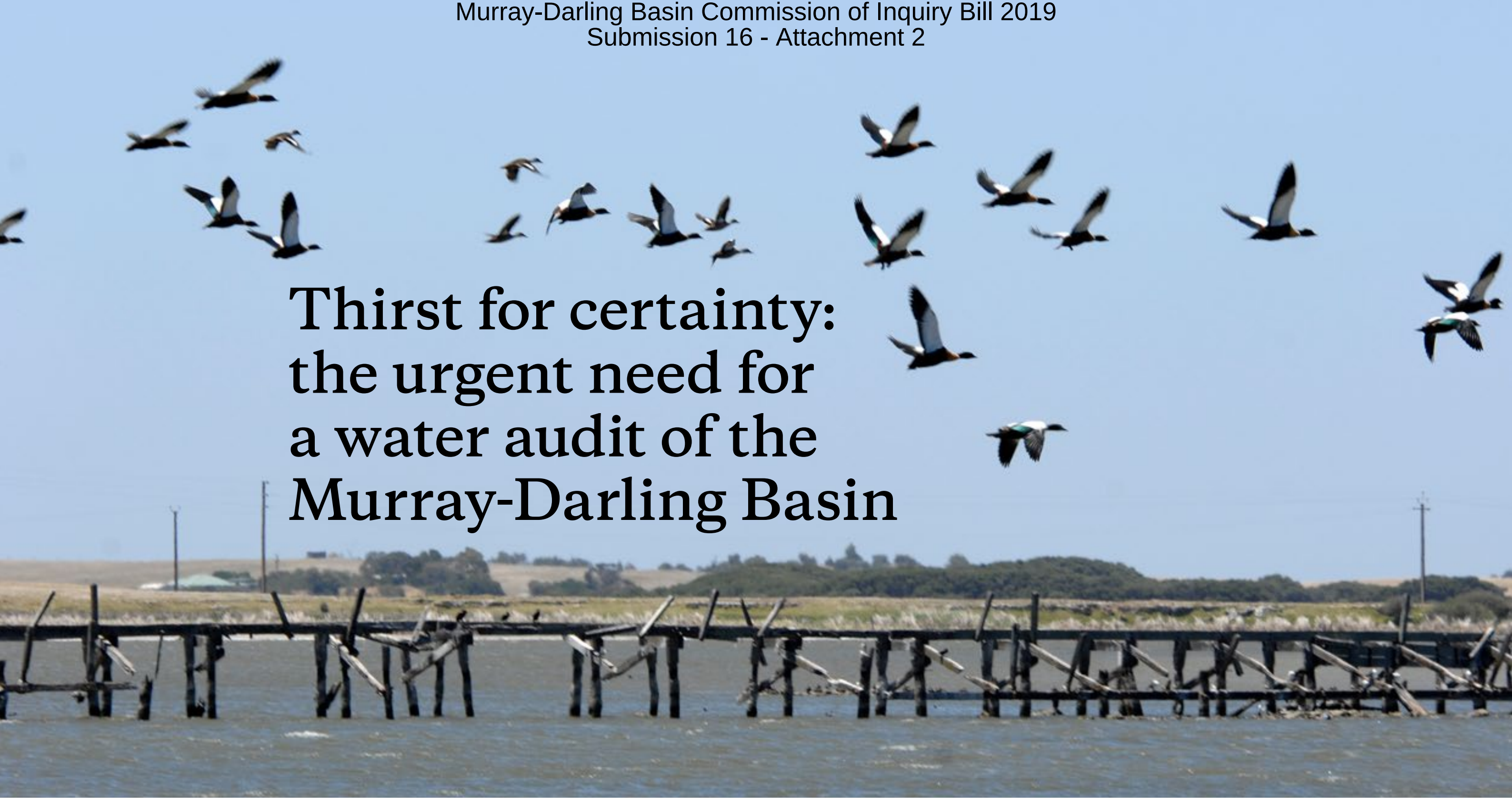

Thirst for certainty: the urgent need for a water audit of the Murray-Darling Basin

Water management in the Murray-Darling Basin (MDB) has generated much public controversy and also widespread distrust in state and federal authorities. A general failure to apply transparent processes from policy development to monitoring, water accounting and compliance has led to a high level of uncertainty with respect to water security across the diversity of community interests within the Basin. There is large uncertainty over what the current and future level of water diversions within the MDB are, and especially in the Northern Basin. Water planners and water users need to know where, how and when water is diverted and returned to aquifers and streams, and how this might be altered with climate change.

