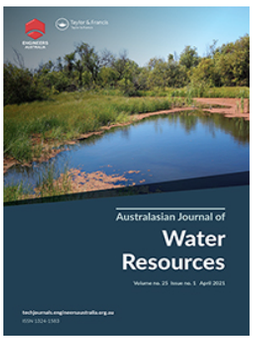

Australasian Journal of Water Resources

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/twar20

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To cite this article: Michael J. Stewardson, Nick Bond, Justin Brookes, Samantha Capon, Fiona Dyer, Mike Grace, Paul Frazier, Barry Hart, Avril Horne, Alison King, Marcia Langton, Rory Nathan, Ian Rutherfurd, Fran Sheldon, Ross Thompson, Rob Vertessy, Glen Walker, QJ Wang, Skye Wassens, Robyn J. Watts, J Angus Webb & Andrew W. Western (2021): The politicisation of science in the Murray-Darling Basin, Australia: discussion of 'Scientific integrity, public policy and water governance', Australasian Journal of Water Resources, DOI: 10.1080/13241583.2021.1996681

To link to this article: https://doi.org/10.1080/13241583.2021.1996681

Published online: 29 Oct 2021.

AUSTRALASIAN JOURNAL OF WATER RESOURCES
https://doi.org/10.1080/13241583.2021.1996681

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DISCUSSIONS

The politicisation of science in the Murray-Darling Basin, Australia: discussion of 'Scientific integrity, public policy and water governance'

Michael J. Stewardson[a], Nick Bond[b], Justin Brookes[c], Samantha Capon[d], Fiona Dyer[e], Mike Grace[f], Paul Frazier[g], Barry Hart[h], Avril Horne[a], Alison King[b], Marcia Langton[i], Rory Nathan[a], Ian Rutherfurd[j], Fran Sheldon[d], Ross Thompson[e], Rob Vertessy[a], Glen Walker[k], QJ Wang[a], Skye Wassens[l], Robyn J. Watts[l], J Angus Webb[a] and Andrew W. Western[a]

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ABSTRACT

Many water scientists aim for their work to inform water policy and management, and in pursuit of this objective, they often work alongside government water agencies to ensure their research is relevant, timely and communicated effectively. A paper in this issue, examining '*Science integrity, public policy and water governance in the Murray-Darling Basin, Australia*', suggests that a large group of scientists, who work on water management in the Murray-Darling Basin (MDB) including the Basin Plan, have been subject to possible 'administrative capture'. Specifically, it is suggested that they have advocated for policies favoured by government agencies with the objective of gaining personal benefit, such as increased research funding. We examine evidence for this claim and conclude that it is not justified. The efforts of scientists working alongside government water agencies appear to have been misinterpreted as possible administrative capture. Although unsubstantiated, this claim does indicate that the science used in basin water planning is increasingly caught up in the politics of water management. We suggest actions to improve science-policy engagement in basin planning, to promote constructive debate over contested views and avoid the over-politicisation of basin science.

ARTICLE HISTORY
Received 10 June 2021
Accepted 18 October 2021

KEYWORDS
Public trust; administrative capture; science–policy interface; environmental science and policy; social network analysis; water resources

1. Introduction

In this paper we discuss '*Science integrity, public policy and water governance in the Murray-Darling Basin, Australia*', a paper by Colloff, Grafton, and Williams (2021a) in the Australasian Journal of Water Resources (published online, 26 April 2021 and in this current issue). Hereafter we refer to Colloff, Grafton, and Williams (2021a) as CGW21. We examine CGW21's claim that scientists engaged in the provision of knowledge to inform water management and policy in the Murray-Darling Basin (MDB) have been subject to possible 'administrative capture'. Administrative capture is defined by CGW21 as the circumstance where scientists promote policies favoured by decision-makers with the objective of gaining personal benefit, such as increased research funding. Coupled with this claim, CGW21 argued that the same cohort can be characterised as 'Issue Advocates' (*sensu* Pielke 2007) because they seek to constrain the scientific questions asked, the decision options explored, and the evidence supporting alternate perspectives in the public policy space. In contrast, the CGW21 authors claimed to be Honest Brokers (Pielke 2007, 17), defined as scientists proposing a range of policy options that might appeal to a wide range of interests.

CGW21 illustrates the risks of administrative capture with a case study which purports to provide evidence of possible capture among a group of scientists (mostly academics, many who are authors of this paper), who were signatories to an Open Letter (Vertessy et al. 2019a; hereafter the 'Open Letter'). The Open Letter was published online, and criticised reporting of water management in the MDB. Specifically, the Open letter responded to the Australian Broadcasting Corporation (ABC) programme 'Cash Splash', aired on TV on 8 July 2019 (ABC 2019). Cash Splash criticised the Basin Plan, which was established in 2012 under the Water Act

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2007 (Australian Government 2012, 2013; Hart 2016a; b; Hart and Davidson 2017), and in particular the role of irrigation efficiency projects in southern New South Wales to recover water for the environment and meet Basin Plan objectives.

Below, we critically examine the lines of evidence used by CGW21 to support the claim of possible administrative capture. We show that statements by the Open Letter signatories are consistent with accepted forms of scientific conduct and science-policy engagement.

We also show that CGW21's analysis of research findings by individual Open Letter signatories relied on selective interpretations to support their contention of bias in favour of current policy approaches. Finally, we show the network analysis applied by CGW21 fails to address the claim that the signatories are more likely to be subject to administrative capture.

In addition to analysing CGW21's claims, we examine the state of science-policy engagement in the MDB. We argue that CGW21's 'us-and-them' perspective of their own scientific authority as Honest Brokers versus the 'captured' views of government-funded scientists is a symptom of deeper problems. We suggest that over-politicisation of science is the key issue that underlies CGW21's comments on the integrity of scientists holding apparently opposing views. We examine possible remedies to address the risks of increasingly politicised science and improve science engagement in water planning.

