the 2020 Evaluation and future review of the Basin Plan. It might be added to through:

- The inclusion of annual irrigated production data by crop type for the period after 2015/16;
- More detailed analysis of the temporary water trading activities within years and between the locations across the southern Basin;
- An improved analysis and estimation of the combined productivity improvements generated by the on-farm infrastructure efficiency investment. In particular, where that investment is associated with off-farm infrastructure investment as part of the water recovery program;
- A better understanding of the challenges for the irrigation infrastructure operators from the Basin Plan water recovery and other drivers of change; and
- Information on the social and economic benefits from the use of water recovered for the environment.

In undertaking this future work, one of the limitations will remain the spatial and temporal scales at which relevant information for evaluating the effects of the Basin Plan can be accessed. It may be possible for the MDBA to make better use of studies undertaken for other purposes or to address different questions. To support any such further analysis and to ensure the findings could be effectively used in the future social and economic work of the Authority, all the data and models used in this analysis will be publicly available.

As it takes a long time for the consequences of a change such as the Basin Plan water recovery to be fully realised, the overall effects of the Basin Plan might not be known for some time. It is reasonable to assume that further effects beyond those observed in the 2017 Evaluation will be present in the data from the next census (to be held in 2021 with relevant data released in 2023). Although that information will not be available to inform the 2020 Basin Plan evaluation, the existing data and knowledge combined with the further work identified above should provide a reasonable basis to inform the next evaluation.

Immediate uses for the modelling results and other data sets

Beyond the immediate use for the social and economic analysis to inform the 2017 Basin Plan Evaluation, the results drawn from this analysis (together with the findings of the Northern Basin Review) have been used to identify those communities which might benefit from structural adjustment support. The Department of Agriculture and Water Resources have relied on this information, and other considerations, to design a program for assisting those communities most affected by the Basin Plan water recovery. Other immediate and relevant questions arise from the work completed so far as a means for helping build an understanding of the changes affecting rural communities and how the Basin Plan might be contributing to those changes. For example:

- The temporary water trade out of the GMID region in 2017/18 (and more specifically post 1 February 2018) was by far the largest net volume recorded. Prices for that traded water were between $70 and $170 per ML. Why did the water trade out of the area at that time instead of being used to irrigate pasture? Was it a function of the need to generate cash flow following the effects of the floods in 2016 and challenging milk price conditions in 2017 which led farmers in general to purchase the cheap hay available in the area at that time? If so, is this an indication of how the years of production are linked across time and therefore cannot be considered as isolated dry, wet or average years?
- With temporary water trade in the southern connected system, how much of the total volume traded is for managing risks of access to water throughout the year compared to the trade for use? In other words, what proportion of the water trade is water being traded multiple times? Does this differ in the different climate years?
- Across the water year, the temporary water prices appear to vary in a range of between 1.4 and 2 fold. Across the years, there also appear to be periods where the prices are rising (July to November), are relatively stable (December to February) and fall (February-March). Do these particular periods offer irrigators with the opportunity to better manage their production in the context of the behaviours observed year-on-year in the water market? Is it possible that access to appropriate sources of information might assist irrigators to better manage their portfolio of water holdings across each water year?

Each of these and numerous other questions might be addressed to assist the MDBA with implementing the Basin Plan by providing greater context and understanding in relation to the changes occurring in the Basin economies and communities.

Beyond the community-level analysis, the MDBA had considered the observed changes in economic and social conditions at an industry and Basin scale. One further relevant scale of analysis might be a regional scale, such as for the Riverland or the GMID. A considerable technical challenge will be to reconcile and align the changes observed at these different scales and to draw out the effects of the Basin Plan water recovery from the other causes of change affecting social and economic conditions across time.

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Appendix 1: GMID fruit production - estimated area, volume, employment

No single source of data was available to describe fruit production across time in the GMID area of northern Victoria. Multiple sources of data were drawn together to indicate the possible level of production since 2001. The purpose was to develop a data set for use in estimating how the Basin Plan may have impacted on fruit production across the GMID.

LGA-level data from the 2001, 2006 and 2011 census indicates the area of fruit trees (including pears, apples, stone fruit) across that period varied around 12,000 hectares (Table A1.1). However, the locations of where the trees had been planted did change. Note Greater Shepparton A straddles across the Shepparton Irrigation Area community and the Kyabram Tatura community; Greater Shepparton B – east is in the Shepparton Irrigation Area; Shepparton B – west is in the Kyabram-Tatura community (as is Campaspe-Kyabram); Moira East and Moira West are located in the Cobram community.

Table A1.1. Estimate area of irrigated horticulture in the shires of the GMID.

Hectares	2001	2006	2011
Greater Shepparton A	1,647	4,459	4,467
Greater Shepparton B – east	2,973	880	917
Greater Shepparton B – west	3,350	2,493	1,645
Moira east	101	534	222
Moira west	3,616	3,824	4,227
Campaspe - Kyabram	366	394	335
Total	**12,053**	**12,584**	**11,813**

Source: Irrigated area data extracted by Australian Bureau of Statistics upon request by MDBA.

From the 2016 census, the area of fruit trees was estimated to be around 9,148 hectares within the Shepparton SA4 region (Australian Bureau of Statistics, 2017). The census data was converted to estimates of the total fruit production in each of the communities modelled (Table A1.2).

Table A1.2. Community-scale estimates of the area of irrigated horticulture in the GMID.

Hectares	2001	2006	2011	2016
Cobram	3,717	4,358	4,449	3,430
Shepparton	6,252	6,170	5,523	4,300
Kyabram - Tatura	2,084	2,056	1,841	1,418
Total area	**12,053**	**12,584**	**11,813**	**9,148**

Note: some of the 5,200 hectares of fruit trees in the Bendigo and Hume SA4 regions might needed to be added to this estimate of 9,148 hectares in order for the 2016 data to be directly comparable with the shire-based data from the previous 3 census. Source: Data for 2016 was derived from Water use on Australian Farms, Australian Bureau of Statistics (Product code 4618).

The estimated change in hectares is insufficient to describe the level of change within the industry. As the local cannery market declined, the fresh fruit market became more important to producers. In addition, the orchard layouts and tree species planted changed considerably between 2001 and

2016. In this timeframe, the volume of apples harvested varied from 65,000 to 75,000 tonnes per annum (data provided to MDBA by Apple and Pear Australia Limited).

For pears, the volume of production fell from around 120,000 to about 90,000 tonnes per annum across the period from 2002/03. It is important to note the volume of pears decreased from 120,000 to 84,500 tonnes between 2002/03 and 2009/10 before increasing back up to around 90,000 tonnes. This suggests that, similar to dairying, many people had decided to leave the industry ahead of the water recovery and since that time, there have been subsequent positive production changes in the pear sector.

When estimating the value of the pear and apple production, it was assumed the prices received were at least $2,000/tonne (source: price suggested to MDBA by Apple and Pear Australia Limited as the breakeven price for apples and pears). That is, $2 per kilogram was required to cover all the costs of production. These results suggest the farm-gate value of fruit production in Shepparton is around 70% of the combined farm gate value of fruit plus milk output. In Cobram, it is around 40% of the combined value and 20% in Kyabram-Tatura.

Further evidence for the timing and extent of change in the different sectors of the GMID was derived from the census employment data. Information was collated for people involved in fruit growing, processing and wholesaling (Table A1.3). For comparative purposes, the full-time equivalent (FTE) employment in dairying is provided. Percentages changes relative to the 2001 estimates of employment are provided in brackets (that is, the percentage of people who have left those sectors).

Table A1.3. Full-time equivalent employment estimates for the Shepparton community (2001-2016).

Shepparton	2001	2006	2011	2016
Fruit growing	119	92 (23)	80 (33)	65 (45)
Fruit processing	136	124 (9)	96 (29)	46 (66)
Fruit wholesaling	63	15 (76)	8 (87)	5 (92)
Dairy farming	379	238 (27)	149 (61)	154 (59)

Source: data extracted and collated for the MDBA by the University of Canberra.

In Shepparton, the dairy sector employment is larger than the fruit growing, processing and wholesaling sectors combined. Employment decline has been constant across time in fruit growing, while for processing it was mostly between 2011 and 2016, and between 2001 to 2006 for wholesaling.

Kyabram-Tatura remains the main centre for fruit processing. There was little change in fruit growing FTE across the period, with fruit processing FTE declining most strongly between 2006 and 2016 (Table A1.4). The major change for fruit wholesaling was between 2001 and 2006.

Table A1.4. Full-time equivalent employment estimates for the Kyabram-Tatura community (2001-2016).

Kyabram-Tatura	2001	2006	2011	2016
Fruit growing	168	178 (+6)	146 (13)	158 (6)
Fruit processing	485	513 (+6)	335 (31)	140 (71)
Fruit wholesaling	96	44 (54)	37 (61)	6 (94)
Dairy farming	1,375	1,007 (27)	783 (43)	782 (43)

Source: data extracted and collated for the MDBA by the University of Canberra.

For Cobram, there was a modest decline in fruit growing employment, with large changes in fruit processing between 2006 and 2016 (Table A1.5). Fruit wholesaling employment declined across the period.

Table A1.5. Full-time equivalent employment estimates for the Cobram community (2001-2016).

Cobram	2001	2006	2011	2016
Fruit growing	197	169 (14)	177 (10)	138 (30)
Fruit processing	81	67 (17)	48 (41)	27 (67)
Fruit wholesaling	48	29 (40)	23 (52)	2 (96)
Dairy farming	1,054	863 (18)	602 (43)	597 (43)

Source: data extracted and collated for the MDBA by the University of Canberra.

