SUBMISSION TO THE PRODUCTIVITY COMMISSION'S MURRAY-DARLING BASIN'S FIVE-YEAR ASSESSMENT ISSUES PAPER

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Overview

This document is a response to the Productivity Commission's inquiry on implementation of the Murray-Darling Basin Plan provided as a consensus statement by five professors of water economics who signed the Murray-Darling Declaration on 5 February 2018. We provide response relevant to three key enquiry terms of reference (TOR):

1) Progress towards implementing the actions required under the Plan within legislated timeframes, including:
   - the extent to which stated water recovery and other targets are on track to be delivered within statutory timeframes; and
   - the likelihood that activities and arrangements now in place will ensure that these targets and timeframes will be met.
2) Supply measures to offset the Basin Plan water recovery target of 2,750 GL by 2019, using the Sustainable Diversion Limit (SDL) adjustment mechanism;
3) Efficiency measures to recover an additional 450 GL by 2024, consistent with the Basin Plan legal requirement to achieve neutral or improved socio-economic outcomes.

Conclusions and recommendations as summarised below. In addition, the Appendix provides a detailed review of the current water economic studies of the Basin plan (as well as a review of the key studies of the peer-reviewed water economics literature) and further documents the logic, evidence and study review basis for conclusions and recommendations.

Key conclusions with respect to the Productivity Commission's terms of reference are:

1. Real environmental water recovery is not likely to be on target because current practice does not account for a) return flows; b) increasing utilisation of water entitlements by stakeholders; c) substitution of groundwater for surface-water diversions and d) climate change impacts over time. Diversion change metrics significantly over represent water effectively available for the environment by omitting lost return flows that benefited the environment previous to the projects (MDB Declaration and Grafton and Wheeler (2018)). An audit of states infrastructure projects and water accounting assumptions would be needed to establish creditable flow net of changed returns for the environment by project for projects to date.
2. Supply of real environmental net flows is a particular concern for infrastructure projects proposed in the sustainable diversion limit (SDL) adjustment mechanism, proper accounting for return flow is likely to show these projects provide less net flow and are higher cost per unit flow than current diversion cost accounting shows. We

also recommend that cost-benefit analysis be applied to rigorously estimate whether there are net economic benefits from undertaking such projects.

3. The actual economics evidence (as reviewed in this submission) does not support that water entitlement buybacks must be precluded to achieve neutral or improved socio-economic outcomes. A large body of creditable economics evidence supports a conclusion that the net economic impacts of water entitlement buyback to date are mostly locally positive on balance once adaptations and compensation re-investment are accounted for. Some recent consulting reports claim large regional costs of water buyback, however absence of accounting for key farm, regional, and local adaptation and compensation re-investment leads to overstated local economy impacts.

The review documented in this submission signifies that current recommendations to reduce the SDLs based on recent water economic modelling are flawed. Hence our recommendations include:

1. **Audit and account for available water recovery to date in terms of the real environmental accounting for return flows**

   Audit all projects and entitlements to date to establish the extent of any deficit between current diversion denominated and real environmental flow recovery net of changes in return flows, increasing water utilisation and increased substitution of groundwater for surface water. Future water diversion estimates (plus re-estimating past water diversions) should be calculated through remote sensing techniques. Future accounting and reporting for Plan should be in real change net of return flow change terms, increasing water utilisation rates and climate change impacts.

2. **Do not preclude water entitlement buyback on the basis of negative socio-economic outcomes**

   Our review of economics supports an independent audit of the socio-economic effects of water recovery accounting for lost irrigation, adaptation and compensation reinvestment in the Murray-Darling Basin. The evidence we reviewed for this submission (attached as an appendix) does not support precluding water entitlement buyback on socio-economic impact grounds. It also highlights significant socio-economic negative impacts associated with on-farm irrigation infrastructure.

3. **Develop stronger governance to ensure cost-effectiveness**

   As well as strengthening monitoring, compliance and property rights across the Basin, current arrangements for project fund accountability to Basin Plan objectives is limited, choices of projects and conditions on funding such as return of real environmental flow net of changed return flow are not mandated in contracts or enforceable by federal government. This creates incentive incompatibilities that reduce environmental and cost-effectiveness. Delivery of payments based on a third body audited performance relative to objectives ─ such as was the case with National Water Reform of COAG funding ─ is recommended as an approach to better align investment incentives to actual environmental performance and cost-effectiveness objectives.

A REVIEW OF THE WATER ECONOMIC STUDIES OF THE BASIN PLAN: SUPPORTING SUBMISSION TO THE PRODUCTIVITY COMMISSION'S MURRAY-DARLING BASIN'S FIVE-YEAR ASSESSMENT ISSUES PAPER

The MDBA in late 2017 proposed to reduce the SDLs by 605 GL via the adjustment mechanism (through activities that allow equivalent environmental outcomes to be achieved with less water or increase the volume of water available for environmental use with neutral or improved socio-economic impact). this means a) stopping further buy-back of water entitlements; b) only recovering water through on-and off-farm irrigation infrastructure subsidies in the future. The economic justification was provided in recent commissioned economic studies by the MDBA and other state and local bodies to assess impacts of the MDB Plan (e.g. KPMG 2016 and RMCG 2016) have predicted considerable job losses and reductions in gross regional production from full implementation.

This Review of existing water economic studies is provided to document the significant limitations to the existing economic analyses undertaken for various government agencies. The information in this review points to significant economic logic and methods flaws in a number of economics studies used to underpin and justify the 605 GL adjustment recommendations.