A water audit is required to make the best use of the water accounts being developed by BOM and state agencies. Without transparent and audited water accounts that include measures or reliable estimates of recoverable return flows, floodplain water harvesting and climate change, large unmitigated risks will remain for all water users. These risks jeopardise the successful implementation of the current Basin Plan, future levels of Sustainable Diversion Limits, and also the reliability of water entitlements within the MDB.

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Water management in the Murray-Darling Basin (MDB) has generated much public controversy and also widespread distrust in state and federal authorities. A general failure to apply transparent processes from policy development to monitoring, water accounting and compliance has led to a high level of uncertainty with respect to water security across the diversity of community interests within the Basin. A key challenge for irrigators is uncertainty in the volume of water entitlements in the setting of Baseline Diversion Limits (BDLs) and, thus, the Sustainable Diversion Limits (SDLs). This is of particular concern in the northern MDB because of the unknown volumes and nature of floodplain water harvesting. A way to mitigate this uncertainty is a comprehensive water audit that would transparently evaluate: (1) return flows associated with changes in irrigation efficiency; (2) how current and future water entitlements are to be calculated in the transition to SDLs, especially with proposed changes to provide tradable water entitlements for floodplain water harvesting; and (3) the consequences of climate change for the reliability of existing water entitlements. We contend that a water audit is urgently needed to respond to the following key questions: Where is the water? How is it being used? And, what volumes of water are being diverted and returned to the system? A comprehensive water audit across all catchments would provide a sound basis for decision-making and ensure that owners of water entitlements get their 'fair share', now and into the future.

Urgent need for a water audit

The past two years have witnessed a number of high-level enquiries in relation to water use and governance in the MDB. These include the South Australia Murray-Darling Basin Royal Commission (MDBRC, 2019), the Productivity Commission five-year assessment of the Basin Plan (PC, 2019), an Academy of Science Review (AAS, 2019) on the Menindee Lakes Fish Kills at the end of 2018 and early 2019, and several enquiries in relation to monitoring and compliance of water diversions (Grafton, 2019). In addition, in 2019 the Australian Competition and Consumer Commission (ACCC) is tasked with reviewing water market trades in the Basin and the Australian National Audit Office (ANAO) is examining negotiated sales of water entitlements by the Federal Government that have occurred from 2008 in terms of their value for money and whether government procurement rules were followed (ANAO, 2019).

Given these current and already delivered enquiries, it would be reasonable to ask, does Australia need another audit with respect to the MDB? In our view, the answer is an unequivocal **yes**. This is because of the large uncertainty over what the current and future level of water diversions within the MDB are, and especially in the Northern Basin.

The fact that the Murray-Darling Basin Authority (MDBA) and state agencies currently either do not know or fail to make publicly available: (1) the volumes of water in private storages; (2) the volume of water diverted through floodplain capture; and (3) the downstream flow effects of increases in irrigation efficiency, should be a matter of concern for both irrigators and those concerned with the Basin's environment. Importantly, uncertainty over private water storage, floodplain capture and return flows undermine the integrity of holders of water entitlements, increase the likelihood of errors in decision-making, and diminishes trust in decision-making by water governance agencies, especially by the owners of water entitlements. Indeed, in May 2019 a $750 million class action was initiated against the MDBA in the Supreme Court of New South Wales citing negligence by the MDBA that the claimants argue has caused them 'severe financial losses' (King, 2019). Irrespective of the merits of the class action, a comprehensive water audit would provide the MDBA, state agencies and irrigators with the data they need to determine whether or not goals and outcomes of water resource planning are being delivered.