2. Context for CGW21's claims

We begin with important context for claims made by CGW21. First, we examine the specific claim made by CGW21 in relation to administrative capture and issue advocacy. Secondly, we place CGW21's claims and arguments in the context of an ongoing scientific debate concerning the performance of the Basin Plan. Finally, we consider the existing controls on the quality of science for basin planning in the MDB. These are all important for framing our analysis of CGW21 in the following sections.

2.1. Claims of administrative capture

We distinguish CGW21's claim of potential administrative capture from its concerns over issue advocacy, which is a widely accepted role for scientists involved in policy analysis (Pielke 2007). CGW21's analysis of research findings by the Open Letter signatories is presented as a case study illustrating the risks of administrative capture. CGW21 (P10) states '*We have provided an assessment of possible administrative capture of scientists engaged in science to support the Murray-Darling Basin Plan and who self-identified by signing an open letter published in The Australian newspaper*'. Specifically, CGW21 claim there is evidence these scientists are '*working within existing policy settings rather than challenging assumptions and policy directions*' for reasons of self-interest, such as '*seeking to be invited to undertake future research*' and '*direct employment within government departments or agencies*'. Commenting on CGW21, Colloff et al. (2021b) goes further by stating definitively that ' ... *science to support the Basin Plan has been subject to a process of "administrative capture", whereby some scientists are incentivised to constrain the scientific questions asked, limit debates and promote policy approaches favoured by decision-makers*'. This is a serious claim questioning the integrity of these scientists.

Whilst CGW21 raises specific concerns that these scientists are acting out of self-interest in response to incentives, elsewhere in the paper their concern seems to be more broadly about issue advocacy by scientists. For example ... '*We contrast the scientist as an Issue Advocate with the US National Oceanic and Atmospheric Administration (NOAA) definition of scientific integrity*' (CGW21, P1). Also this statement ... " *The second possible form of capture, and our focus herein, is administrative capture whereby some scientists act as Issue Advocates to support or contribute to science that constrains the scientific questions asked, the decision options explored, or to narrow the evidence, data and views that are considered within the public policy space*" (CGW21, P3). This is also implied in '*While typically, not labelled advocates, those who speak in defence of orthodox views, and also seek to restrict the science-policy debate, are Issue Advocates*' (CGW21, P5).

CGW21's conflation of issue advocacy with concerns about science integrity in basin policy engagement is inconsistent with current thinking on the accepted forms of science-policy engagement. Pielke (2007) proposed the 'Issue Advocate' as one of four roles a scientist might legitimately take, whilst another is 'Honest Broker'. '*The Issue Advocate seeks to compel a particular decision, while an Honest Broker of Policy Alternatives seeks to enable freedom of choice by a decision-maker*' (Pielke 2007). Pielke (2007, 7) argues all four roles are "*critically important and necessary in a functioning democracy*'.

Many scientists, acting as Issue Advocates, have contributed to positive changes in society. As a prime example, Prof. Peter Cullen, from The University of Canberra and also a founding member of the Wentworth Group of Concerned Scientists, spent many years advocating for water reforms (e.g. Cullen 2006). This included the provision of environmental flows that will have long-lasting benefits for freshwater ecosystems in Australia. During this time, Prof. Cullen worked closely with government, which is consistent with the pragmatic approach of policy

analysis of the Open Letter signatories, described below. In particular, he led broad and sustained research collaborations with government through his role as Director of the Cooperative Research Centre for Freshwater Ecology which was funded by State and Commonwealth governments.

CGW21's concerns in relation to administrative capture of the Open Letter signatories, distinct from issue advocacy, are clarified in this statement … *'In signing the open letter, all signatories publicly declared themselves as Issue Advocates, as defined by* Pielke (2007). *While all signatories are Issue Advocates, in this context, not all are administratively captured as some may have genuinely and altruistically believed that not changing the Plan until 2026 is in the public interest. To identify to what extent there may be administrative capture by some signatories, we investigate the science outputs of some of the letter signatories which favour or support the existing Plan, the current policy settings or the agendas of the Plan's implementing agencies but which are not well supported by broader scientific evidence.'* (CGW21, P7).

Our focus is on CGW21's claim that research funding or other government incentives have induced at least some of the Open Letter signatories to provide findings in favour of current policy settings. However, it is noteworthy that no direct evidence is provided in CGW21 to support the claim that scientists are incentivised in this way. CGW21 instead rely on indirect evidence; specifically, that signatories, acting as Issue Advocates, have provided an interpretation of evidence in favour of current policy settings. In addressing this claim, we are more concerned with the interpretations CGW21 makes of the evidence, than with issue advocacy.

2.2. Context of contested views on basin plan performance

Whilst CGW21 have used the frame of scientific integrity, contested views of the basin plan are at the heart of their concerns. Their evidence of administrative capture leverage their own scientific findings regarding poor performance of the Basin Plan and address the legitimacy of opposing claims by the Open letter signatories. Here we highlight that these claims are part of an ongoing debate between scientists with different views and different approaches to science-policy engagement. We will return to this later in the paper when we examine underlying problems in MDB science-policy engagement that are exposed by CGW21's claims.