Although many of the studies have undergone peer review, we document how they are still likely overestimates of local impacts primarily through methodological approaches failing to fully account for key aspects of relationships between farm water use, water trade, farm adaptation, uncertainty, risk, compensation reinvestment, and regional economic impacts consistently with key findings from peer-reviewed research in economic journals over the past decade.

Our review of the more recent studies (namely KPMG 2016; RMCG 2016; Ernst and Young 2018, MDBA 2016) indicates that a number of assumptions underpinning these analyses are fundamentally inconsistent with economic principles and farming realities. Not surprisingly, the empirical findings from previous peer-reviewed literature, thus, differ markedly from the findings in the more recently-commissioned work. Moreover, these inconsistencies result in very large exaggerations of the costs to communities from the Plan implementation. Overall, the key concerns with some of the newer studies are:

1. **Overestimating the Relationship between Water Use and Farm Production**: Failure to recognise the true production relationships between water and agricultural outputs and characterising production changes as directly proportional to water availability. This is not borne out in practice or in tested theoretical contexts;
2. **Ignoring Positive Economic Impacts of Water Entitlement Buyback and the Negative impacts of Irrigation Infrastructure Subsidies**: There are a number of positive economic impacts of adjustment mechanisms, such as buyback, and the consequent positive impacts of spending within communities, while at the same time there are a number of negative impacts of infrastructure subsidies (such as reflows). Studies often ignore the benefits of buyback while also ignoring the costs of irrigation infrastructure;

3. **Key Term Definitions**: Poor definition of rudimentary terms like water use efficiency, water entitlements, allocation such that what is being assessed and measured is indeterminate;
4. **Sample Selection Biases**: Sample selection exists where specific ill-affected communities or community members are chosen and then presumed to be representative of a wider population;
5. **Statistical Modelling Issues:** Less-than-rigorous statistical approaches that confound mis-specified assumptions about hydrological, agricultural and/or economic relationships;
6. **Inadequate documentation**: In some cases inadequate citing of information such that the evidence cannot be meaningfully reviewed or tested and must be taken on trust.

Details of our concerns are summarised below:

1. **Overestimating the Relationship between Water Use and Farm Production**: KPMG (2016) and RMCG (2016) assume a direct proportional relationship between reductions in farm water use and farm irrigated hectare production.
   1.1. No published (in a peer-reviewed academic journal) research has ever found this, because of farmer adaptation, surplus water use, and farm restructuring following buyback (eg Wheeler et al. 2014, 2014a; Wheeler and Cheesman 2013). In addition there is a lack of recognition that it is farm revenue, not production that is the key impact that should be assessed. Evidence from peer reviewed journal article evaluating actual reductions in Basin wide farm revenue from less water in drought (Kirby et al. 2014; Connor et al. 2014) find that reductions in revenue is *much less* than proportional to reduction in water available. Averaged across crops the studies find as little as 0.1% reduction in farm production revenue to around 0.6% for each 1% reduction in water allocations noting there are significant variations by crop (Kirby et al. 2014). Modelling of impacts prior to the Plan implementation by Adamson et al. (2011) and Wittwer and Griffith (2011) estimate reductions in revenue to be about 0.4% and 0.2% for each 1% reduction in available water in percentage terms, respectively.
   1.2. Assuming revenue reductions proportionate to water reductions ignores the fundamental micro-economic concepts of input level changes, input type substitutions, and output mix changes. The reality is that farms adapt to less water substantially. Wheeler et al. (2014) provide a description of multiple mechanisms that lead to much less than proportionate output reductions in response to MDB water availability reductions.
   1.3. Much of the modelling (e.g. KPMG 2016, MDBA 2016, RMCG 2016) ignores all long-term influences (eg increasing urbanisation; increasing temperatures; falling commodity prices, technology change) on irrigated farm production. Assuming that water use is the only long-term driver provides misleading policy advice that will only be detrimental to rural communities in the long-term.
   1.4. It seems that, based on the evidence summarised above, that the error of omission of no accounting for any of these sorts of adjustment in the KPMG and RMCG reports, lead to an overstatement of the negative effects of water buyback impacts. In some cases the overstatement may be more than double what we would reasonably expect based on the best available evidence.
2. **Ignoring Positive Economic Impacts of Water Entitlement Buyback and the Negative Impacts of Irrigation infrastructure Subsidies**: A further key omission in the KPMG and RMCG (2016) studies that leads to large overstatement of MDB water buyback cost is

that they ignore local benefit from local expenditure by farmers because of compensation for water in buyback. MJA (2017) do not make this error in their recent modelling of impacts in the Murrumbidgee, and show that there is actually a positive impact that arises for communities from water recovery.

2.1 A question that arises is whether evidence backs the assumption that water buyback compensation is, in fact, spent locally. A considerable amount of peer reviewed academic research supports the notion that much of the compensation money does stay in the local economy. Wheeler et al. (2014) and Wheeler and Cheesman (2013) who surveyed thousands of irrigators across the southern MDB from 2008-09 to 2010-11 provide convincing evidence that many irrigators who sold water to the Australian Government continued farming in the southern MDB, and have predominately sold their surplus/buffer water (water not used in production). Further, water sales proceeds have been used to reduce debt (and hence interest payments), restructure and reinvest on farm. Irrigation infrastructure subsidies do not allow for debt repayments.