Auditing is an activity of verification, checking, evaluation and interpretation of a set of accounts. It is most widely applied to the auditing of financial statements. Financial auditing may include: the checking of accounting records; verification of the validity and reliability of accounting information based on the information available; and comments on the adequacy of the accounts to determine the state and the financial health of the organisation. Our call for a water audit of the MDB is based on these same auditing principles, namely, to verify, check, evaluate and interpret catchment and basin-scale water accounts to establish progress against the objects of the Water Act (2007).

The Bureau of Meteorology (BOM) publishes a National Water Account that currently comprises 10 regions, including the MDB. Its water accounts include a range of information such as changes in inflows, outflows and storages (BOM, 2019a). In preparing its water accounts, BOM has statutory obligations in relation to: collecting, interpreting and disseminating water information; conducting regular national water resources assessments; publishing an annual National Water Account; providing regular water availability forecasts; issuing national water information standards; advising on matters relating to water information; and enhancing understanding of Australia's water resources (BOM, 2019b).

BOM partners with State and Territory water agencies – as well as with other Australian Government agencies, water utilities and various water agencies – to collect the data used to construct the National Water Account. New South Wales (NSW) is a leader in implementing General Purpose Water Accounting Reports (GPWAR) that seek to provide consistent and transparent information to water stakeholders, internal staff, external government agencies, universities, water brokers and the general public (NSW DOI, 2019a). Notwithstanding the gaps in existing water accounts, the BOM and state water accounts would form the basis of a comprehensive audit of the MDB.

In sum, to be able to make the best use of existing water accounts and to identity and resolve gaps in knowledge and measurements, there is an urgent need for a water audit. It would be a hydrological audit, using the best available science, of water storages (including privately-owned storages), end-of-system flows, diversions, and return flows by catchment for all categories of water diversions within the MDB. In addition to quantity or volume data, a water audit should also provide basic water quality measures (salinity, Biochemical Oxygen Demand, acidity, etc.) at key locations to allow water users and water planners to make judgements about how the water they access can be used. While an audit would be done on an annual basis, it would also be important to have an historical series of water data and measures so as to allow, where at all possible, analyses, comparisons and evaluation by water users, water agencies and researchers.

Uncertainty Factor 1: Recoverable return flows

Water diverted for irrigation that is not consumed (transpired or evaporated) and that returns to groundwater or streams represents recoverable return flows (Grafton et al., 2018). Return flows and other water flows associated with irrigation diversions are illustrated in Figure 1.

Recoverable return flows are not properly accounted for in terms of water entitlements in the MDB which are denominated in gross rather than net volumes of water (diversions less recoverable return flows). The common assumption by many, including the MDBA, has been that increases in irrigation efficiency, especially during the 1998–2010 Millennium Drought, resulted in virtually nil recoverable return flows at the Basin scale. This assumption was queried in a submission to the Parliamentary Inquiry into Water Use Efficiency in Australian Agriculture (Grafton & Williams, 2017), and later investigated by the Australian Broadcasting Corporation's Background Briefing (ABC, 2019).

In 2018 the MDBA commissioned researchers at the University of Melbourne to evaluate the effects on return flows of water infrastructure investments to increase irrigation efficiency. This study concluded that irrigation efficiency may have reduced return flows by 121 billion litres/year under the assumption that groundwater-stream and river connectivity factors (CF) vary between 0.2 and 0.3, where a CF of 0 means groundwater is completely disconnected from river flows (Wang et al. 2018, p. 8). Williams and Grafton (2019) assume a CF of 1.0 on a decadal basis that they justify on