The contested perspectives on water management that underpin CGW21's arguments, also propel much of the broader public discourse about the Basin Plan. There has been vigorous, and at times febrile, public debate about this complex piece of public policy. Water policy in the basin has taken many years to develop, and has some way still to go before the achievement of the goals of the most recent reforms can be properly assessed, due to the lag-times expected for these goals to be achieved, including population responses of long-lived native fish species (MDBA 2019). Cash Splash, The Open Letter, CGW21 and this response are artefacts of this long-running debate, each providing different perspectives on performance of the Basin Plan. Like many complex policy challenges, there are significant legacy issues that influence future policy settings, data availability and relationships. We provide this context here and later argue that the current state of science in the MDB, including this debate and policy interactions, has contributed to the claims made by CGW21.

Over the last decade, scientists have contributed diverse findings regarding water policy interventions resulting from the Water Act (2007) (Australian Government 2013) and the Basin Plan (Australian Government 2012). This includes contested perspectives on: environmental water recovery through irrigation efficiency (Grafton and Wheeler 2018; Grafton et al. 2018; Wheeler et al. 2020; Wang, Walker, and Horne 2018; Walker et al. 2020, 2021); the outcomes of environmental water delivery (Chen et al. 2020; Thom et al. 2020; Kirsch, Colloff, and Pittock 2021; Ryan, Colloff, and Pittock 2021; Moxham et al. 2019; Stewardson and Guarino 2018a; Webb et al. 2018); the causes and remedies for fish deaths in the Darling River (Moritz et al. 2019; Vertessy et al. 2019b); risks to basin water resources with climate change (Pittock, Williams, and Grafton 2015); and efficacy of water governance arrangements (Thompson et al. 2019; Grafton 2019; Grafton et al. 2020).

Contested scientific views of the Basin Plan have been highly visible within Australia. Disagreement over the Basin Plan has been a frequent feature of mainstream media over the last two decades (Mesikammen et al. 2021), and the views of scientists are often prominent in these reports. As an illustration, both the Open Letter and CGW21 were the basis for mainstream print media articles soon after they were released (Ritchie 2019, Hannam 2021). Scientific perspectives have also been a feature of numerous government inquiries examining contested views on the Basin Plan over the last decade. This includes the 2018 South Australian Royal Commission which received evidence from scientists concerned about the performance of the Basin Plan (Walker 2019). More recently, these debates have been re-examined in five books published in 2021 (Beresford 2021; Beasley 2021; Hamilton and Kells 2021; Hart et al. 2021; O'Gorman and Sutter 2021) and featured in a Quarterly Essay article (Simons 2020).

Amongst scientific analysis of basin water policy, it is helpful to identify two differing scientific approaches, which we will label as 'pragmatic' and 'idealistic' using the names of related (but not identical) forms of policy analysis described by Daniell, Morton, and Insua (2016). It is important to note that we do not make any value judgements about these approaches, they simply reflect different ways of engaging with information and the science-policy landscape.

The Open Letter Signatories broadly take the pragmatic approach, although there is variation individually and on different issues. With this approach, scientists use available evidence to assess the performance of specific basin interventions, generally acknowledging uncertainties in their findings. Scientists avoid generalised conclusions of success or failure of the Basin Plan that are inherently value-laden and are likely to be premature (given the ongoing roll-out of the Plan and the long lag time for some ecosystem responses). They suggest improvements in water policy settings, accepting that science is one input to basin policy decisions amongst multiple stakeholder views. They engage with water policy agencies to ensure their research is relevant and accessible to decision-makers. They also seek to participate in collaborations across disciplines, organisations and sectors (e.g. Cooperative Research Centres) to tackle major R&D challenges and benefit from diverse perspectives and capabilities.

The authors of CGW21 are amongst those who take the idealistic approach, at least in some of their work. In the case of the MDB, idealists are more likely to be sceptical that the current policy setting and management arrangement will succeed in delivering improved conditions in the basin. They draw on available evidence to highlight shortcomings in the current approaches and propose significant changes in policy settings. They may choose to seek impact from their work, in addition to academic publication, by contributing to public forums including government reviews and inquiries, social media commentary, and interviews on radio and in print media. They generally choose to work with like-minded partners (e.g. academics and NGOs), instead of those with more formal decision-making power in the current systems (e.g. government authorities and the industry partners delivering current systems). Scientists taking this approach tend not to work closely with decision makers, so solutions posed as a result of analysis may be unimplementable without significant additional work along political and practical lines.

With this context, the claims in CGW21 can be understood as being made by scientists who generally take an 'idealistic' approach who consider that scientists adopting a more 'pragmatic' approach are potentially subject to administrative capture. We deal with these specific claims in the following sections and show that evidence of potential capture is weak. The context of the different scientific approaches is important because it may go some way to explaining the conditions that led to these claims. Specifically, it seems likely that CGW21 has misinterpreted the pragmatic approach of the Open Letter Signatories as potential 'administrative capture'.

2.3. The controls on integrity of science in basin planning

CGW21 describes how threats to science integrity might impact public trust in water governance and the quality of policy outcomes. However, their focus is on the integrity of individual scientists, and largely overlooks the existing government controls in place to protect the integrity of science used in the Basin Plan. There will inevitably be diverse scientific views on the efficacy of water policy settings. Informed by these scientific findings, it is the government's role to make policy decisions. We briefly consider some of the existing controls used by government to assure the quality of science used in the Basin Plan.

The Murray Darling Basin Authority (MDBA), the agency responsible for developing the Basin Plan, draws on scientific capabilities to ensure integrity in the deployment of science for the Basin Plan. The authority itself (equivalent to a board) has included at least one scientist since the MDBA was first established. The MDBA has also established the Advisory Committee on Social Economic and Environmental Science (ACSEES) with a diverse range of disciplines and organisational backgrounds to support the MDBA in the use of science for implementing and evaluating the Basin Plan.