2.2 Statements are often made that local irrigators do not want to sell their water (eg Blackwell et al. 2016; p. 8), which ignores the reality that buyback is a) voluntary and b) the volume of academic literature in this area (of large-scale, representative surveys of irrigators across the Basin) that shows that irrigators actually show strong support for market-based mechanisms (e.g. Loch et al. 2014).

2.3 Failure to recognise important knowledge gaps, such as the impacts of infrastructure on return flows (e.g. Qureshi et al. 2010), such that some policy options can markedly overstate water recovery. There is also no focus on the environmental/economic/social benefits of water recovery at higher levels. It has been noted that attempting to monetise these values is too complex (MDBA overview 2016), but such studies do exist for the Basin. By not making communities aware of these results it prevents a balanced perspective of the possible outcomes of water recovery.

2.4 No current report discusses the paradox of irrigation efficiency and the rebound effect (e.g. the increase in farm water use that can arise from increased irrigated land and changed crop mix), albeit Ernst and Young (2018) show evidence of the rebound effect.

2.5 In addition, the increased risk impacts for communities from conversion of annual to permanent cropping through infrastructure subsidies (e.g. increasing risk during drought and increased electricity price) is not discussed. There is increasing evidence across the Basin that there has been a significant increase in permanent cropping (SunRise 2015), and that this adds additional pressure for irrigators in terms of higher electricity costs (Adamson and Loch 2018).

3 **Key Term Definitions**: Many reports do no clearly define the importance of key terms, such as water use efficiency, irrigation efficiency or water productivity (e.g Ernst and Young 2018). There is also a lack of recognition regarding the difference between water entitlements recovered in a region, water allocations made to a region and water diversions used within a region. In other words, there is: a) water entitlements long-term average annual yield (LTAAY) owned by stakeholders in a region (highest ML); b) water allocations received annually by the region (lower than 1)) and c) water allocations/diversions used in a region by stakeholders (usually lower than b)). These differences are critical if one wants to estimate socio-economic impacts from changing water use. There are two potential impacts, 1) impact on current water use (which may not change at all given if stakeholders have buffer-surplus water), and 2) impact of future

potential water use (which should not be used in an economic analysis of impact). It has been shown that historically irrigators in the MDB only have used around 70% of their water allocations they receive, and that over time, water utilisation rates are increasing (Wheeler et al. 2014).

4 **Sample selection biases:** Sample selection biases where specific ill-affected communities (15) were chosen for modelling in the Northern Basin (KPMG 2016) and then presumed representative of a wider population (which includes 67 communities) for recommendations regarding SDL reductions.

5 **Statistical Modelling Issues**: Many reports (KPMG 2016, MDBA 2016, RMCG 2016) employ less-than-rigorous statistical approaches that confound mis-specified assumptions about hydrological, agricultural and/or economic relationships. There is no noted checking regarding issues around endogeneity, collinearity, heteroscedasticity or serial correlation (or where tests were done, incorrect tests was chosen) bringing into question the validity of the modelling results. Sample sizes used were also very small.

6 **Inadequate documentation**: There was a lack of referencing and care in most consulting reports, which make it hard to review and check data sources. This would appear to result in an upward bias in the estimates of economic losses associated with water recovery.

6.1 Although a number of documents were peer reviewed, considerable problems with the recent studies were not highlighted, probably because the peer reviewers were not experts in either water economics in the MDB nor experts in CGE modelling (which is what should have been used to model local community impacts). It should also be noted that many of the peer reviewer comments appear to have been ignored altogether (e.g. RMCG 2016) or argued against (e.g. Blackwell et al. 2016 provides a summary of the response to their peer review).

Appendix A provides the review of some of the more recent water studies conducted, while Appendix B provides an overview of the existing peer-reviewed published studies.

APPENDIX A: KEY CURRENT STUDIES OF REGIONAL IMPACT FROM THE BASIN PLAN

MDBA (2016) *Documentation for the hydrology land-use modelling*, Canberra: (assumptions within this fed into KPMG (2016).

Overview: 15 regression models (modelling hectares under cotton production) are reported for Northern Basin communities. All regressions are different, and as stated in the report, the models have been chosen to maximize the R^2.

Examples of different regressions and variables:

Cotton production (ha) = Water diversions (measured differently for each region through surface water/groundwater/allocations received) + off-allocations (eg previous diversions last year) + rainfall (current or t-1) + cotton production (t-1) + dummy for some years of production

Problems with these models:

1. No consistency with choices of variables or types of variables which we contend is consistent with the choice of variables so as to maximize R^2. Lack of test statistics provided (only F test provided) which calls into serious question the robustness and reliability of the results. MDBA technical overview (2016: pp 17-19) does outline additional testing, but does not report statistics and there are also questions regarding the validity of the tests chosen. The data used for the modelling are a time-series (though MDBA 2016 argue they are not); and appropriate methodology must be taken into account.
2. Collinearity is likely to be substantial. This which makes policy advice based on the use of estimated coefficients from individual variables problematic. Serial correlation may also exist, but is not tested and it exists the estimated model needs to correct for it.
3. Variables often represent the same thing (eg: they use all current water allocations in a given year to drive current cotton production, PLUS all water diverted last year (regardless if it has been used in the crop or not) – again suggesting serious collinearity plus complete infeasibility of actual reality of water production.
4. Key variables that drive cotton production are missing: eg: climate temperature variability, cotton prices, technology change, drought etc. There is also no estimate of environmental water bought back within communities, hence they cannot be used to suggest the relationship between environmental water purchase and cotton production. MDBA technical overview (2016) argue that omitted variable bias is not an issue, albeit they do not conduct the appropriate test to indicate this. They also show that the correlation between cotton prices and irrigated land is actually reasonably high (e.g. page 18 reports a correlation of 0.37), which calls into question why a panel time-series regression was not used.
5. There is no indication of the differences between water entitlements owned by a region, and actual usage of water entitlements. For instance, a proportional relationship was assumed, but many irrigators have buffer/surplus water and do not currently use all their water entitlements.