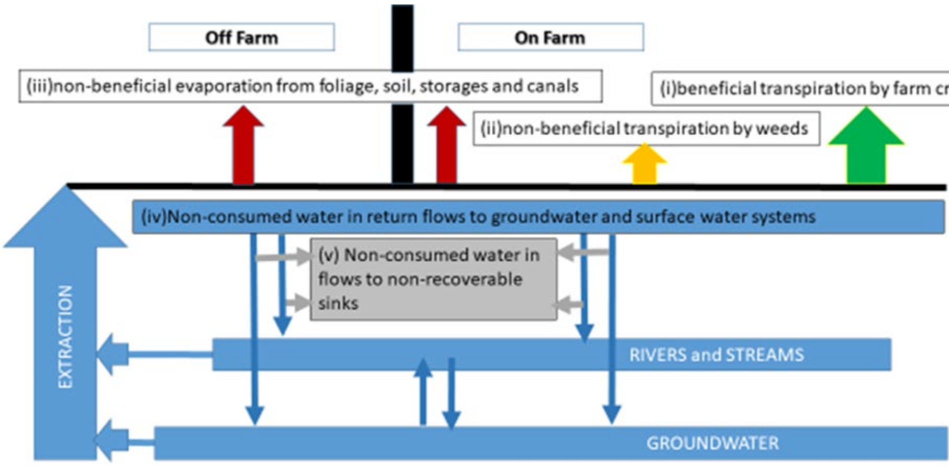

Figure 1: Possible water flows associated with irrigation diversions.

Source: Williams and Grafton (2019). Used with permission.

the grounds that water flows must satisfy the Conservation of Mass. Using the mid-point estimates of Williams and Grafton (2019), in terms of possible recoverable return flows as a proportion of water diversions, they estimate that the reduction in recoverable return flows associated with increases in irrigation efficiency, funded through some $4 billion in Federal Government expenditures on on-farm and off-farm irrigation efficiency over the past decade, is some 700 billion litres/year.

In sum, the most recent estimates of the effects on recoverable flows of increases in irrigation efficiency indicate the impact is material, with estimates ranging from over 100 GL/year to some 700 GL/year, or more. Changes to recoverable return flows associated with a switch from seasonal crops (Davies, 2019) to perennial agriculture represent an additional uncertainty. Importantly, both Wang et al. (2018) and Williams and Grafton (2019) argue for the need for much better water accounting in the MDB. Their finding is also consistent with Recommendation 1 of the *Parliamentary Inquiry into Water Use Efficiency in Australian Agriculture Report*, namely, the need to undertake:

> "… baseline measuring of regional ground or surface water systems at the commencement of each program, and then ongoing measuring to determine impacts of changed water practices resulting from water-use efficiency funded projects." (House of Representatives Standing Committee on Agriculture and Water Resources, 2017 p. xi)

Uncertainty Factor 2: Overland flows and floodplain harvesting

Overland flow is water that runs across the land after rainfall, either before it enters a watercourse, after it leaves a watercourse as floodwater, or after it rises to the surface naturally from underground. Floodplain water harvesting (MDBA, 2019a) is the capture and use of these overland flows across a floodplain by use of diversion embankments which, typically, direct water flows into extensive, shallow (up to 3–4 m depth) on-farm storages for irrigation use. As noted by NSW Department of Primary Industries (NSWDPI, 2017, p. 1):

> "The unrestrained harvesting of water from floodplains lessens the amount of water reaching or returning to rivers for downstream river health, wetland and floodplain needs as well as downstream users."

Capturing water in overland flow interceptions on a floodplain is the last substantial capture of water to be licensed in the Basin (NSWDOI, 2019b). In NSW, floodplain harvesting requires a water access licence, a basic landholder right or a licence exemption, as well as local government approval for construction of storages. Licensing and monitoring of floodplain harvesting is important to ensure that licence holders stay within their limits and do not impact downstream users. Thus, such licensing needs to be an integral part of water resource plans noting that the voluntary registration of storage structures has already commenced in the Barwon-Darling and Gwydir Valleys.

In Queensland, floodplain harvesting has been much less constrained; until recently it did not require licensing (QGBQ, 2019, p. 1), although local planning laws applied to the construction of levees and contour banks. There has been an attempt to regulate floodplain water harvesting under the cap system since 1995, but it has never been fully measured and accounted for water management purposes (MDBA, 2019a). As a result, floodplain water harvesting is an important area of uncertainty in relation to the actual water extraction in the northern catchments of the Basin that include: the Condamine-Balonne, Moonie, Border Rivers, Barwon-Darling, Gwydir and the Namoi.

The magnitude and extent of floodplain harvesting generates large uncertainties in terms of consequential effects on declines in river flows (Williams, 2017). Without appropriate and timely measurements, including evaporative losses from storages of harvested water, water balances of the MDB, and by catchment, will remain substantially incomplete. Partially in response to these uncertainties, work is currently underway in both NSW and Queensland to better understand how much water is harvested from floodplains now, and how much was being harvested prior to the Basin Plan. NSW is also developing General Purpose Water Accounting Reports that, while still incomplete, represent a major improvement in terms of water accounting in the MDB (NSWDOI 2019a).