The MDBA undertakes 5-yearly evaluations of the Basin Plan. For the most recent report, MDBA (2020a) undertook an analysis of Basin Plan outcomes drawing on studies from other government agencies and the broader scientific community. The evaluation names 73 individuals and organisations who provided research, feedback and advice to support this evaluation. The evaluation and supporting reports integrate expertise and analysis from a wide range of sources and included independent review to validate findings.

In addition to the MDBA's 5-yearly evaluation, the Commonwealth government has completed several other reviews on various aspects of the Basin Plan and broader water reforms. The Water Act requires the Productivity Commission to undertake a 5-yearly assessment of Basin Plan implementation and progress towards achieving its objectives (PC 2018). Importantly, the Productivity Commission's independence is underpinned by an Act of Parliament and its processes and outputs are open to public scrutiny. There have been numerous other government reviews

including: The ACCC Murray-Darling Basin water markets inquiry (ACCC 2021); the Interim Inspector General's study into the impact of lower inflows on state shares (IIGMDBWR 2020); and the independent assessment of social and economic conditions in the Basin (Sefton et al. 2020).

The Commonwealth government also undertakes targeted scientific reviews of topics where there are contested scientific findings. Examples include review of the impact of irrigation efficiencies on return flows (Wang, Walker, and Horne 2018), fish deaths in the Darling River (Vertessy et al. 2019b), and management of the Lower Lakes (Chiew et al. 2020). These reviews have been undertaken by multi-disciplinary science teams with the full report released publicly, ensuring transparency. These are important statements of the current state of knowledge, identifying where gaps exist and areas of contested knowledge.

These elements should contribute to the integrity of the science used to inform development, implementation, and review of the Basin Plan, but the effectiveness of these controls has not been reviewed to date. We also note there is no overarching plan for science quality assurance in basin planning, although we are aware that this is in development by MDBA. Embedding an independent review of science quality assurance procedures will build confidence that the controls adopted by the MDBA are adequate and performing well.

3. Science-policy stance of the open letter statements

CGW21 characterise the Open Letter as primarily advocacy to retain the current water policy and protect '*science agendas and funding*' (CGW21, P7). As we elaborate in the following paragraphs, the Open Letter did not advocate for a specific policy response nor make definitive conclusions concerning Basin Plan performance as either a failure or success. Though supportive of the Basin Plan in the broad, the Open Letter was critical of specific aspects of water management in the MDB and highlighted the need for further action by governments. The signatories' support for adhering to the agreed timeline for review of the Basin Plan reflected the group's collective view that the plan had not yet been implemented in full and that the hydro-ecologic outcomes envisaged to result from the plan required more time to manifest.

The Open Letter made three contributions in relation to implementation of the Basin Plan. First, it provided clarifications in response to criticisms of the Basin Plan raised in the Cash Splash Program (described as myths in the Open Letter). This included evidence related to effects of: new irrigation developments on basin diversion; irrigation efficiency projects on water savings; and ecological effects of the Basin Plan. These statements were made in response to Cash Splash. The lack of balance in Cash Splash was confirmed later by the Australian Media and Communications Authority (an independent Commonwealth statutory authority) which found that the story had breached impartiality standards (ACMA 2020). ACMA's (2020) report concluded that ...*'While it was acceptable for Four Corners to present critical commentary, the program did not present sufficient information from other relevant perspectives to enable viewers to make up their own minds about the (IE) scheme'*. The ABC's own Media Watch also criticised Cash Splash for similar reasons.

The second contribution of the Open Letter was to highlight problems with the current implementation of the Basin Plan. This included the need for: more comprehensive and rigorous analysis of the impacts of the Basin Plan; more detailed hydrological audits; debate on the relative merits of environmental water recovery through buy backs and water efficiency projects; examination of adverse outcomes from water trading; and timely completion of the water resource plans by State governments. The Open Letter placed these problems in the context of existing research or other programmes that go some way to addressing the problems outlined, but are insufficient to resolve the issues. This contribution of the Open Letter identified areas of poor knowledge and potential weakness in the current policy that might be improved with changes in policy settings.

The third contribution of the Open Letter was to argue in support of the current schedule for review of the Basin Plan in 2026. This statement provided a constrained policy-related recommendation, restricted to the timing for review of the Basin Plan, but not the outcome of such a review in terms of changing or retaining the current settings. In that sense, the recommendation does not seek to 'reduce scope of choice' as suggested by CGW21. Further, the logic for this recommendation was clearly stated in the Open Letter and accessible for interrogation. The Open Letter suggested that the pre-agreed timeframe for review was appropriate to evaluate the hydrological and ecological effects of the Basin Plan, particularly due to delays in implementation and the highly variable climate sequence governing basin responses.

CGW21 misrepresents this recommendation by claiming that the Open Letter signatories did not accept that the Basin Plan could be improved. They say '*Their narrative appears to be "a bad plan is better than no plan at all . . . The rhetorical question is then "why settle for a bad Plan that appears to be inconsistent with the objects of the Water Act when a reformed Plan could deliver on them?"*'. In fact, the Open Letter was quite clear that the signatories have many concerns about the performance of the Basin Plan, and the

adequacy of the Basin Plan settings, and the recommendation relates to the timing of review of the Basin Plan only.

4. Contested views of basin plan performance

CGW21 argued that findings of the Open Letter signatories in relation to analysis of the Basin Plan (in the Open Letter and other publications) have made selective use of evidence to favour current government policy. They examined five cases, all of which relate to the performance of basin water policy interventions, where CGW21 provide an alternate narrative, mostly drawing on their own findings or those of their collaborators. The section below analyses the cases presented by CGW21.