In 2001, fruit growing, processing and wholesaling employment was around half the employment in dairy farming (across these 3 communities) (Table A1.6). By 2016, while both sectors had declined considerably, the fruit growing, processing and wholesaling sectors were reduced to around 38% of the employment in milk production.

Table A1.6. Full-time equivalent employment estimates for the Shepparton, Kyabram-Tatura and Cobram communities (2001-2016).

Combined area	2001	2006	2011	2016
Fruit growing	485	439 (9)	403 (17)	361 (26)
Fruit processing	702	704 (0)	479 (32)	213 (70)
Fruit wholesaling	207	88 (57)	68 (67)	13 (94)
Dairy farming	2,808	2,108 (25)	1,534 (45)	1,533 (45)

Source: data extracted and collated for the MDBA by the University of Canberra.

Appendix 2: Estimating seasonal worker requirements

Many farmers in the basin employ seasonal workers to assist them with various farm operations. Seasonal workers include workers from outside the communities of interest who are not currently identified in the census employment data. They will include people who come from other areas in Australia and from overseas to undertake specified tasks for short periods of time such as fruit picking or vine pruning. Potential approaches for collating the seasonal worker data set were considered by the University of Canberra (https://www.mdba.gov.au/sites/default/files/pubs/2016-Census-Community-Profiles-Report.pdf). No existing data source (or combined data sources) was identified as being suitable for informing the MDBA community-level modelling. As suggested by NATSEM, the MDBA undertook new survey work and analysis to provide estimates of seasonal workers employed and changes to the demands for these workers over time. Seasonal worker requirements were estimated for each perennial and some annual crops.

How the seasonal worker employment data was derived

Survey respondents were asked to provide information on the area of each crop type, the number of seasonal workers engaged at particular time points throughout the year and the period over which those employees were engaged. While the main focus of the survey was to estimate the seasonal worker requirements in horticulture and viticulture, the MDBA sought to understand the requirements of dairy and rice growers. Estimates on seasonal worker requirements in cotton were derived from the MDBA social and economic analysis for the Northern Basin review.

Data was collected via telephone and face-to-face interview of farmers operating different types of irrigation enterprises. 38 farmers from South Australia, southern New South Wales and northern Victoria responded to the survey. As indicated in Table A2.1, the business owners represented both specialised and mixed irrigated production. Survey participants were also asked to indicate how the demands for seasonal workers might have changed across time.

Table A2. 1 Industry participants providing the MDBA with data on seasonal worker requirements.

Commodity grown	Geographical area	State(s)
Almonds	Merbein	Victoria
Wine grapes	Paringa	South Australia
Citrus and wine grapes	Waikerie	South Australia
Apples and Pears	Goulburn	Victoria
Apples	Ardmona	Victoria
Wine grapes and Citrus	Renmark	South Australia

Commodity grown	Geographical area	State(s)
Wine grapes	Mildura	Victoria
Citrus	Gol Gol	New South Wales
Almonds	Waikerie	South Australia
Dairy	Goulburn	Victoria
Citrus and wine grapes	Waikerie	South Australia
Apples and Pears	Shepparton	Victoria
Horticulture crops	Shepparton	Victoria
Kiwi and Plums	Shepparton	Victoria
Apples, other horticulture	Shepparton	Victoria
Cotton and Corn	Coleambally	New South Wales
Citrus	Sunraysia	Victoria, New South Wales
Dried fruits	Merbein	Victoria
Rice and other crops	Coleambally	New South Wales
Rice and other crops	Coleambally	New South Wales
Apples, pears, other horticulture	Shepparton	Victoria
Rice	Coleambally	New South Wales
Rice	Benerembah	New South Wales
Cotton and wheat	Benerembah, Griffith	New South Wales
Almonds	Renmark	South Australia
Apples, other horticulture	Shepparton	Victoria
Horticultural crops	Shepparton	Victoria
Peaches, apricots	Cobram	Victoria
Dried fruits	Mildura	Victoria
Citrus	Riverland	South Australia
Pears and Nectarines	Shepparton	Victoria
Table grapes	Mildura	Victoria
Dried fruits	Mildura	Victoria
Citrus	Colignan	Victoria
Employee contractor	Renmark	South Australia
Government representatives	Renmark	South Australia

Data collected through the survey was transformed to provide an estimate of total seasonal worker demands at the enterprise level. The findings of that analysis were then checked with the data providers. Survey participants provided guidance to the MDBA on whether the estimates were a reasonable representation of the seasonal labour requirements. In some cases, they indicated how and why the estimates might be improved.

The survey results indicate seasonal worker requirements may be influenced by the size of the operations. However, further data collection and analysis would be required to test this proposition. While the final results of the survey are presented as a weighted average estimate of seasonal workers required per 100 hectares, the range across the survey participants is also provided (Table A2.2).

Table A2. 2. Estimates of seasonal worker requirements for each crop type.

Commodity	Area (Ha)	Work days					FTE	FTE/100 ha
		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total		
Grape	573	300	750	0	0	1,050	4.04	0.7 (0.4-2.1)
Citrus	1,184	2,030	11,450	20,040	3,080	36,600	140.77	11.9 (6.2-35.2)
Stonefruit	130	3,465	200	740	3,060	7,465	28.71	22.1 (18.8-39.6)
Pomme fruit	319	3,835	1,100	5,100	1,140	14,135	54.37	17.0 (11.3-31.5)
Almond	8,080	18,420	3,626	9,441	378	31,865	122.56	1.5 (0.9-48.6)
Rice	1,002	250	50	0	0	300	1.15	0.11 (0.08-0.25)

To assist the MDBA with interpreting the community-level modelling results, it was necessary to consider the seasonal worker requirements associated with each crop type. Their demands for goods and services flowed through to other sectors of the local economies. The strongest effects would have been felt in the non-agriculture private sector, which includes retailing, accommodation, food and grocery stores). Results provided in Table A2.2 indicate the temporal demands by these workers in each community. For example, most workers are required in April to June for grapes and July to September for citrus production. The summary also provides data on the aggregate yet variable seasonal worker requirements, especially in those communities which rely on production from several commodities. The corresponding influx and retreat of seasonal workers from communities in different seasons of a year also contributed to the regular, local economic stimulus and slow down.

While this information assisted the MDBA to estimate the effects of the Basin Plan water recovery, it has substantive limitations. The sample size of the survey was small (n=38). As such, it provided a good general indication of the seasonal worker requirements. The data developed in the survey is based on participants' memory, making it difficult to draw any strong conclusions with respect to the changes in seasonal worker demands across time. Estimates should be regarded as indicators of seasonal worker requirements and not as comprehensive estimates.

Appendix 3: Changes for Irrigation Infrastructure Operators

This Appendix describes the high-level water delivery operations of six irrigation companies (Murrumbidgee Irrigation, Coleambally Irrigation, Murray Irrigation Limited, Central Irrigation Trust, Renmark Irrigation Trust, and Goulburn Murray Water). It then considers the option for exploring and identifying the contribution of the Basin Plan to the various challenges they face. It is anticipated the influence of the Basin Plan is likely to depend on where and when that purchase of entitlements and irrigation infrastructure investment occurred, and the relative scale of the recovery.

For each of the irrigation companies, the Basin Plan is likely to have had varying degrees of positive and negative influence. Commonwealth investment into the water delivery (off-farm) infrastructure is likely to have had a positive influence on the irrigation businesses, and in many cases the wider communities in which they operate. The purchase of water entitlements from irrigators within those some areas may have a negative effect on IIOs. At the same time, water recovery through investment in on-farm infrastructure might have both positive and negative influences on the operations of irrigation companies. A consequence of these influences is the potential flow through effects to the fixed and variable water delivery revenue streams of the irrigation companies.

An initial examination of the operating costs and returns for the irrigation companies (based on their annual reports) highlighted how the cost and revenue streams have been changing alongside the evolving internal structures of each organisation since 2000/01. The appropriately complex business arrangements might be reflected in their decisions to invest in programs to improve their operating efficiency, a shifting balance between fixed and variable charges, and the addition of new elements to their businesses. To simplify the current task, the MDBA has sought to examine options for separating the effects of the Basin Plan from all the other factors contributing to the challenges and changes facing irrigation companies by examining:

- Changes to the water entitlements held by irrigators
- Variations in on-farm deliveries, including the minimum and maximum delivery volumes, and
- The volume of water delivery rights or shares (WDR) which have been terminated.

The analysis period of 2000/01 to 2015/16 includes a period of low annual allocations during consecutive years of drought and higher allocations during major flood events, indicating the influence of climatic conditions on the volume of water delivered to farms. Other possible factors relevant to understanding the causes of change in the revenue and costs streams where not used at this time either because they are highly complex in how they have been derived or the information is not readily accessible.

It is noted that an examination of the 3 factors listed above may not provide conclusive evidence of the effect the Basin Plan has had, so far, on the irrigator companies. Consultations with some operators indicated, in their view, the full effects of the Basin Plan may not be observed at the present time due to the climatic conditions experienced in the last 10 years and the lag between the policy change and the apparent effects. Further, the irrigation companies indicated how they had implemented (or are in the processes of implementing) internal changes to stabilise their revenue streams and address or minimise the risks arising from the multiple factors influencing the operation of their businesses. The following sections outline some key observations which may require future consideration in understanding the effects of the Basin Plan on irrigation companies.