As licensing, monitoring and compliance arrangements are improved in relation to floodplain water harvesting (NSWDOI, 2019b; QGBQ, 2019), these updated volumes "will need to be incorporated in the water limits and water resource plans." (MDBA 2019a). This is of particular importance in the Northern Basin where it appears that water diversions have substantially increased since the implementation of the Cap in 1995 (see Figure 2).

The MDBA (2019b) has estimated that the Northern Basin BDL from regulated rivers and watercourses is 2,370 billion litres/year while interceptions from floodplain harvesting is 207 billion litres/year, interceptions for farm dams are 1,182 billion litres/year and commercial forestry interceptions are 52 billion litres/year. By comparison, the Australian Academy of Science report (AAS, 2019) examined the magnitude of current levels of floodplain harvest and concluded that data for the growth in off-river storages or current volumes of floodplain capture remain poor, with only one full assessment which set floodplain storage at approximately 3,300 billion litres across all of the Darling River and its tributary catchments in 2007 (AAS, 2019, p. 21, Figure 9b; Webb Mckeown & Associates, 2007). Thus, the magnitude of floodplain harvesting could be much larger than the current estimates being used by water agencies.

A key goal of the NSW Floodplain Harvesting Policy is to bring existing floodplain water harvesting into the water entitlement system. This is to be achieved by estimating the current long-term average level of diversions of unregulated floodplain water harvesting that will be set equal to the lower value of the new modelling estimates for the diversions in the 1993–94 and 1999–2000 water years (Weber & Claydon, 2019). If the estimated current level of extractions is higher than the long-term average then all landholders who had approved overland flow water harvesting infrastructure in place, as of July 2008, will incur the same prorated reduction in extraction volumes. This may well result in water entitlements with, as yet, unknown water allocations that will need to comply with the BDLs (MDBA, 2019b) and SDLs of the Basin Plan (MDBA, 2019c).

In sum, despite efforts underway to better estimate floodplain water harvesting, there remains substantial uncertainty in relation to the volumes of water diverted from such interceptions. This is not only problematic for state water agencies in relation to achieving

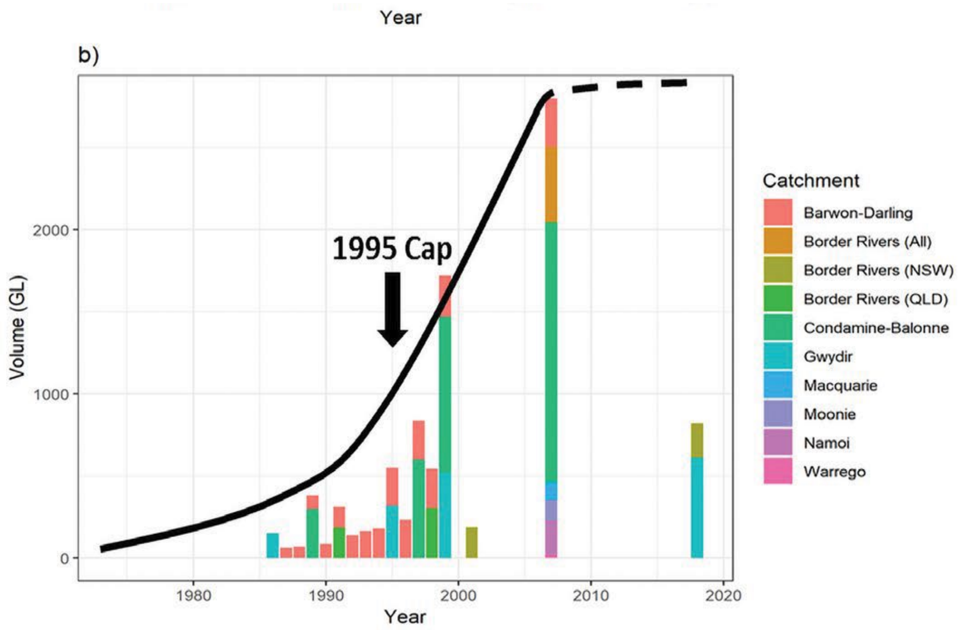

Figure 2: Estimated and projected surface water diversions in the Darling River and its tributary catchments from 1960 to 2020 (AAS 2019, Appendix 3 for data availability and sources).