4.1. Ecological benefit of the basin plan

CGW21 cited Webb et al. (2018) as evidence of the potential administrative capture of researchers involved in the Open Letter (9 Open Letter signatories were among the 14 authors of Webb et al. 2018). They argued that Webb et al. (2018) reports positive outcomes of environmental water being delivered under the Basin Plan that CGW21 considered '*are not well supported by the scientific evidence*'. We refute this contention and note also that Webb et al. (2018) does not '*claim in the article for widespread environmental benefits of the Plan*', as suggested by CGW21.

Webb et al. (2018) states '*we are generally seeing environmental changes of the types and magnitudes expected at this stage of the plan*'. Webb et al. (2018) provided examples of short-term responses to environmental watering, explaining why large-scale and long-term responses are not expected to be seen this early in the implementation of the Basin Plan process. Using the example of golden perch (*Macquaria ambigua*), the paper explained how large-scale responses against Basin Plan objectives for fish, birds and vegetation will only be realised through iterative, long-term restoration of shorter-term environmental processes such as migration, spawning, and primary production through the delivery of environmental water, and other complementary management actions. The paper described how these processes are being investigated by monitoring programs.

As a minor part of the paper, Webb et al. (2018) did note some 'Basin-scale' changes in vegetation, based on monitoring conducted under the Long-Term Intervention Monitoring (LTIM) Project (Capon and Campbell 2017). However, the paper made no claim about their temporal duration. CGW21 cited Moxham et al. (2019) as evidence against the conclusions in Webb et al. (2018) regarding vegetation responses. However, Moxham et al. (2019) reported on environmental watering effects on floodplain vegetation at a single site (Hattah-Kulkyne National Park) and made no attempt to assess large-scale changes. Furthermore, this study also reported vegetation responses to environmental water that are very similar to those reported in Capon and Campbell (2017) for the different sites in the LTIM Project. Therefore, we contend that the results of Moxham et al. (2019) are consistent with the conclusion regarding vegetation responses reported in Webb et al. (2018).

4.2. Basin-scale environmental water delivery

As evidence of potential administrative capture, CGW21 claimed that Stewardson and Guarino (2018a) provided an overly favourable view of the Commonwealth's environmental watering program, noting that Stewardson is one of the Open Letter signatories. CGW21 justified this claim using a spurious narrative focused on a single sentence from Stewardson and Guarino (2018a). In the following paragraphs we show how CGW21 have misrepresented this paper's findings, taking one sentence out of context. We highlight how they overlooked prominent statements linked to research findings in Stewardson and Guarino (2018a) that are more relevant to their findings regarding both the success and limitations of the government program.

Stewardson and Guarino (2018a) reported on the first year of a five-year monitoring program to evaluate the hydrological outcomes of environmental flows delivered by the Commonwealth Environmental Water Office (CEWO). CGW21 cite a single sentence from this paper's abstract, which states '*The case study provides a successful example of implementing a basin-scale program for environmental water delivery*'. By isolating this single statement and presenting it out of context, CGW21 have misrepresented the conclusions of Stewardson and Guarino (2018a) as being overly favourable to policy. Importantly, the sentence immediately following the selected statement reads: '*However, there remains a great need to improve the knowledge, governance and planning tools for managing environmental water for a broad range of ecological demands that operate at the basin scale*'. Other statements include: '*In the three valleys where none of the environmental water entitlement can be actively managed … there was little or no improvement in baseflow or fresh scores attributed to the Commonwealth environmental water delivery*' (P977) and '*there was some minor wetland and floodplain inundation achieved using environmental water*' (P976). Maps and figures are provided throughout the paper to illustrate the limited contribution of Commonwealth environmental water to baseflows, freshes and out-of-channel flows including inundation of wetlands. This paper also discussed the policy

constraints on delivery of higher in-channel environment flows that are preventing achievement of many of the wetland inundation targets. A key finding was that: '*There is little evidence yet in the MDB that the CEWO's basin-scale environmental watering actions have successfully targeted … basin-scale processes*' (Stewardson and Guarino 2018a, 983).

The above statements demonstrate that Stewardson and Guarino (2018a) provided a more nuanced view on the hydrological outcomes of environmental flow delivery under the Commonwealth program. In isolating a single sentence from this paper, CGW21 created the false impression that the reporting was more absolute in its findings in order to support their claim that the authors are overly favourable in reporting outcomes of environmental watering. The issues in CGW21's claims are amplified by failing to acknowledge that the statement they quote refers to successful delivery of a Basin-scale program, and not to the successful achievement of hydrological outcomes. This is made clear in the introduction of Stewardson and Guarino (2018a), which presents the context and problem that is the focus of the paper.

It is of note that CGW21 referred to a single paper of a series by Stewardson and Guarino (2018a). The 2018 paper describes outcomes from the first year of a five-year study (and hence focuses on delivery of the environmental flow program and not its outcomes). Publicly available reports from the program's later years (Stewardson and Guarino 2016, 2017, 2018b, 2019, 2020) are not referred to, and CGW21 neglects to consider statements made in these reports when evaluating the integrity of reporting by Stewardson and Guarino. These reports describe both the improvement and shortfall in hydrological outcomes. The final report (Stewardson and Guarino 2020) concluded that: '*there was only one valley, the central Murray, where the targeted [baseflow] outcome was achieved in every year*' (P38); there was a 16% increase in Murray River flows, '*which is close to half of the target volume*' (P40); and the lateral connectivity target is only '*fully achieved for isolated years in the Lachlan, Campaspe, Lower Darling and Murrumbidgee Valleys*' (P41).