Water access entitlements, WDR terminations

Irrigators access water in the irrigation districts through two entitlements - an entitlement to access water and a WDR. With the entitlements to access water, state governments provide allocation announcements on the volume of water available against particular types of licences throughout the water year (essentially, the financial year). Water recovery for the Basin Plan has focussed on these entitlements. Holding a WDR enables irrigators to receive water or drainage services through the network of an irrigation company, or irrigation infrastructure operator (IIO). In some cases where irrigators have sold their water access entitlements, they may have also terminated their WDR.

Irrigators generally pay a fixed annual fee for their WDR which contributes to the ongoing cost of maintaining and upgrading the irrigation infrastructure. A termination of those rights might incur a termination fee. Rules for determining those fees have been developed to ensure a balance between the interests of irrigators that are leaving an irrigation district and the irrigators who wish to remain. Under the ACCC rules, the maximum termination fee allowed is up to 10-times the annual delivery right charge unless an irrigator has an agreement with its operator to pay a lesser amount[1].

In the short term, irrigation company access to termination fees would help them adjust to the changing demands upon their irrigation networks. However, in the longer term, the termination of WDRs will reduce irrigation companies' revenue stream. Depending upon the proportion of irrigators who terminate their WDR, the companies have raised concerns about the potential financial constraints this might place on their organisations.

The termination of WDR between 2008/09 and 2015/16 (after the separation of land and water ownership in 2007) and the change in water entitlements held by irrigators within the networks managed by IIOs provides a starting point for this analysis. Across the 6 irrigation companies examined, the volume of water entitlements held has declined by between 17.2 per cent and 35 per cent (Table A3.1). Not all this decrease in the entitlements held by irrigators is associated with the Basin Plan water recovery. A considerable volume of water has also been traded to areas outside of the networks managed by the irrigation companies. At the same time, the WDR terminations reported by these 6 companies represents a decline between 3.3 per cent and 12.6 per cent of the rights held in 2008/09. The decline in WDRs is lower than for irrigation entitlements across the six irrigation companies. This observation may suggest some farmers are selling their water entitlements but keeping the WDRs and thereby retain the opportunity to irrigate their farms at some time in the future using water acquired through the temporary water market. Others may not be intending to

[1] Available from: https://www.accc.gov.au/system/files/Permanently%20selling%20your%20water%20and%20terminating%20your%20delivery%20right.pdf

irrigate in future but are seeking to avoid the immediate requirement to pay the termination fees, thereby continuing to be charged the annual fixed fees.

Table A3.1. Changes in water entitlements and termination of WDRs between 2008/09 and 2015/16.

IIO	Change in water entitlements 2008/09 to 2015/16	WDR terminated 2008/09 to 2015/16
Murrumbidgee	(17.2%)	(3.3%)
Coleambally	(18.6%)	(12.3%)*
Central Irrigation Trust	(35.0%)	(12.6%)
Murray	(23.5%)	(9.8%)
Renmark	(20.5%)	(6.2%)
Goulburn Murray Water	(19.1%)	(4.0%)

Source: MDBA aggregation of data from annual reports prepared by irrigation companies. *Note: for Coleambally Irrigation, customers requested the re-activation of terminated WDR. The net effect has been the majority of the 12.3 per cent of WDR terminated have been reactivated. A key objective of that business has been to encourage WDR to have a value so that customers may choose to retain or trade WDR.

On-farm deliveries

In general, the irrigation companies are seeking to rely on revenue streams which balance a mix of fixed and variable charges in an equitable way. In most cases, the variable charges relate to the volume of on-farm water deliveries. Analysis of the on-farm water delivery volumes covers the period between 2000/01 and 2015/16. While this is longer than the period examined for changes in water delivery rights and entitlements, it provides a mix of wet and dry years for comparative purposes, particularly given the significant annual variations in water delivery and indicates the fluctuations in the variable revenue of the irrigation companies.

A comparative assessment of the differences in volumes between the maximum (peak) and minimum (trough) annual water deliveries shows a marked variation of between 26 per cent and 98 per cent across the 6 companies (Table A3.2). The variability in water use differs to the variations in water entitlements and WDR as described in the previous section. For example, with the Central Irrigation Trust, the change in entitlements held by irrigators is greater than the change in the volume of water deliveries. For each of the other companies, the converse applies.

Table A3.2. Variation in water delivery volumes between peak and trough years

IIO	Peak (GL)	Peak year	Trough (GL)	Trough year	Variation (GL)	Variation
Murrumbidgee	857	2000/01	210	2007/08	(647)	(75%)
Coleambally	413	2000/01	36	2007/08	(377)	(91%)
Central Irrigation Trust	84	2001/02	62	2010/11	(22)	(26%)
Murray	1,240	2001/02	29	2007/08	(1,210)	(98%)
Renmark	39	2000/01	20	2010/11	(19)	(50%)
Goulburn Murray Water	1,948	2000/01	519	2010/11	(1,429)	(73%)

Source: MDBA aggregation of data from annual reports prepared by irrigation companies

Variability between the respective peaks and troughs in water delivery (Table A3.2) is a function of the types of entitlements held, climatic fluctuations, permanent and temporary water trade, and the means of recovering water for the environment. This volatility in water delivery may be a challenge to irrigation companies, particularly those more dependent on revenue from their variable charges.

Comparison of maximum irrigation deliveries

A comparison of the peak volume of water delivery by each of the irrigation companies between 2000/01 and 2015/16 could potentially shed insights into the effect of the Basin Plan water recovery. A decline in peak water delivery volumes might be expected in response to the recovery of water entitlements, the termination of delivery rights, and the permanent and temporary trade of water into or out of the networks operated by the irrigation companies. Of the IIOs examined, Renmark and Goulburn Murray Water had a lower maximum in 2012/13 (after most of the water recovery) than in 2001/02 (prior to the water recovery; Table A3.3). For Coleambally Irrigation, the 2012/13 maximum is slightly higher than in 2000/01. For the other irrigation companies, there was little change.

Table A3.3. Comparison of maximum water delivery between 2000/01 and 2012/13

Maximum delivery comparison	Irrigation companies
Higher	Coleambally Irrigation
Lower	Renmark Irrigation Trust, Goulburn Murray Water
No significant change	Murrumbidgee Irrigation, Central Irrigation Trust, Murray Irrigation Limited

Source: MDBA aggregation of data from annual reports prepared by irrigation companies

The observations of maximum water deliveries for Coleambally Irrigation across time demonstrate the challenges in seeking to separate out how the Basin Plan has contributed to the changing circumstances of the irrigation companies. Considerable investment in the efficiency of water delivery from private funds and from infrastructure investment by the Commonwealth combined with internal changes to the operations of the business have contributed to the ability for increasing the maximum volume of water delivery.

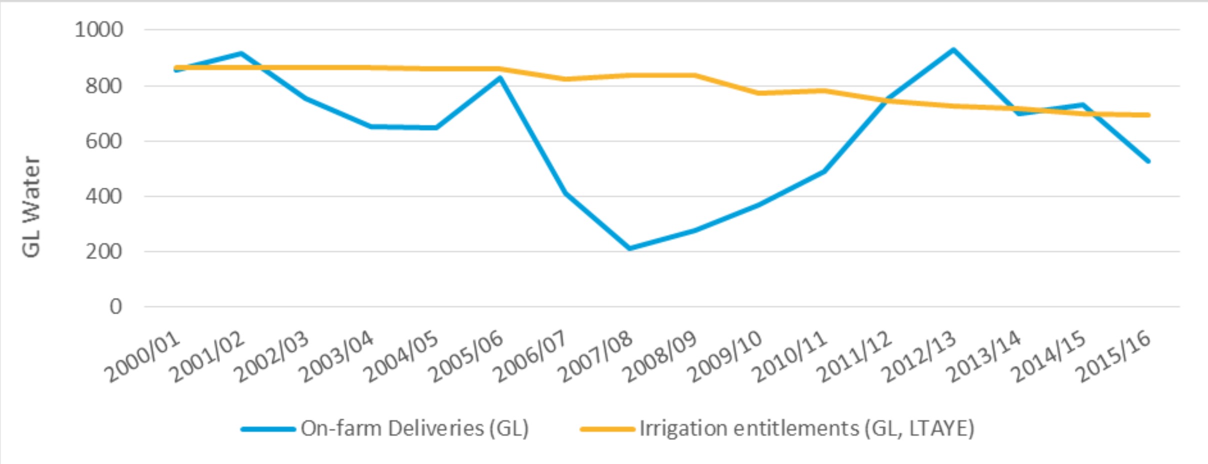
The irrigation company data summarised in Table 3.3 provides a comparison of the maximum annual volume delivered by each company before and after multiple sources of change, including the majority of the water purchases for the Basin Plan water recovery. In considering this information, the irrigation companies also reflected on the expectation from WDR and entitlement holders that the capacity for maintaining the peak volume of water deliveries be retained within the networks even though there might be considerable variation in the total volume of water delivered each year.

Individual irrigation company information

Murrumbidgee Irrigation

Murrumbidgee Irrigation (MI) delivers water to over 3,000 landholdings and is owned by more than 2,500 customers, covering an area of 670,000 hectares. Water deliveries varied by over 75 per cent (between 932 GL and 210 GL) across the period from 2000/01 to 2015/16 (Figure A3.1). A comparison of the peak delivery volumes shows the peak volume has remained relatively stable (920 GL in 2001/02, 930 GL in 2012/13). Conversely, the volume of irrigation entitlements followed a modest linear decline, averaging around 1.5 per cent per annum (yellow line, Figure A3.1).