Note: GL = 1 billion litres.

Source: AAS (2019, p. 21). Used with permission.

the goals of water resource plans, but also affects the future reliability of existing water entitlements. Should water entitlements for floodplain water harvesting become tradeable it would also almost certainly increase the utilisation rate of previous floodplain water harvesting licences. This, in turn, could affect the reliability of the water entitlements of downstream water users and alter the downstream flows. Only a comprehensive and transparent water audit at both a catchment and basin scale will provide the required information to effectively manage these changes.

Uncertainty Factor 3: Climate change impacts

The MDB is particularly sensitive to changes in its water flow characteristics induced by climate change because of its latitude and possible reductions in cool season rainfall and river flow (CSIRO, 2012; Whetton, 2017) and also the potential for increased warm season rainfall in the northern tributaries of the Darling River system (AAS, 2019, Appendix 5, p. 119). In CSIRO's 'dry climate scenario' (CSIRO, 2012) there are projected to be large reductions in runoff and water availability throughout the Basin. In CSIRO's 'wet climate scenario' there could be substantial increases in runoff and water availability in the Northern Basin, grading towards little change in the south. Importantly, if daily extreme rainfall increases, as projected, then even if average rainfall were to decline, floods might increase in severity.

CSIRO projections (CSIRO, 2012) based on hydrological models assume stationarity, namely, that natural systems fluctuate within an unchanging envelope of variability. However, climate change undermines the presumption of stationarity that has been used for modelling and for decision-making in relation to water supplies, water demands, and climate variability (Milly et al., 2008). This is important because a lack of stationarity in climate and hydrological processes increases the uncertainty associated with water planning going forward. Importantly, the 2012 Basin Plan SDLs were based on a historical climate without modelling climate change impacts (Pittock et al., 2015).

Current projections suggest that a rise of 1°C in the surface temperature is projected to result, on an annual basis, an approximate 9% reduction in subsurface soil moisture in the Southern MDB (Cai et al., 2009). But uncertainties still need to be resolved around these projections because Milly and Dunne (2016) and Yang et al. (2019) show that an increase in evapotranspiration may be offset by a decrease in evapotranspiration caused by decreased stomatal conductance in crops and pasture as a result of an increased concentration of carbon dioxide in the atmosphere. Further, even with an unchanged average rainfall in the MDB, increased temperatures could increase variability of flows, and also reduce flows. If this were to occur through increased soil evaporation, this would result in additional uncertainties in terms of the possible future effects on Basin ecosystems.

In sum, there is an urgent need for audited water accounts in the MDB. Such audited accounts must be developed at appropriate scales, and with confidence intervals, to evaluate the hydrological effects to projected changes in rainfall and temperature under climate change. While there is already ongoing hydrological research on climate change effects in the MDB, it is inadequate for the needs of policy development and the requirements of water resource plans, including the Basin Plan. Without a renewed focus on the risks of climate change, including the effects on the future reliability of water entitlements, water decision-makers will be severely handicapped in terms of their medium and long-term planning.

Conclusions

We highlight three important uncertainties with respect to water and its current and future uses in the MDB. These uncertainties can be mitigated, but only with a comprehensive, transparent set of audited water accounts that build on existing data sources. These audited water accounts are urgently needed by owners of water entitlements and water agencies responsible for managing water releases and diversions. This is because both water planners and water users need to know where, how and when water is diverted and returned to aquifers and streams, and how this might be altered with climate change.

A water audit is required more than ever to make the best use of the water accounts being developed by BOM and state agencies. Without transparent and audited water accounts that include measures or reliable estimates of recoverable return flows, floodplain water harvesting and climate change, large unmitigated risks will remain for all water users. These risks jeopardise the successful implementation of the current Basin Plan, future levels of SDLs, and also the reliability of water entitlements within the MDB.

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