CGW21 further claimed the findings of Stewardson and Guarino (2018a) are at odds with conclusions made by Gawne et al. (2016) and Chen et al. (2020). These comparisons are misleading, for different reasons. The results provided by Gawne et al. (2016) are consistent with Stewardson and Guarino (2018a) and they are based on the same data and analysis undertaken by Stewardson in both cases. To the extent that the reporting is different, it reflects a different focus in these two papers, not that the findings are at odds with each other. In relation to Chen et al. (2020), this paper was not published at the time of writing the Open Letter or Stewardson and Guarino's (2018a). Regardless, this is an uninformative comparison because Chen et al. (2020) evaluated environmental water delivery using an entirely different benchmark. Specifically, this study evaluated wetland inundation relative to a benchmark of inundating all wetlands and floodplains in the Murray-Darling Basin to a depth of 0.5 m. This benchmark is unachievable using environmental flows due to limited dam release capacity, and unrelated to the hydrological targets in the Basin Watering Strategy used by Stewardson and Guarino (2018a).

4.3. The independent assessment of fish deaths in the lower darling

CGW21 commented on two commissioned reviews examining the causes of mass fish kills in the lower Darling River over the summer of 2018–19. They argued the respective findings of the two reviews reflect differences in the disposition of the review teams in relation to the water policy *status* quo, asserting that one was demonstrably constrained in its recommendations, while the other was not.

The first of these reviews (Vertessy et al. 2019b) was not commissioned by the MDBA as claimed by CGW21, but rather by the then Minister for Agriculture and Water Resources, The Hon. David Littleproud. CGW21 failed to mention the second of these reviews (Moritz et al. 2019) was commissioned by the Leader of the Opposition at the time, The Hon. Bill Shorten, highlighting the politically-charged environment that surrounded these reviews.

It bears mention here that the two resulting reports recorded that the two review teams collaborated openly and positively, sharing data, preliminary findings and recommendations across their respective teams. Furthermore, both reviews involved high-level consultation with experts and affected stakeholders, as well as extensive peer review of their findings. To date, neither review has attracted any negative critique across scientific literature.

Each review had its own specific Terms of Reference, which governed the composition of the review teams, the scope of analyses and the recommendations they made. Nonetheless, the two reviews reached broadly similar conclusions, differing only in the relative emphasis they accorded to the antecedent drought conditions and water extractions by irrigators as *proximate* causes of the fish kills. Both reviews made strong commentaries about the deleterious effects of climate change and patterns of water extraction on the riverine health of the Darling River. The reviews both argued the need for significant policy reform to avert repeat crises in future.

CGW21 asserted that '*The marginal policy changes recommended by* Vertessy et al. (2019b) *are in marked contrast to the substantive policy recommendations*

*provided in the report by the Australian Academy of Science (*Moritz et al. 2019)'. However, comparison of the 27 recommendations of Vertessy et al. (2019b) and the 8 recommendations of Moritz et al. (2019) reveal this claim to be unsubstantiated. Quite sensibly, both reviews recommended a mix of actions, some of which are readily implementable while others involve significant policy reforms and a longer timeframe. Examples of more 'challenging' policy-related recommendations made by Vertessy et al. (2019b) include: changes to water sharing arrangements under the Barwon-Darling Water Sharing Plan (rec. 1); and introducing protections to first flushes, low flows and environmental flows to improve system connectivity (rec. 6). Aside from ignoring the substantive recommendations of Vertessy et al. (2019b), CGW21 presented no evidence to demonstrate administrative capture as the basis for variance in scientific interpretation of the Vertessy et al. (2019b) and Moritz et al. (2019) reports.

4.4. New irrigation developments

CGW21 questioned '*the depth of scientific contestation in the open letter*'. To address this concern, we need to firstly review some of the claims made by the Cash Splash program as the open letter was a direct response to the claims.

Scientists interviewed in Cash Splash suggested that the Commonwealth's irrigation efficiency program had led to increases in water use rather than water savings. For example, '*. . . these programs . . . being designed for water recovery purposes in the Murray-Darling Basin. They're increasing the irrigation land area and they're increasing their water use over time*'; '*. . . The efficiency program has become a massive subsidy for large agribusiness. That has facilitated the increase of irrigation water, not a decrease*'.

In response, the Open Letter stated that *'the emergence of new irrigation developments in the Basin does not mean that irrigators are extracting more water than they did before the Plan. Water extractions in the Basin are capped (now to a lower level than previously) and new enterprises can only be established if they purchase existing water entitlements from others*.'

CGW21 note competing evidence that *'capping diversions is no guarantee that more irrigation water will not be diverted in the future because of increased use of existing water rights, substitution to unmetered or unmonitored groundwater sources, failure to undertake adequate monitoring and compliance of water diversions and the consequences of inadequately regulated and monitored floodplain water harvesting (*La Nauze 2019; Wheeler et al. 2020).' This statement is notably different from the original Cash Splash claims of increased water use.

While both Wheeler et al. (2020) and Hughes, Donoghoe, and Whittle (2020) found that water productivity (value of agricultural product per ML water), area of irrigation and water demand have increased over time for those farmers who participated in irrigation efficiency programs, they differ in their findings on the source of water for their increased use. Hughes, Donoghoe, and Whittle (2020) found that aggregated on-farm changes in the southern MDB are largely consistent with trade of water under an effective cap, which would lead to the expected reduction in diversion of water for irrigation. Wheeler et al. (2020) argued that the source of water for the rebound effect was due to processes other than trade, and that the same processes occurring around the MDB could lead to increased diversions at the Basin-level.

We note that about 95% of water recovery from the irrigation efficiency program occurred in the southern Murray-Darling Basin, with 70% from off-farm projects and 30% from on-farm projects. In the southern Basin, 98% of watercourses/regulated river take is metered, or about 80% of all forms of take, for the period 2012–13 to 2017–18. (MDBA 2020b). We consider it thus improbable that a compliance model using this quality of data would not detect a variation of more than 600GL/y for the southern MDB for diversions to increase as a result of the efficiency program, as suggested in CashSplash.