Figure A3.1. Murrumbidgee Irrigation deliveries and water access entitlements, 2000/01 to 2015/16



Source: MDBA aggregation of data from irrigation company annual reports.

Consultations with MI operators reveal it has been challenging to observe the effects of the Basin Plan because there is a lag between a multitude of policy and other changes, and the aggregated responses of the IIOs and the irrigators to those changes. A requirement to separate irrigation water entitlements and WDR was initiated in 2007. The separation of those entitlements was realised in 2011 although some customers are still seeking to understand what the changes mean with respect to the rights for ordering and receiving water deliveries. The ownership of WDR also has implications for the rights to carry over water and for accessing internal enhancements to the allocations of water against entitlements that may become available during the water year. Each of these matters have the potential to influence the total volume of water delivered.

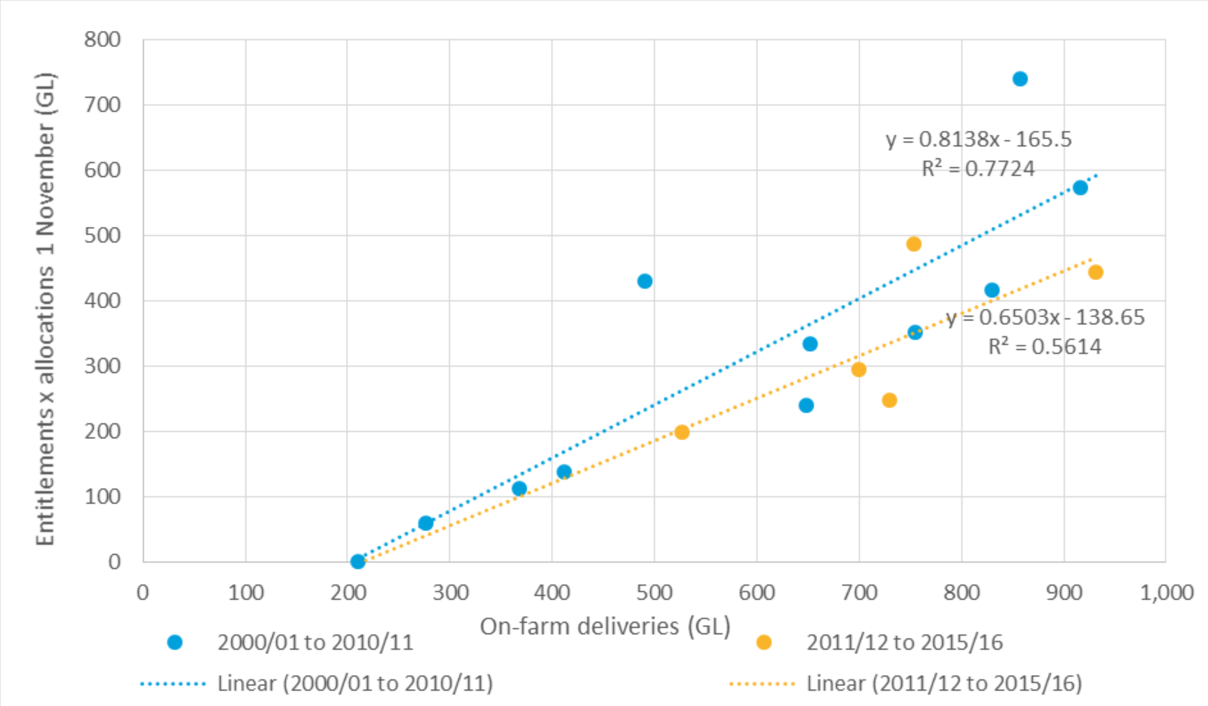
While the volume of water entitlements held by irrigators has fallen by around 20 per cent since 2000/01 (including 17 per cent since 2008/09), changes to the WDR are quite different. While 3.3 per cent of the delivery rights held by irrigators have been terminated, the total volume of water delivery rights issued and held by irrigators has increased by just over 2 per cent. These changes have potential implications for the demands upon the network and the mix of fixed and variable charges the irrigation company might obtain in future.

Adding to those changes are the recovery of water for the environment through the Basin Plan and other programs, the benefits from upgrading the network infrastructure through company investment and funding from the Commonwealth water recovery programs, and the on-farm infrastructure investment. At the same time, the mix of crops grown and the locations where permanent and annual crops are grown across the MI footprint has been changing considerably. Further causes of change, which may be leading to an increased activation of licenses and an increased proportion of allocated water being used, might include the increased carryover provisions (rising from 15 per cent to 30 per cent) and irrigators seeking to use new contractual options such as forward water purchases and leasing arrangements to underpin production.

With the nature, timing and scale of these changes, it is difficult to separate out the positive and negative influences of the Basin Plan water recovery on the operations of MI. From MI's perspective, the effects of the environmental water recovery purchases might become more evident in a run of dry years. Still then, it might be hard to identify the Basin Plan effects. For example, one of the internal interventions being established by MI is a drought delivery strategy to provide clarity for their customers on how the water deliveries might be managed during such occurrences.

Observations of water deliveries relative to water available for production before and after the Basin Plan (and other) water recovery provide further insights for consideration. For the period 2000/01 to 2010/11, there was a fairly consistent relationship between the annual farm deliveries of water by MI and the volume of water available to support production decisions (allocations on 1 November times the volume of general security water access entitlements held by irrigators; Figure A3.2, blue line). However, for the period from 2011/12 to 2015/16, the volume of water deliveries relative to the volume of water available to support production decisions increased (Figure A3.2, yellow line). That is, the myriad of changes made to the operational efficiency of delivering water (combined with irrigator decisions and methods for utilising that water and water policy changes) has led to an enhancement of water use within the irrigation network footprint for a particular volume of water availability, even though the volume of entitlements held has decreased.

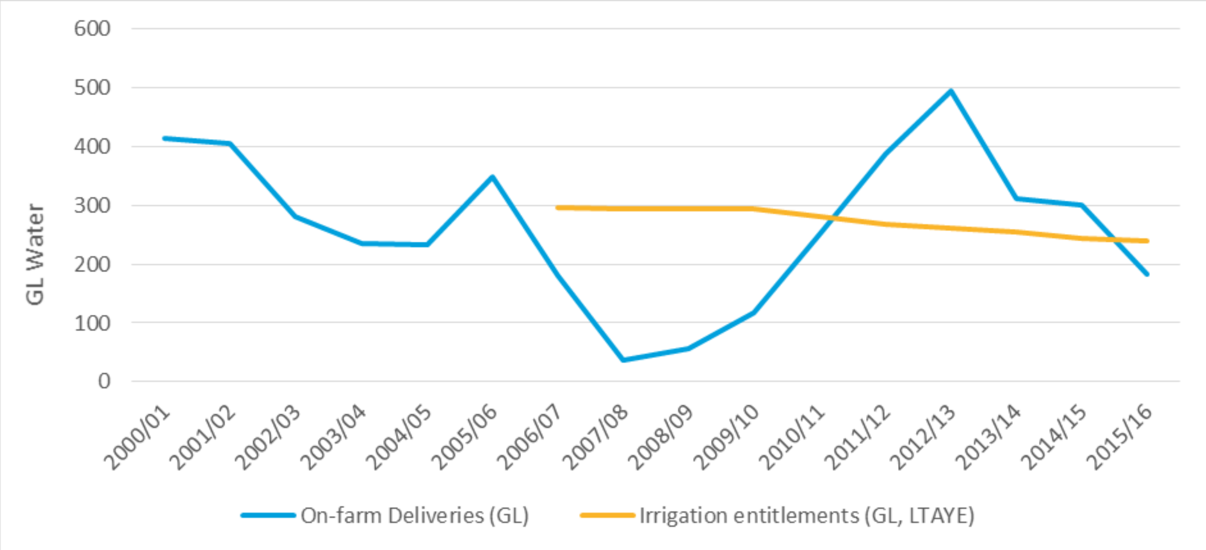
Figure A3.2. On-farm water deliveries and water availability on 1 November against general security water entitlements within the Murrumbidgee Irrigation network, 2000/01 to 2015/16



Coleambally Irrigation

Coleambally Irrigation Co-operative Limited (CICL) is wholly owned by its members. CICL total annual water delivery volumes exhibited significant variability between 2000/01 and 2015/16 (Figure A3.3). From 2000/01 to 2007/08, the annual delivery volume fell 91 per cent, reflecting the considerable variability in supply. However, relative to the delivery volume in 2000/01, the maximum water delivery volume increased by almost 21 per cent in 2012/13. The increase in the maximum water delivery volume occurred at a time when the entitlements held by irrigators had been falling. Since 2006/07, the average decrease in entitlement volume was around 2.3 per cent. The decline in entitlements was a function of the sale of water to irrigators outside the CICL network, the recovery of water for the environment through the Basin Plan, and other non-Basin Plan recovery programs.