6. Poor documentation of information sources, equations and results.
7. Conclusion: these results are not suitable for policy advice and fail to even show any meaningful relationship between cotton production and water diversions. Where these estimates are used, there are almost certainly will result in overestimation of the economic effects of water recovery.

These results then fed into:

KPMG (2016) Northern Basin Community Modelling: Economic Assessment of Water Recovery Scenarios, Nov, prepared for MDBA:

Overview: The report developed a community model to estimate the effects (FTE jobs in the farm and agricultural supply area) on 21 communities in the Northern Basin following a change in surface water availability. Baseline was 1999-00 to 2013-14 and used to estimate the impact on jobs from environmental water recovery, in the context of climate, productivity improvements and other factors.

The report states time-series modelling of the impact of irrigated jobs in the community and irrigated hectares (plus other variables) was not undertaken because of the small sample size, but there are more than sufficient observations with a pooled cross-sectional time-series (especially if they included all areas in the Northern Basin rather than a small sample).

KPMG modelled over census years of 2001, 2006 and 2011:

$$\ln L_{j,c,T} = \alpha_j + \beta_j \cdot \ln X_{c,T} + \varepsilon_{j,c}$$

Where L= FTE jobs in a sector j (IrrigFarm, NonIrrigFarm, AgSup, Other private business) and X was a set of variables, namely: 1) ha of cotton production; 2) grazing production ha x rainfall index; 3) cropping production ha x rainfall index and 4) FTE jobs in the whole sector (take Other Private business FTE jobs)

For Irrigated Farms in particular, the models only included irrigated hectares in a community and a dummy for the different communities. Log functional forms were used. These results were then used to simulate changes in water diversions.

Problems include:

1. Self-selection bias of the original 21 communities. Communities are smaller areas than statistical local areas, and the 21 communities were within the highlighted SLA areas in the table below. MDBA stated in their technical overview (2016), that this selection was taken deliberately to model the communities that would be most affected. Sample bias always results when communities are self-selected for modelling purposes. This is obvious from the table below which highlights all the areas in the Northern basin that could/should have been used in the modelling. Then 15 communities out of the 21 were then modelled (the communities which were dropped for modelling are highlighted in the SLAs in green below), for the 3 census years, to give a total number of observations of 45 for each community. By doing so, the analysis does not take into account impacts on nearby areas (which spatial modelling would take into consideration) and also reduces the number of areas modelled, plus ignores specifically modelling areas downstream that would benefit

from increased diversions. A panel cross-sectional analysis across all SLAs and communities would have provided more robust results (and would have provided more representative results across the northern MDB), rather than a number of regressions using 45 observations and having too many independent variables within each model.

Northern Basin SLAs, Irrigation Farm businesses, Area Watered and Volumes applied

SLA name	Number of businesses	Total area watered (ha)	Total volume applied (ML)
Toowoomba (C) - North-East	np	np	np
Toowoomba (C) - West	np	np	np
Moree Plains (A)	142.5	73,821.2	456,011.7
Narrabri (A)	148.9	51,171.1	260,265.9
Waggamba (S)	48.8	32,516.3	189,116.2
Balonne (S)	80.5	23,750.0	167,028.0
Walgett (A)	42.2	20,632.2	114,834.8
Gunnedah (A)	117.9	17,884.4	62,906.9
Wambo (S)	103.7	17,566.6	57,259.3
Narromine (A)	106.2	14,903.7	83,276.9
Millmerran (S)	66.1	13,027.6	34,863.5
Jondaryan (S) - Pt B	176.0	11,913.8	33,787.6
Warren (A)	54.2	11,572.9	79,334.9
Pittsworth (S)	95.0	10,895.5	30,899.1
Bourke (A)	16.5	7,980.6	65,414.7
Liverpool Plains (A)	91.5	7,782.5	23,347.4
Gwydir (A)	48.5	7,397.2	25,658.1
Tamworth Regional (A) - Pt B	213.1	6,826.7	23,120.5
Mid-Western Regional (A) - Pt A	157.0	5,551.9	10,547.6
Stanthorpe (S)	279.8	5,089.2	10,197.6
Inglewood (S)	76.9	4,944.3	15,758.7
Inverell (A) - Pt A	58.4	4,397.9	13,889.6
Tara (S)	20.4	3,636.5	8,508.1
Clifton (S)	85.9	3,325.0	6,261.6
Tamworth Regional (A) - Pt A	104.7	2,701.5	9,985.8
Murilla (S)	20.6	2,634.4	10,732.9
Warwick (S) - North	76.6	2,598.8	4,815.1
Chinchilla (S)	43.9	2,361.0	7,232.5
Wondai (S)	43.6	2,112.7	6,503.7
Warwick (S) - East	86.5	1,772.0	4,419.0
Wellington (A)	43.2	1,704.8	5,847.3
Dubbo (C) - Pt B	31.4	1,584.9	6,224.6
Mid-Western Regional (A) - Pt B	32.1	1,576.6	4,642.6
Rosalie (S) - Pt B	51.0	1,529.6	3,211.4
Warrumbungle Shire (A)	39.3	1,366.6	3,718.4
Tenterfield (A)	54.8	1,365.6	3,623.7
Warroo (S)	8.9	1,342.3	6,894.9
Warwick (S) - West	34.3	1,270.9	np
Booringa (S)	8.0	1,147.4	np
Jondaryan (S) - Pt A	32.5	1,131.0	2,785.3
Bathurst Regional (A) - Pt A	35.7	1,076.2	3,042.6
Crow's Nest (S) - Pt B	51.4	1,070.2	2,623.5
Cambooya (S) - Pt B	52.5	975.1	2,224.2
Cambooya (S) - Pt A	16.4	918.5	1,574.8
Armidale Dumaresq (A) Bal	17.1	762.5	np
Murweh (S)	11.7	690.8	np
Dubbo (C) - Pt A	31.7	617.1	1,753.3
Paroo (S)	7.8	591.7	np
Inverell (A) - Pt B	13.4	561.9	1,166.1
Walcha (A)	12.2	468.6	1,052.2
Lithgow (C)	13.4	457.4	712.5
Bungil (S)	6.7	450.0	np
Glen Innes Severn (A)	7.7	379.4	np
Bogan (A)	5.4	327.4	np
Uralla (A)	9.7	318.0	np
Rosalie (S) - Pt A	19.4	281.8	709.1
Brewarrina (A)	2.5	252.4	np
Gilgandra (A)	12.1	210.0	826.5