4.5. Impact of irrigation infrastructure and efficiency improvements (IE) on return flows

Cash Splash also made statements: '*Professor Quentin Grafton has been warning for years that the government has grossly exaggerated the amount of water returned to the rivers under the water for infrastructure scheme. "it's less than half of what the government claims. And in the worst case scenarios we've gone backwards, not forwards. That in fact the amount of water in the environment has actually in fact declined as a result of these efficiency subsidies and not gone forward*".'

In response, the Open Letter stated that '*assertions that water efficiency projects funded by the Federal Government (IE program) are yielding little or no water savings are not supported by available evidence*'.

In their highlight of competing advice, CGW21 note that *'the report by* Wang, Walker, and Horne (2018) *was commissioned by MDBA and not independently peer-reviewed, although a peer-reviewed paper was recently published, with significant modifications from the original report (*Walker et al. 2020*). Contrary independent findings that showed little or no water savings from irrigation efficiency projects were also published in a peer-reviewed journal (*Williams and Grafton 2019*), available in testimony to a parliamentary inquiry from 2018 and provided directly to the MDBA in October 2018*.'

To clarify and correct the CGW21 statement, all the work in Wang, Walker, and Horne (2018) on irrigation returns has now been published as peer-reviewed papers (Walker et al. 2020, 2021) and there is no significant change in the methods or predictions between these publications and the original report. Walker et al. (2020) is a response to Williams and Grafton (2019) with respect to the connectivity and in the process fills in missing detail from Wang, Walker, and Horne (2018). In addition to the review by Wang, Walker, and Horne (2018), the Productivity Commission provided an assessment of relevant evidence and found the risk of reduced return flows was not significant (PC 2018).

The comments by Professor Grafton on Cash Splash are based on a calculation of return flows that assumes a closed system, meaning that any reductions in seepage will produce the same magnitude of reduction in return flows (Williams and Grafton 2019). However, in practice, impacts are attenuated by other adjustments in the groundwater balance produced by seepage reductions such as reduced evapotranspiration from shallow water tables.

Wang, Walker, and Horne (2018) and Walker et al. (2020) did not assume a closed system, but instead quantified the connectivity based on pre-existing groundwater modelling and found the reduction in return flows was less than half the reductions in seepage. The role of connectivity in explaining the discrepancy between the Wang, Walker, and Horne (2018) and Williams and Grafton (2019) studies was identified by the latter. Such a simple explanation is possible due to the similarity in the range of estimates of the ratio of seepage impacts to water savings from the two modelling approaches (Walker et al. 2021). The concept of a less than perfect connection is not new and has been discussed in various reports such as MDBC (2006) and NSW (2010). It is now published in a peer reviewed journal (Walker et al. 2020).

5. Network analysis of the Open Letter signatories

In this section, we examine the claims made by CGW21 related to professional linkages between the Open Letter signatories. Two hypotheses were explored in the CGW21 analysis. This first is that '*a close network of researchers is evidence of a mutually supporting group that increases the benefits from, and likelihood of, administrative capture*'. The second hypothesis is that the Open Letter signatories were clustered more closely than a comparable group of water scientists, and thus more likely to be subject to administrative capture.

With respect to the first hypothesis, there was no reference or evidence provided to support the contention that close networks of researchers are more vulnerable to administrative capture. We are unaware of any publication that has suggested that this is true. Close connections are a normal and desirable hallmark of scientific discovery in the same field and region. Similarly, strong network linkages in science and industry partnerships such as Cooperative Research Centres (CRCs) are inevitable and demonstrate an engaged group of scientists committed to translating research outcomes for use by industry and government. By working and publishing alongside one another, scientists explore a range of ideas and expose their research to the interrogation and scrutiny inevitable with such collaborations.

The network analysis then seeks to test the second hypothesis that Open Letter scientists were particularly closely clustered. CGW21 did not test whether the Open Letter signatories are any more closely clustered than any comparable groups of researchers within Australia or internationally. Rather, CGW21 rely on a comparison of the network of Open Letter signatories with that of a cohort consisting of 'researchers' who made individual witness statements at the South Australian Royal Commission (SARC) into the Murray-Darling Basin (Walker 2019). These two networks are not comparable for several reasons. There are fundamental differences including size, career stage and disciplinary spread between the two groups, all of which affect the extent of professional collaborations. Differences in network size also confound the comparison. While the SARC cohort included 22 witnesses, at least 5 of those did not actively undertake research which included publication and collaboration. This means that there were more signatories to the Open Letter than there were active researchers in the SARC cohort (27 vs 17 respectively). This difference in network size means that the number of possible connections between Open Letter scientists is almost three times greater than that for the SARC network. In not considering these differences in network size and composition, the CGW21 analysis is unable to robustly test the second hypothesis.

CGW21 concludes that '*Whilst the network analysis does not prove administrative capture, it does show much closer links*'. However, there is neither evidence to support that there are unusually close links between the Open Letter authors nor that closer links within networks increase the probability of administrative capture. As a consequence, the network analysis seems irrelevant to their argument.

6. Honest brokers?

In this section we analyse a claim made by the CGW21's authors, that they are Honest Brokers (as per Pielke 2007). Specifically, they make this claim to also say they have no particular policy bias or tendency

towards Issue Advocacy, which as Pielke (2007) and we note is a reasonable position for scientists to take (see Section 2.1).