Figure A3.3. Coleambally Irrigation deliveries and water access entitlements, 2000/01 to 2015/16



Source: MDBA aggregation of data from irrigation company annual reports; Entitlements in long-term average available yield equivalents

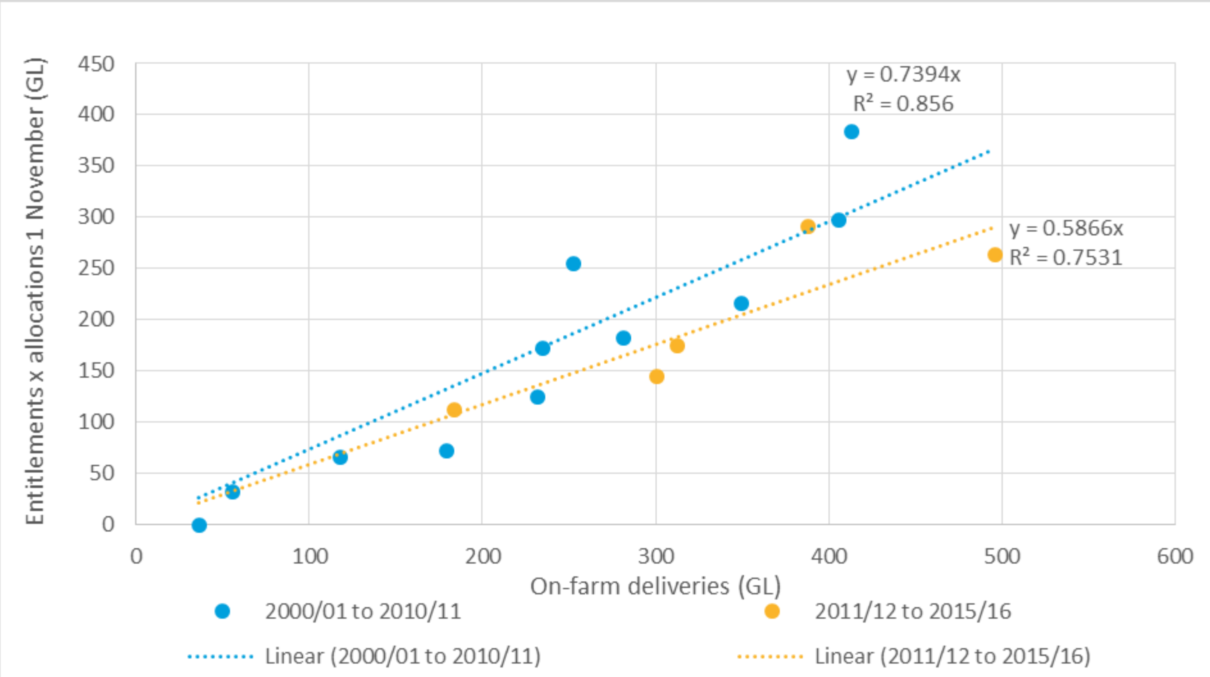
Given the increase in the maximum volume of water delivered as the entitlements held by irrigators within the network decreased, considerable effort would be required to define the effects of the Basin Plan water recovery. In addition to those observed changes, CICL has made considerable changes to the operations of the irrigation company, including bringing forward some planned investment to upgrade the off-farm irrigation infrastructure. That investment was delivered by the company and through the off-farm water recovery programs of the Commonwealth.

The internal policy changes to the operation of CICL were designed to help the organisation maintain its financial stability. Part of those changes are associated with the holdings of WDR by shareholders. Although around 12 per cent of the WDR had been terminated, CICL has reactivated those rights to irrigators through a delivery entitlement incentive scheme (in 2015). As a consequence, there has been little overall change in the total volume of WDR retained by water users. This has helped the company respond to the potential adjustment (financial) pressures which might have otherwise arisen from the change in entitlements held by irrigators. It represents one element of a broad set of policy changes adopted by CICL for providing greater certainty to water users through a more stable pricing system.

The CICL move was away from a mix of fixed and variable charges for water delivery to a system largely based on fixed costs, provided a range of benefits to WDR holders. They could use up to 110 per cent of the WDR volume. Water use beyond that volume incurs a variable charge (which is a fixed-charge equivalent amount). Benefits for WDR holders also include the distribution of some of the water savings derived by the company and WDR form the basis for sharing access to flows in the advent of supply restrictions.

Beyond the operational changes for the irrigation company as described above (and the benefits those changes might provide to CICL members), the irrigator decision-making is also a function of a wide range of other factors similar to those underpinning production decisions within the network managed by Murrumbidgee Irrigation. The outcomes of these changes appear to be reflected in the relationship between the annual volume of water deliveries and the water available for production on the 1 November each year (based on general security entitlements held times the allocation percentage). This relationship is fairly consistent for the period from 2000/01 to 2010/11 (Figure A3.4, blue line) with the maximum volume of water delivered through the network of around 420 GL.

Figure A3.4. On-farm water deliveries and water availability on 1 November against general security entitlements within the Coleambally Irrigation network, 2000/01 to 2015/16



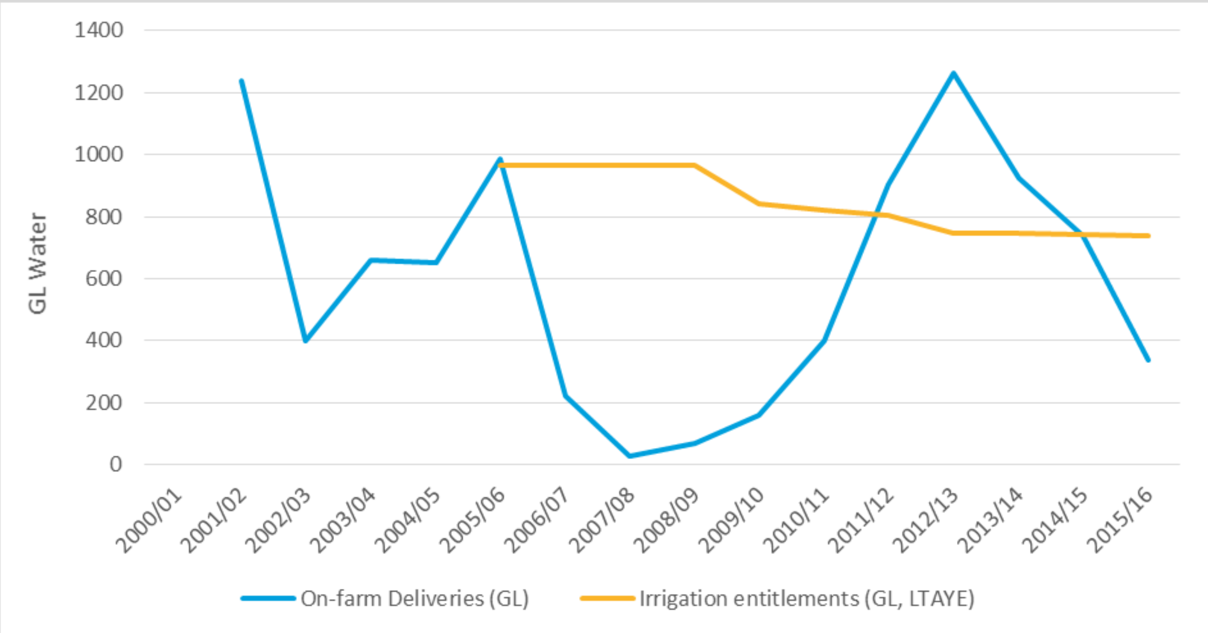
For the period from 2011/12 to 2015/16, the maximum potential volume of water delivered increased to almost 500 GL. As was the case for Murrumbidgee Irrigation, the net outcome of multiple on and off-farm changes (including the recovery of water for the environment) has led to an increase in the volume of water delivered relative to the volume of water available for production on 1 November each year. For example, if the water available for production at that time is 200 GL (Figure A3.4), water deliveries were estimated to be around 270 GL (before the water purchases, infrastructure upgrades and sale of water out of CICL to other irrigators). After the Basin Plan water recovery and other changes, the estimated volume of water delivered relative to the 200 GL of general security water availability on 1 November has increased to around 340 GL.

In the context of all these changes, it is difficult to determine the overall contribution of the Basin Plan to observed levels of water delivery, or the cost and revenue streams of CICL. Improvements to the network infrastructure and operation of that infrastructure might mean CICL is better placed to support the on-farm delivery demands associated with the general security entitlements and allocations. However, a key challenge remains anticipating the water demands of irrigators throughout the year as the crop mixes (and subsequent water requirements) continue to change.

Murray Irrigation

Murray Irrigation Limited (MIL) demonstrates the highest level of variability in annual water deliveries across the irrigation companies examined. Between 2001/02 and 2015/16 the annual water deliveries varied between 30 GL and 1,260 GL (or by around 97.5 per cent, Figure A3.5). Across the 11 years between 2005/06 and 2015/16, the volume of entitlements held by irrigators fell by around 24 per cent (an average rate of around 2.7 per cent per annum). However, the volume of WDR fell by approximately 9.8 per cent. This decrease in WDR largely appears to represent the volume of WDR terminated with only a small volume of new WDR being issued since 2008/09. Most of the water delivery right terminations occurred in 2009/10 and 2013/14.