Guyra (A)	8.9	198.2	494.9
Bendemere (S)	3.4	140.1	np
Warwick (S) - Central	11.1	134.8	np
Crow's Nest (S) - Pt A	15.2	110.2	1,497.1
Tambo (S)	2.2	93.6	np
Bulloo (S)	1.2	65.4	np
Coonamble (A)	5.6	56.2	np
Goondiwindi (T)	1.2	4.7	np
Toowoomba (C) - South-East	2.2	3.3	np
Dalby (T)	1.2	1.6	np

Source: ABS: Water Use on Australian Farms 2005-06, 4618.0. Data at SLA level was provided by ABS through customer request.

2. Again, the water relationship was modelled as linear and proportional when the peer-reviewed academic literature does not show this linear relationship. Indeed, the authors themselves state (p. 43) that a non-linear relationship should be further explored in terms of the results.
3. No spatial influences explored within the regressions, all impacts assumed to coexist within one another.
4. The only variable modelled in the irrigated FTE employment model was irrigated hectares (plus community dummies) – hence ignoring the multiple and longstanding other influences (eg: drought, climate, prices, economies of scale, technology change etc). Technology change in the cotton sector has been a major reason of falling employment in this area, and this is ignored in this modelling.
5. The marginal impacts of water have not been attributed for properly, with little accounting of on-farm resource movements.
6. No evidence of control for heteroscedasticity or collinearity, or a test for serial correlation in the error terms.
7. Conclusion: economic effects of water recovery are overestimated, including likely job losses.

Blackwell B, McFarlane J, Stayner R. (2016) Final Review Report for the Murray-Darling Basin Authority (MDBA) An Independent Review of the Social and Economic Modelling Inputs to the Northern Basin Review, report to the MDBA, October.

Highlights the peer review of the Northern Basin Review, and outlines a number of issues with the modelling.

- The peer review was reasonably comprehensive, albeit does not survey and cover the existing water economic literature that comprehensively
- Many of its criticisms/comments were not taken on board by KPMG or MDBA (eg R2 – concentrate on farm returns, F/C3 – job losses overestimated; R9-timeseries nature of modelling not allowed for; R11/R12-lack of referencing, diagnostic testing and support for key assumptions)
- The peer review did not specifically highlight the reflows issue, the sample selection bias, the increasing water utilization issue, the lack of evidence between water use and farm production, and a number of other statistical issues of the modelling.

MDBA technical overview (2016) *Northern Basin Review: Technical overview of the social and economic analysis*, Canberra:

The issues with this technical overview are associated with the problems identified above for MDBA (2016); KPMG (2016) and Blackwell et al. (2016).

RMCG (2016), *Basin Plan – GMID socio-economic impact assessment*, prepared for GMID Water Leadership Forum, available online:

This study was commissioned by the GMID water leadership forum to estimate the socio-economic assessment of the Basin plan, particularly for GMID. It provides a mix of modelling of assumptions between the relationship of water use and production, and the associated community level impact on jobs and income. It assumes a 20% reduction in water entitlements is directly related to $580 million/year and 1000 jobs.

Issues with this study:

1. Data sources for nearly every figure in this report are not provided, making it hard to check the assumptions and information. Much of the data seems incorrect. For example, the figures for water use of sectors across time do not match up at all water diversion figures from the MDBA's water monitoring reports, nor their transitional reports from 2012 onwards.
2. Page 16: the authors assume a direct proportional relationship between milk production post Millennium drought and post the 2002-03 drought with water entitlement buyback. They assume that because milk production fell by 500ML annually this was a direct cause of water buybacks (eg no allowance for any other influence on milk production such as milk prices, economies of scale, etc).
3. There seems to be a lack of understanding in the report between 1) water entitlements LTAAY owned by persons residing in a region (highest ML); 2) water allocations received annually by the region (lower than 1)) and 3) water allocations/diversions used in a region (usually lower than 2)). These differences are critical if one wants to estimate socio-economic impacts from changing water use. For example, 1) changes slowly over time given buyback and water trade, while 2) varies considerably depending on climate factors, while 3) also varies depending on climate and the amount of buffer-surplus water irrigators have. For example, it has been shown that historically irrigators in the MDB only have used around 70% of their water allocations they receive (Wheeler et al. 2014).
4. Following on from above, RMCG estimate a 20% reduction in water availability (eg 2) above) for GMID, namely 335GL reduction. They then assume a direct linear relationship between water use and milk production (ignoring surplus water, on-farm resource movements, other adaptation measures).
5. No other modelling was undertaken, eg: the impact of milk prices, economies of scale, capital, terms of trade, climate, etc have NOT been considered.
6. When reporting on the impacts of buyback within communities, the report is highly selective of the available evidence. For example, in Annex 3 it quotes the report that Wheeler and Cheesman (2013) was based on, namely what farmers have done since selling water entitlements, and then incorrectly provides an estimate of the impact on farm production (which is wrong and overstated). This is used to support the direct correlation between water use and production. Importantly, other academic research highlights that the relationship is not proportional, and sometimes not even significant between water use and farm production given farm adaptation measures.

RMCG continue in Annex 3 to claim farmers could only afford to keep producing after selling permanent water by buying temporary water on the market – thus ignoring findings in Wheeler and Cheesman (2013) that clearly stated there were a number of reasons why production did not change (eg: surplus water, farm adaptation, substituting feed for watering pasture, debt reduction, restructuring etc).

7. The model on water price impacts is highly simplistic and fails to consider the substantial influences that exist, and that have been shown in peer-reviewed literature.
8. As a result, given that all these above assumptions fed into the economic impact modelling by Econsearch, their scenario modelling of job and GRP cannot be used for policy advice. Further, their results overestimate the economic effects of water recovery.

MJA (2017) *Economic impacts of Commonwealth water recovery in Murrumbidgee*: report for the Federal Department of Agriculture and Water Resources Report

This provides an example of a proper economic analysis that takes into account actual gross value, dynamic community adjustment through CGE analysis. This study shows that gross value added is likely to increase in the Murrumbidgee by $470million (with up to 300 jobs) by 2034.

Ernst and Young (2018) *Analysis of Efficiency Measures in the Murray-Darling Basin*, report for Murray-Darling Ministerial Council, January,

This report analyses the socioeconomic impact of efficiency measures. Some of the deficiencies of the report include an almost complete failure to account for the relevant research in the peer-reviewed academic literature. Further, a number of statements are provided that are not supported by evidence but represented as fact (e.g. p. 65: "There is evidence that past programs of water recovery and on-off farm irrigation infrastructure have affected irrigators, irrigation networks, communities and the Basin as a whole".)

Overall issues within this study include:

1. Report is meant to highlight all the socio-economic impacts of water use efficiency measures. First of all, they do not define what is meant by water use efficiency – there is a specific term that this means (namely output produced by water consumed). The report is actually referring to irrigation efficiency (water utilised by the crop). Careful definitions are needed when addressing the issue of efficiency as differences in understanding will require different policy and cause different outcomes.
2. There is a lack of recognition in this report about the return flows issue (namely that irrigation efficiency reduces – to some unknown extent as the research work has not been done in this area – runoff to surface water and recharge to groundwater) and the corresponding impact on Community and Basin (ie. reduces overall sustainability). The only recognition seems to be a dotted line on p. 79 running from reduced run-off to a box "potential environmental outcomes" (which is probably to be interpreted as "positive" impact).
3. There is a whole literature on the impact of irrigation infrastructure upgrades on farm water use, with the most common results indicating the "Jevons Paradox" and the rebound effect. Namely, instead of 'saving water', subsidies intended to increase irrigation efficiency may, in fact, increase farm water applications because farmers

bring on more irrigated land, and change crop use. This report does suggest that this scenario may occur (e.g. p 85 with an increase in water demand by farmers as one of the options).

4. The report recognises that one effect of the infrastructure program is to change farmer behaviour and have them adopt higher value crops (e.g. permanent crops) BUT this report classifies this as a **positive** (e.g. page 87) outcome. From a community point of view, the increased conversion away from annual to permanent cropping imposes external costs because increased conversion increases the risk profile of irrigated farming in the future and in a drought (see Wheeler et al. 2014 for more discussion about how water markets saved many farmers in the Millennium drought).
5. P. 87 (and p. 96) – again there is a complete lack of recognition in this report about surplus/buffer water, and increasing utilisation of water entitlements. The Report's assumption is that water entitlement ownership is the same as water entitlement use (p. 87) which means that irrigators need more water they are obliged to purchase water entitlements. This assumption is incorrect. Further, report fails to mention increased electricity prices may result, but this is not emphasised.
6. No recognition in this report that there is a trade-off between spending on infrastructure and spending on other community services. For example, the estimate that spending on health/education services versus infrastructure may result in 2 -3 more permanent job creation (Wittwer and Dixon 2013).
7. No recognition in this report about the need to focus on agricultural profits, not agricultural production.

APPENDIX B: OVERVIEW OF KEY PEER REVIEWED WATER TRADE AND FARM WATER USE STUDIES CONDUCTED IN THE MDB

Study	Methodology	Detail
THEORETICAL MODELLING STUDIES		
Peterson, D., Dwyer, G., Appels, D. and Fry, J. 2004. Modelling water trade in the southern Murray-Darling Basin. Productivity Commission Staff Working Paper. Melbourne: Productivity Commission.	Computable general equilibrium (CGE) model analysis of the Impacts of reductions of 10, 20 and 30% in water availability in the sMDB under conditions of no trade, intra-regional trade only, and both intra- and interregional trade	The model estimates that moving from no trade to intra- and interregional trade together more than halves the impact of the reductions in water on the gross regional product in sMDB, and moving from no trade to intra-regional trade lessens the impact by 35-42%. Including interregional trade reduces it another 22 to 24%. Modelled value of trade from 1997-98 to 2001-02.
Qureshi, M.E., Shi, T., Qureshi, S.E., Proctor, W. 2009. Removing barriers to facilitate efficient water markets in the Murray-Darling Basin of Australia, *Agricultural Water Management*, 96, 1641-1651.	Irrigation water demand optimisation model	1) Reduction in water market barriers in the sMDB would increase annual net returns significantly 2) Expanding from intraregional trade to interregional trade
NWC 2010. The impacts of water trading in the southern MDB: an economic, social and environmental assessment. National Water Commission, Canberra.	CGE model was used to estimate the aggregate economic impacts of water trading at the regional, state, sMDB and national levels	Found water trading in the sMDB increased Australia's gross domestic product in 2008–09
Mallawaarachchi, T, Adamson, D, Chambers, S & Schrobback, P 2010, Economic analysis of diversion options for the Murray–Darling Basin Plan: Returns to irrigation under reduced water availability, report for the Murray–Darling Basin Authority, Risk and Sustainable Management Group, School of Economics, the University of Queensland.	Partial equilibrium model	Assessed allowing water trade inter-regions with reallocation of water from consumptive to environment in the MDB allowed increased gross value of production
Adamson, D., Quiggin, J., Quiggin, D., 2011. Water Supply Variability & Sustainable Diversion Limits: Issues to Consider in Developing the MDB Plan.	State contingent modelling	Modelled 2,900GL transferred to the environment with trade occurring within the identified northern and southern Basin occurs. It found that 23% less water will be available for irrigation diversions which will cause the area irrigated to contract by from between 16-22%. The reduction in plantings will reduce the gross value of irrigation by about 11-13% and economic returns by 10-14%. Flow to the Coorong was modelled to increase by 30-41%.
Grafton, R and Jiang, Q 2011, 'Economic Effects of Water Recovery on Irrigated Agriculture in the MDB', *Australian Journal of Agricultural and Resource Economics*, 55, 487-499.	Hydro-economic model	Results indicate that substantial reductions in surface water extractions of up to 4400 GL per year impose only a moderate reduction on net profits in irrigated agriculture
ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences) 2011. *Modelling the economic effects of the Murray-Darling Basin Plan.* Report prepared for the MDBA. ABARES project: 4311 (November).	Comparative static partial equilibrium model	Simulates water trading both within and between MDB regions, using census data from 2000-01 and 2005-06. Estimated a range of scenarios of water reallocation, before and after interregional trade. For example, Scenario 2 assessed 2800 GL SDL with Cwlth investment in infrastructure, with and without trade.

Wittwer G. (2011) Confusing Policy and Catastrophe: Buybacks and Drought in the Murray–Darling Basin, The Economic Record, Volume 30, Issue 3, Pages: 289-430	CGE modelling	The irrigation output loss is about half the loss based on a direct calculation using database weights (i.e., 1.9 per cent for drought instead of 3.4 per cent, and 0.7 per cent for buybacks instead of 1.4 per cent). This reflects water moving to other uses: the average product of water is higher in perennials than in rice, so through water trading, rice output will fall by a larger percentage than the fall in overall water availability resulting from either drought or buyback." He also concludes that some capital and labor in irrigation "moves into dry-land production as water availability falls. This in turn explains the smaller modelled impact shown in column (2) 2.7 per cent) relative to the direct impact (column (1), 3.3 per cent) of drought on dry-land output. Similarly, dry-land output increases relative to forecast in the buyback scenario"
NWC, 2012. Impacts of water trading in the southern Murray-Darling Basin between 2006-07 and 2010-11. NWC, Canberra.	CGE model - Modelled without access to water trade in the sMDB. CGE - Modelled expanded intra- and inter regional trade as a consequence of National Water Initiative reforms in the sMDB.	1) Examines aggregate economic effects of water trade on irrigator water adjustment within and across irrigation regions from 2006/07 to 2010/11. 2) NWI institutional reforms were estimated to have reduced the impact of drought within the sMDB from $11.7 billion to $7 billion over the 2006/07 to 2010/11 period—with higher magnitude benefits being incurred during exceptionally dry years when the need to reallocate water was highest
Wittwer, G., Griffith, M., 2011. Modelling drought and recovery in the southern MDB. Aust. J. Agric. Resour. Econ. 55, 342–359.	CGE modelling	The prolonged drought from 2006–07 to 2008–09 in south-eastern Australia presented severe difficulties for dry-land and irrigation farmers in the southern Murray-Darling basin. A dynamic multi-regional computable general equilibrium model (TERM-H2O) is used to estimate the economy-wide small region impacts during and after drought. Drought reduces real GDP in some small regions by up to 20 per cent. Irrigation water trading and farm factor movements alleviate losses. The drought results in an estimated 6000 jobs being lost across the southern basin. Depressed farm investment during drought results in farm capital not returning to baseline levels after drought. Consequently, job numbers in 2017–18 remain 1500 below forecast in the southern basin.
Banerjee O (2015) Investing in recovering water for the environment in Australia's Murray-Darling Basin, International Journal of Water Resources Development, 31:4, 701-717	CGE modelling Murrumbidgee	Assumed that half of compensation is respent locally and find "positive impact on GRP is attributed to the increase in government expenditure in the region and the increase in output from a few sectors, including construction, communications and business services." "Considering the results for the Murrumbidgee, real GRP, household consumption, employment, wages, imports and aggregate capital stock increase".
Wittwer, G. & Dixon, J. (2013), "Effective use of public funding in the	CGE modelling	Policy instruments designed to increase environmental flows in the Murray–Darling