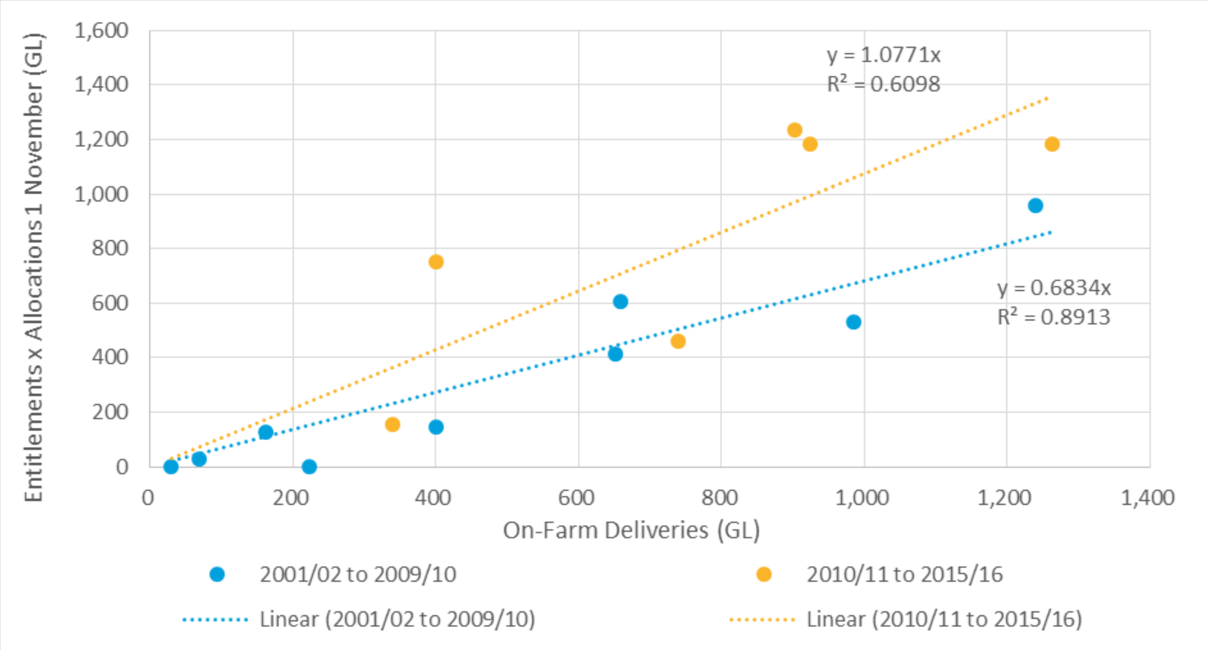
Figure A3.5. Murray Irrigation deliveries and water access entitlements, 2000/01 to 2015/16



Source: MDBA aggregation of data from irrigation company annual reports

In considering how the Basin Plan might be contributing to the challenges facing MIL, attention was given to the relationship between the annual on-farm water deliveries and the surface water allocation volumes against the general security entitlements on 1 November each year (Figure A3.6).

Figure A3.6. On-farm water deliveries and water availability on 1 November against general security entitlements within the Murray Irrigation network, 2001/02 to 2015/16



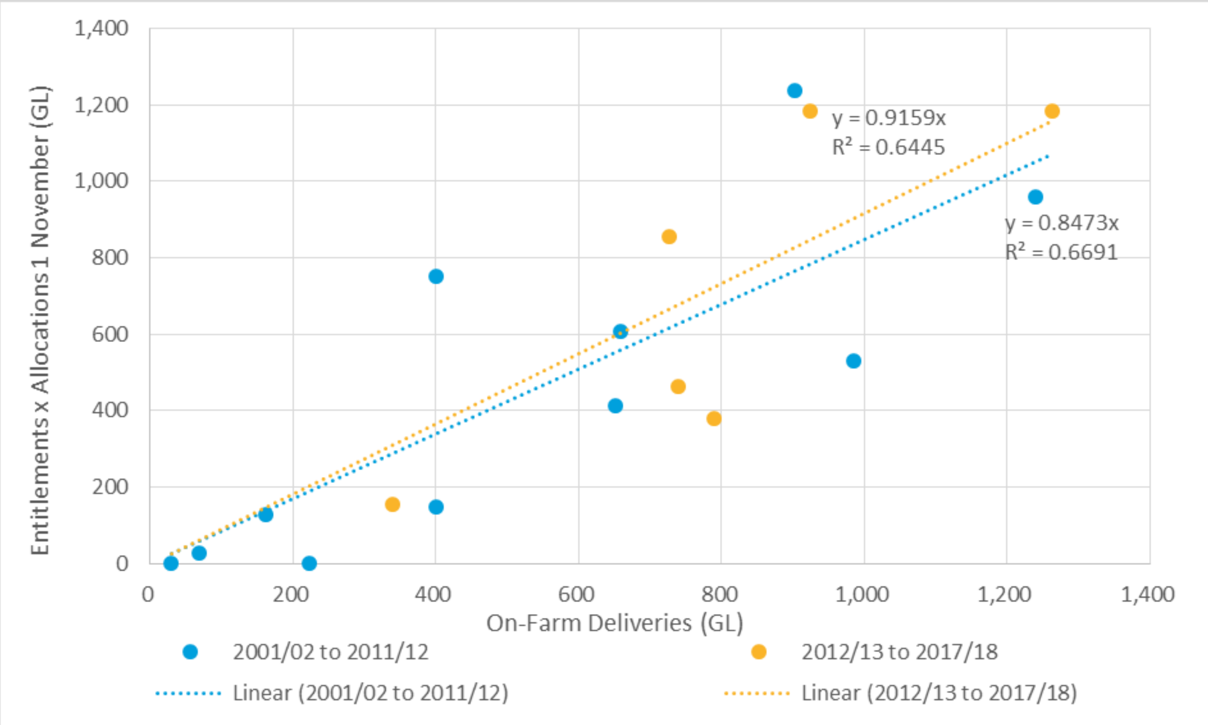
The first observation is that unlike the relationships presented for CICL and MI, the yellow line (for 2010/11 to 2015/16) sits to the left of the blue line (from 2001/02 to 2009/10). That is, the volume of water delivered in a year for a given volume of surface water available to support production decisions on 1 November is smaller in more recent times than was the case in the period up to 2010/11.

A number of factors may be contributing to these observations. The full benefits of the system upgrades being delivered through the off-farm and on-farm infrastructure investment had not been fully realised by the end of the period examined. In the latter period, negative perceptions relating to the operations of MIL and the combined effects of multiple drivers of change (including the Basin Plan water recovery) may have a significant effect on decisions by irrigators not to utilise a larger proportion of the available water. If this is the case, these initial findings might be a function of the time periods used to examine the relationship.

If the periods examined were alternatively 2001/02 to 2011/12 and from 2012/13 to 2015/16, the yellow line in Figure A3.6 moved slightly to the right (closer to the blue line). That is, decisions in relation to the annual on-farm deliveries between 2012/13 and 2015/16 for a given level of allocations against entitlements held were marginally closer to those for the period prior to 2012/13. In examining the same timing changes to the water delivery-water availability relationships with CICL and MI, the yellow lines presented in Figures A3.2 and A3.4 shifted even further to the right (data not shown). This indicates the observations in Figure A3.6 are quite specific to the conditions determining water use in the MIL network and the time period used for the analysis.

On the question of timing, the provision of 2 years of additional data on water deliveries by MIL gave further evidence that perceptions and confidence between 2011/12 and 2015/16 may have been a significant contributor to the water use decisions observed for irrigators within that network (as presented in Figure A3.6). By including this additional data and examining the periods from 2001/02 to 2011/12 and from 2012/13 to 2017/18, the more recent period of water deliveries relative to water available for production are closer to those experienced prior to the recovery of water (Figure A3.7). These results indicated more positive sentiments relating to irrigation water use within the MIL network across the last 2 years. These findings suggest a lack of confidence in utilising the water available within the MIL footprint between 2010/11 and 2015/16. This confidence seemed to improve in 2016/17 and 2017/18 (as indicated by the close proximity of the blue and yellow lines of Figure A3.7).

Figure A3.7. On-farm water deliveries and water availability on 1 November against general security entitlements within the Murray Irrigation network, 2001/02 to 2017/18



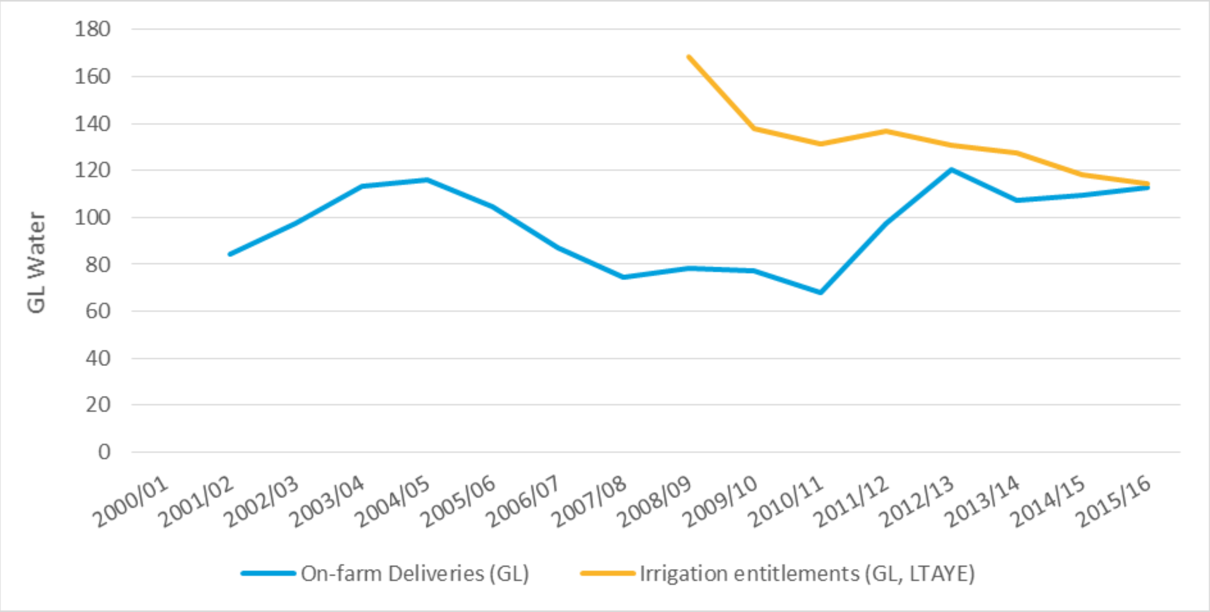
Further analysis would be required to examine how the changing mix of irrigated crops might be influencing water use (deliveries demanded) within the MIL network. Preliminary analysis indicates water use in each year might also be a function of water use and carryover decisions (and therefore demands upon the network operated by MIL) in the previous year.