Murray-Darling Basin: a comparison of buybacks and infrastructure upgrades", Australian Journal of Agricultural and Resource Economics, 57(3): 399-421.		Basin are compared using TERM-H_2O, a detailed, dynamic regional CGE model. Voluntary and fully compensated buybacks are much less costly than infrastructure upgrades as a means of obtaining a target volume of environmental water, even during drought, when highly secure water created by infrastructure upgrades is more valuable. As an instrument of regional economic management, infrastructure upgrades are inferior to public spending on health, education and other services in the Basin. For each job created from upgrades, the money spent on services could create between three and four jobs in the Basin.
APPLIED ECONOMIC STUDIES		
Study	**Methodology**	**Detail**
Qureshi ME, Schwabe K, Connor J, Kirby M. 2010. Environmental water incentive policy and return flows. Water Resourc. Res. 46(4). https:/doi.org/10.1029/2008WR007445	Theoretical model and analysis of irrigation data	Found that when incentive programs involve water savings being split between irrigators and the environment and there are high rates of return flows, efforts to generate water for the environment through increases in irrigation efficiency can actually reduce net water available for the environment substantially.
Loch A, Wheeler S, Boxall P, Hatton-Macdonald D, Adamowicz WL, Bjornlund H. 2014. Irrigator preferences for water recovery budget expenditure in the MDB Australia. Land Use Pol. 36: 396-404.	Statistical analysis of irrigator survey records	Analysed over 950 irrigator survey records in the southern MDB to highlight where irrigators would prefer to have water recovery money spent. Contrary to popular beliefs, there is almost as much support for market- based options (eg allocation trade, leasing, water entitlement buyback) as irrigation infrastructure expenditure.
Wheeler S, Cheesman J. 2013. Key findings from a survey of sellers to the Restoring the Balance programme. Econ. Pap. 32:340–52	Statistical analysis of irrigator survey records	Analysed 589 records of irrigators who had sold permanent water to the federal government. Key findings included: Almost 80% of irrigators surveyed said they believed their decision to sell water had been an overall positive decision and had not had to make any changes on farm. Those that did make changes, did the following: This includes an increase in buying water allocations, increasing irrigation efficiency, changing crop mix, utilising carry-over more, increasing off-farm employment, with a small percentage of people buying water entitlements again. Also, many of those who sold all their surface water to the Commonwealth were moving into retirement (hence scaling down anyway), while some were employing other methods (eg utilising groundwater sources) to enable them to keep farming. 30% sold water for debt reasons. Irrigators who sold water only historically had used 75% of their entitlements on average
Wheeler S, Zuo A, Bjornlund H. 2014. Investigating the delayed consequences of selling water entitlements in the Murray-Darling Basin. Agric. Water Manag. 145:72–82	Log-linear pooled cross-sectional analysis	Modelling was conducted on 1893 irrigator survey records in the southern MDB from 2008-09 to 2010-11. It suggests that to date, many irrigators who sold water to the Australian Government and continued farming in the southern Murray-Darling Basin have predominately sold their surplus and buffer

		water (water not used in production). There is only weak evidence from the regression modelling to suggest that there is a lagged negative impact on net farm income from selling water entitlements, which supports the notion that the reduction in farm production has been offset by many irrigators using water sales proceeds to reduce debt (and hence interest payments), restructure and reinvest on farm.
Wheeler S, Zuo A, Hughes N. 2014a. The impact of water ownership and water market trade strategy on Australian irrigators' farm profitability. Agric. Syst. 129:81–92	Fixed effects panel regression models	This study uses irrigation industry survey data collected over a five year period from 2006/07 to 2010/11 (n=3428) across the Murray-Darling Basin to investigate the relationship that water trade strategy and water ownership have with farm viability (namely farm net income and rate of return). It was found that the actual volume of water received (which is a measure of water allocations for that region and size and security of water entitlements) is a more significant and positive influence on net farm income than water ownership per se, with this result most strongest in the horticulture industry. Water reliability is not as important in the broadacre industry as other industries. Selling water allocations was a significant and positive influence on higher net farm income and rates of return. Buying water entitlements was sometimes associated negatively with farm viability in our time period, with no statistical significance found for the impact of selling water entitlements on farm viability in the current year.
Kirby M, Rosalind Bark, Jeff Connor, M. Ejaz Qureshi, Scott Keyworth, (2014) Sustainable irrigation: How did irrigated agriculture in Australia's Murray–Darling Basin adapt in the Millennium Drought? Agricultural Water Management, 145, Pages 154-162.	Econometric analysis of ABS census data	Averaged across crops the studies find as little as 0.1% reduction in farm production revenue to around 0.6% for each 1% reduction in water allocation with significant variation by crop
Connor, J, John M. Kandulu, Rosalind H. Bark, 2014. Irrigation revenue loss in Murray–Darling Basin drought: An econometric assessment, Agricultural Water Management, 145, 163-170.	Econometric analysis of ABS census data	Comparison revealed that marginal revenue changes in response to water allocations estimated are much less than those implicit in other economic assessments of water scarcity impacts for the same basin that used different methods.