In addition to the common challenges facing each of the irrigation companies, the adjustment pathway from the drought, environmental water recovery and other factors influencing production has been quite different for MIL to the experiences observed across the networks operated by the other irrigation companies. For MIL, this may have had implications for their revenue and costs, particularly the revenue from variable water charges during that period of adjustment.

Central Irrigation Trust

Central Irrigation Trust (CIT) supplies water to multiple parts of the River Murray in South Australia. Through the period from 2000/01 to 2015/16, the maximum annual volume of water delivered would appear to have remained around 120 GL (Figure A3.8). Through the drought period, annual water deliveries fell to around 55 per cent of the maximum deliveries. This contrasts to the much larger proportional decreases in water deliveries at that time for Murrumbidgee, Murray and Coleambally irrigation companies. The smaller range in water delivered appears to be largely a function of the types of entitlements held by irrigators and landuse in the areas supplied by CIT dominated by permanent plantings.

Figure A3.8. Central Irrigation Trust deliveries and water access entitlements, 2000/01 to 2015/16



Source: MDBA aggregation of data from irrigation company annual reports; Entitlements in long-term average available yield equivalents. Note: information on Loxton Irrigation Trust water deliveries prior to 2008/09 have not been included in the blue line for Figure A3.8.

Understanding the business challenges for CIT and drawing out the potential effects of the Basin Plan water recovery are not as straight forward as comparing the trust entitlements managed, water deliveries and other factors such as revenue and costs across time. Within the timeframe examined, the CIT has included Loxton Irrigation Trust (2002), Lyrup Irrigation Trust (2008), and Sunlands and Golden Heights irrigation trusts (2011). The MDBA has sought to account for these changes in the volume of water delivery rights held, which to some degree obscures the effects of water recovery on the business operations. Further data collection would be required to account for the variations in water deliveries and water entitlements held by Trust members in order to properly separate out the effects of the Basin Plan from all other sources of change.

CIT felt that, at the time of undertaking its analysis, the full impacts of the Basin Plan water recovery had been masked by two years of high water availability since the water recovery occurred, with each year of high water availability leading to high levels of water availability in the following year. It was felt the impacts of the Basin Plan would be more obvious if the Basin runs into a drought for 2 to 3 years.

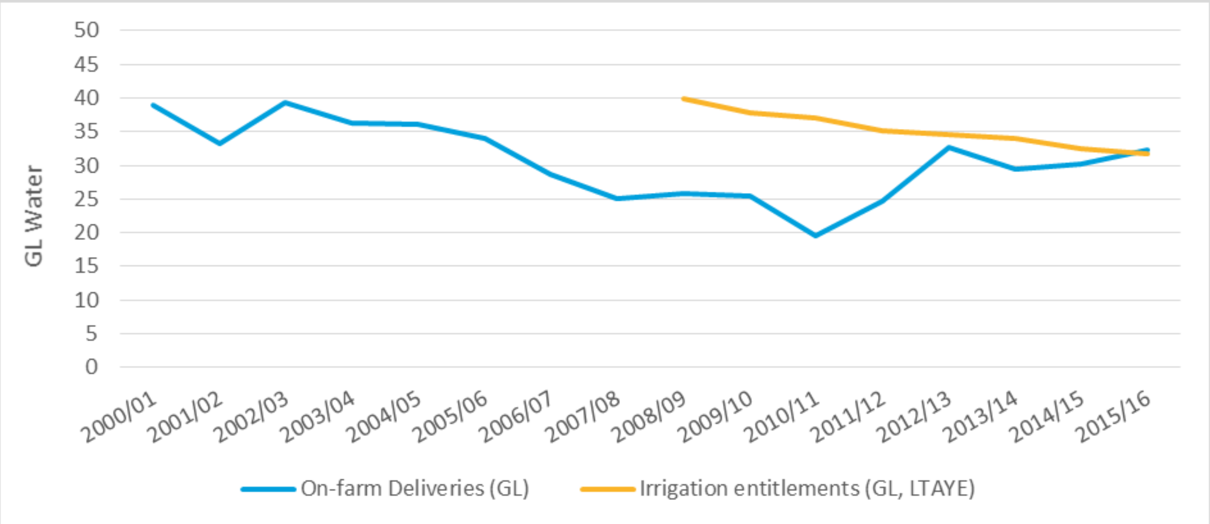
Other factors proposed by CIT as being relevant to understanding the current and long-term challenges for that IIO include:

- Where CIT had previously been a net exporter of water (through temporary trade) it was now a net importer;
- With around 155 GL of WDR held by members, CIT needed to retain the capacity (and therefore manage the network) to meet potential obligations for supplying all their customers at some future time;
- Where irrigation blocks had sold their water entitlements but the WDR have been retained (not terminated), it is difficult to collect the fixed water charges from those not irrigating;
- While there had been limited change in the footprint of irrigation within the CIT areas, there is some concern one possible outcome from the next 2 to 3 year drought could be a step decrease in the area irrigated and the associated demand for water deliveries. This raises potential risks for both the CIT and the individual member of CIT. CIT was concerned the future minimum volume of water delivery might be below that required to operate the system effectively, placing the CIT business under additional financial stress. CIT noted that for irrigators, the value of their farming businesses (and therefore their assets) is a function of the trust operator's ability to deliver water effectively;
- The last CIT modernisation program occurred in 2010. Questions regarding what further transformation of the business might be needed will be considered in the near future. Part of that consideration will be where the WDR have been retained or terminated, the concentration of entitlements held by irrigators, and the annual water delivery volumes to different parts of the network in recent years.

Renmark Irrigation Trust

Renmark Irrigation Trust (RIT) is a community-owned irrigation service provider founded in 1893, pumping water from the Murray River in South Australia (SA). Across the period examined, RIT maximum annual water deliveries fell from 39 GL (2000/01) to 32 GL (2012/13) (Figure A3.9). The decrease relative to the maximum delivery volume of approximately 50 per cent in 2010/11 is significant in the context of the irrigation entitlements held and the predominance of permanent plantings within the network operated by RIT.

Figure A3.9. Renmark Irrigation Trust deliveries and water entitlements, 2000/01 to 2015/16



Source: MDBA aggregation of data from irrigation company annual reports; Entitlements in LTAYE.

Since 2008/09, the volume of water access entitlements owned by irrigators within RIT fell by just over 20 per cent. At the same time, the volume of WDR terminated has been around 6 per cent, with the majority of the WDR terminations occurring in 2009/10. This difference in the volume of water access entitlements sold by RIT water users (much of it associated with the recovery of water for the environment) and the smaller volume of WDR terminations indicates the potentially higher demands for irrigation water deliveries within the network.

Further insights provided by RIT have helped the MDBA understand the processes of adjustment being pursued to address the challenges arising from multiple changes, including the Basin Plan water recovery. These include the consequential effects of the National Water Initiative, the Water Act 2007, water charge rules, the water trading rules, drought, farmer exits, changing market demands for the products of irrigation, changes to the mix of permanent crops grown and improved efficiencies of water use. In addition to the policy changes and shift in crop types grown, there have been a number of other parts to the adjustment processes proceeding in the background, as indicated below. Addressing or responding to each of these changes comes at a cost and the difficulty raised by RIT is possibly not having sufficient time to adjust to these changes while at the same transferring additional costs onto those who remain irrigating.

Following the exit block grants (with entitlements transferred to the Commonwealth) WDR were terminated on 276 hectares of land previously irrigated. The associated termination fees were used to cover the reduced access charges revenue that would have otherwise been collected. After 8-9 years, funds arising from the payment of the termination fees have largely been exhausted. Where small block irrigators exited, RIT felt the ‘Swiss cheese effect’ provided little attraction for the land to be redeveloped. However, government grants through the South Australian River Murray Sustainability (SARMS) Irrigation Industry Improvement Program (3IP) supported the re-development of approximately 38 hectares of these properties.

Drought and water restrictions, reduced water entitlements, gains in on-farm irrigation efficiency, exit of some small block irrigators, and what RIT perceives as the increased costs and risks of irrigating have collectively contributed to reduced water use by irrigators in their district. Some of the associated fall in RIT revenue has been recovered through an increase in charges. With water use in recent years being around 30GL per annum (compared to an average of 35 to 37GL prior to the Basin Plan, other policy changes and drought), it represents the loss of one to two Full-Time Equivalent (FTE) employees[2]. However, new developments and the pumping of environmental water within the network is expected to offset some of these revenue losses.

The increasing demands for water arising from the recent expansion of permanent plantings outside of RIT and the reduction in water availability arising from the recovery of water for the environment contributed to increased prices for permanent and temporary water. RIT felt these higher prices have a number of knock-on effects for their business. A number of property owners sold their water entitlements separately and left those properties with no water. The need to purchase either

[2] Assume that the cost of water is $20 per ML and the average wage is $100,000.

temporary or permanent water is thought to make the properties less attractive to buyers. Less experienced irrigators who lease in allocations for use on some of that land are required to provide security to RIT in lieu of not holding water entitlements. Others who deliberately sold water entitlements to the Government with a view to leasing in allocations as a business option have also been affected by the higher than expected and more volatile allocation prices.

There is a perceived future risk of properties (particularly smaller ones) in the RIT district becoming unviable and, exiting which may further reduce water usage through the RIT network. As with CIT, a concern for RIT is the possibility of a step decrease in irrigation water demands should a significant number of people leave the network at once.

RIT staff spend considerable time educating irrigators on procedures and options for water trading and the proposed approach for managing through periods of water restrictions. Further advice is provided on how telemetry will help to provide water use information on a 'live' basis. Managing water accounts and providing up-to-date information to customers places increasing demands upon the business. To meet their compliance requirements, RIT has installed telemetry to more closely monitor water usage by its customers. Each of these activities come with a cost. Add the pressure of increased electricity costs for running the network pumps, RIT feels the level of business risk could lead to additional reductions in water usage, putting further pressure on RIT to increase its charges.

The operation of RIT pumps, and in particular the costs of operating those pumps, can be affected by the river height. RIT acknowledges Murray River Operations in South Australia have been exceptionally good in communicating with RIT on changes to the river water level. The river operators are aware of the potential risks to RIT should there be an excessive decline in the river water level for any reason. To date, the impact on RIT has not been significant due to relatively small river level drops. The additional electricity costs to pump water when the water level drops have been largely offset by the reduced pumping costs when the river height rises again. According to RIT, if there were a significant and permanent fall in the water level though, either the pumps wouldn't operate or it would be extremely costly to modify the pumps and pumping stations to extract water from the river.

RIT raised other concerns in relation to the potential effects of a decrease in water quality, such as with the hypoxic (no oxygen) blackwater events[3]. RIT supplies untreated river water to stock and domestic users in addition to water for irrigation. Hypoxic water and the associated dying of organic matter can cause odour problems and skin irritation. Furthermore, debris within the water may result in irrigator filter blockages. RIT therefore frequently flushes its pipelines to maintain water movement during the blackwater events. Bryozoa, which has been an ongoing issue for RIT pipelines,

[3] Blackwater can occur during flooding when organic material is washed off the floodplain and into the river system. This event can lead to a sudden decrease in the oxygen available to aquatic beings. The black appearance of the water is due to the release of dissolved carbon compounds, including tannins, as the organic matter decays – similar to the process of adding water to tea leaves. Available from: http://www.environment.gov.au/water/cewo/publications/factsheet-hypoxic-blackwater-events-and-water-quality

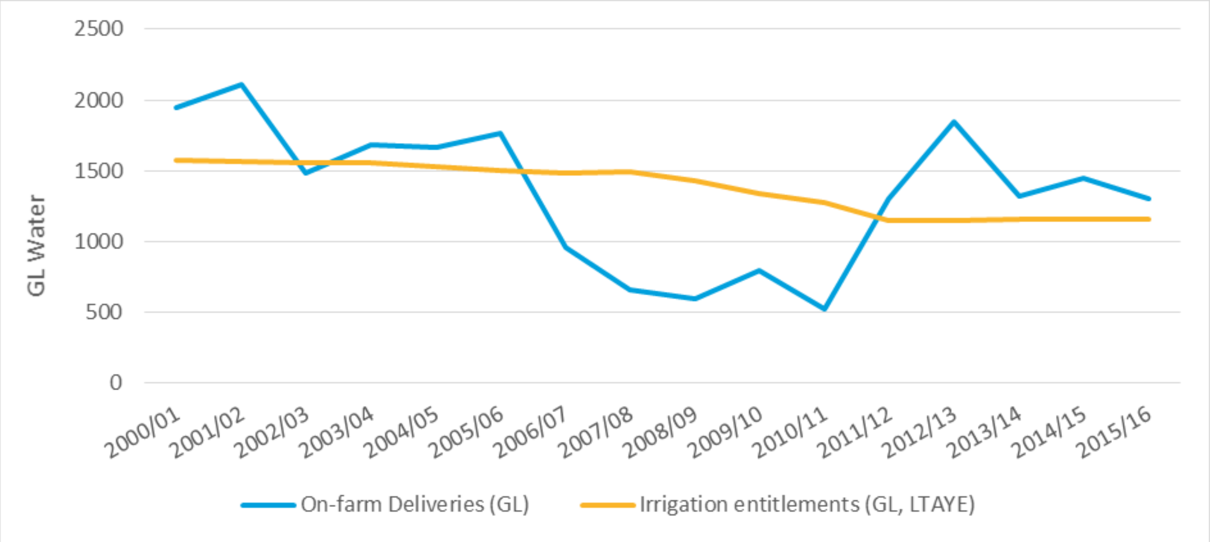
irrigation water filters and river management, may exacerbate the effects of a blackwater event. In the past, the potential risks of blue-green algae contamination have required RIT to stop pumping. It is expected environmental flows, if managed correctly, will help alleviate the problems arising from algal blooms and blackwater events and possibly easing some of the associated potential cost pressures.

RIT have entered an agreement with the Commonwealth Environmental Water Holder for delivering water to floodplain rehabilitation sites. The water delivery will be through RIT infrastructure at an equivalent delivery price to that paid by RIT irrigators. This agreement has offset some of the reduced pumping by irrigators. It has also provided a 'win-win' situation where the environmental watering schedule allows for flushing of some RIT pipelines whilst delivering water to the designated sites.

Goulburn Murray Water

Goulburn Murray Water (GMW) manages the delivery of irrigation water in the Goulburn Murray Irrigation District. Across the period 2000/01 to 2015/16, GMW annual surface water deliveries varied between 520 GL and 2,110 GL (Figure A3.10). Since the Basin Plan water recovery, the permanent trade of water out of the area supplied by GMW and the introduction of the current carryover provisions, the maximum volume of water delivered by GMW has fallen by around 13 per cent (to 1,840 GL). Over the same time period, high reliability water entitlements owned by irrigators fell 26 per cent and the volume of WDR decreased by approximately 4 per cent.

Figure A3.10. Goulburn Murray Water deliveries and water access entitlements, 2000/01 to 2015/16



Source: MDBA aggregation of data from irrigation company annual reports; Entitlements in long-term average available yield equivalents

Given the levels of change in water deliveries by GMW, the entitlements owned by irrigators and the proportion of WDR terminated, it is quite difficult at this time to separate out the impacts of the

Basin Plan from all the other causes of change. A range of other factors, which are also contributing to the strategic assessment of the future operations for GMW, include challenges such as[4]:

- Reduced inflows into catchments due to climate
- Connections Project benefits (and financial challenges) through the upgrade of the network "backbone"
- Changes in international commodity prices and variability within the domestic pricing of commodities
- Managing a network where channel usage in 80 per cent of the network accounts for around 18 per cent of deliveries.

In light of these factors, and when trying to separate out the effects of the Basin Plan, there are also the positive contributions for water management from the off-farm infrastructure investment to upgrade the network backbone while at the same time having the countering influence from the purchases of water entitlements on the potential demands for irrigation water volumes. These changes to the irrigation water demands by farmers are further influenced by both the improved on-farm efficiencies contributing to changes in the methods of farm production (some of which has been facilitated by Commonwealth investment in water savings through the on-farm water recovery programs).

All these changes, together with the variability in the temporary trade of water into and out of the area (which varies from year to year) are likely to flow through to differing patterns in the timing and volumes of water deliveries demanded across the network. Some of the confounding matters in this regard are the on-farm and off-farm infrastructure upgrades still being completed and irrigators just starting to realise the benefits from the improved water delivery systems available to them.

Possible next steps in the analysis of change

The analysis and consultations described some of the many factors impacting on the irrigation companies. While the effects of the Basin Plan water recovery are fairly difficult to differentiate at present, most of the IIOs expressed concerns about the potential to observe those effects in the upcoming years or if there is a sequence of 2 to 3 very dry years. Further analysis of the positive and negative Basin Plan influences on IIOs might include:

- Analysing the financial data from each irrigation company which underpins their financial performance (as summed up in their profit and loss statements). To do so would require consistent data for periods before and after the Basin Plan water recovery;
- Consulting with each irrigation company to better understand the reasons for changes in financial performance;
- Better understanding how the Basin Plan has contributed to changes in the behaviours and practices of the business operations. To do this, MDBA might consider:
- Developing an understanding of how the changes affect the fixed and variable revenue sources

[4] Walsh M, Ewart S, Heeps D, 2018, ‘Goulburn Murray Water Review’, Strategic Advisory Panel.

- Disaggregate water delivery revenue from termination fees and other sources of income
- Take account of how structural changes (e.g. network reconfigurations) have affected each IIO.

What is clear from this preliminary analysis is that while there are common factors influencing the degree of challenges facing the irrigation companies, there are also internal factors to consider. These specifically relate to the structure of the IIO operations, including how they derive their revenue. Although it is difficult to determine how the Basin Plan water recovery is contributing to these changes, it is still necessary to use the available information to at least describe the net, aggregate degree of change and to identify the possible adjustment pathways (and challenges) arising from those combined influences.