However, through CGW21's own writing, they acknowledge their group's frequent engagement in policy dialogues (CGW21, p3) both in the scientific literature and in the mainstream media, including declarations of their views in social media. These contributions almost universally identify problems with current policy settings and propose alternate approaches. The evidence thus suggests that the CGW21 do not typically act as Honest Brokers, as they claim. Rather the evidence suggests they are aligned with a policy agenda that is more critical of the current Basin Plan settings and want to see a range of changes made. Pielke (2007) describes such behaviour as stealth issue advocacy (i.e. claiming impartiality but actually advocating a position). Pielke's (2007) view is that: '*Stealth issue advocacy poses threats to the scientific enterprise. If the public or policy-makers begin to believe that scientific findings are simply an extension of a scientist's political beliefs, then scientific information will play an increasingly diminishing role in policy-making, and a correspondingly larger role in the marketing of particular political agendas*.'

We emphasise the important role of scientists in leading well-informed critical review of water policy, and transparent policy advocacy. Our concern with CGW21 is the possibility of stealth issue advocacy. We do not want our criticisms of CGW21's argument to be read as a general criticism of scientists bringing an idealistic approach (*sensu* Daniell, Morton, and Insua 2016) to water policy analysis or advocating for change. Scientists, and particularly university-employed academics, can have a vital role in openly advocating for policy change across all aspects of society, and should be proud to be open Issues Advocates based on their own policy analyses and scientific work. Their privileged position in terms of authority, employment security and intellectual independence, affords scientists the opportunity to speak out on contentious issues supported by the principle of academic freedom. We applaud scientists who seek to contribute to better outcomes in the basin whether they do this in close collaboration with water policy agencies or in isolation.

7. Discussion

7.1. Over-politicisation of Basin science

Our view is that CGW21's claims are indicative of overly-politicised science. CGW21's claims rest on the notion that the Open Letter signatories favoured current policy settings in order to receive some benefit such as research funding. If the claims were well-supported, then it seems reasonable that such a publication will contribute to addressing a legitimate threat to scientific integrity. However, with little evidence to support their claim, it seems that CGW21 has misinterpreted the contrasting, but legitimate, views and approach of the Open Letter signatories as evidence of potential administrative capture. This is indicative of a deeper problem, the over-politicisation of science, obstructing normal debate amongst basin scientists holding different views. As Leith et al. (2017) observe … '*When people disagree, they form coalitions, framing the problem forcefully or otherwise to highlight the centrality of their concerns and the insignificance of the concerns of others. Such activity constructs divergence between groups; the moral and virtuous on one hand, the sullied and selfish on the other. In-groups and out-groups create divisions which are the seeds of conflict*'.

Complex policy problems, like the Basin Plan, have two features that are well-recognised challenges for science-policy engagement. Specifically, large uncertainties in policy performance provide for multiple interpretations of the available evidence, and there is also disagreement over policy objectives. Sarewitz (2004) described this challenge where '*those holding different value perspectives may see in the huge and diverse body of scientific information … different facts, theories, and hypothesis relevant to and consistent with their own normative frameworks*'. He goes on to put this simply, '*for a given value-based position in an environmental controversy, it is often possible to compile a supporting set of scientifically legitimated facts*'.

The risk of over-politicisation of science in such complex public policy challenges, is well understood. Leith et al. (2017) explains' … *where goals are controversial and there is substantial uncertainty about the effectiveness of policy options for achieving them, defining the most useful or effective way for scientists to engage is not straightforward.*" In such cases, '*Over-politicisation occurs when different interests develop their own science supporting their preferred outcome, and battle it out in the media or the courts. Classic symptoms of over-politicisation are seen when problems are dressed up as technical questions rather than acknowledged as disagreements about values and goals, or when different groups appear to be talking about different problems yet all are appealing to the authority of science*'.

This last sentence is particularly relevant here. By suggesting the Open Letter signatories are subject to potential administrative capture, CGW21 create a distinction between their own 'credible' science, free from any influence of government, and science of the signatories which has been 'sullied' by engagement with policy makers. This is consistent with cases observed by Gieryn (1983) where groups of scientists have sought to demarcate their own 'scientific' work from varieties of

'non-science' in order to acquire intellectual authority. Such behaviour is inherently political. Whilst respectful debate between scientists can be healthy, claims of superior scientific authority are indicative of the over-politicisation of science (Leith et al. 2017). Leith et al. (2017) explain that '*When disenfranchised stakeholders realise that their interests are being ignored or threatened, they will often see the chosen science as untrustworthy, and the chosen solutions as unacceptable*'.

Compounding the risks of over-politicisation is the tendency for policy analyses to report findings without communicating their uncertainty. Manski (2019) observes several practices contributing to, what he describes as, 'incredible certitude' in policy analysis that can be recognised in the Basin Plan debate. He describes 'duelling certitudes' where contradictory predictions are made with alternate assumptions. This applies to the different estimates of return flow impacts from irrigation efficiencies calculated using different assumptions of groundwater connectivity. He also describes 'wishful extrapolation' which fits the arguments used in CGW21 where linkages between scientists are used to support a case for potential administrative capture, despite there being no reasonable evidence presented in the paper to support such a connection. He also describes 'media overreach' where there is premature or exaggerated public reporting of policy analysis. An example relevant to the contestation in Sections 4.4 and 4.5 was illustrated in April 2018, when one of the CGW21 authors was interviewed by ABC Radio's Background Briefing for the two-part series 'Best laid plans: The Murray-Darling Basin in crisis'. Grafton stated ' . . . *so just imagine taking the $3.5 or $4 billion of taxpayer's money and just throwing it down the drain. We've spent a lot of money, a huge amount of money, and essentially we've got nothing for it*' (ABC 2018). This statement was made prior to the underpinning research on the impact of IE on return flows (discussed in Section 4.5) being accepted for publication in 2019 (Williams and Grafton 2019).

Over-politicisation of science is likely to be a growing problem for water reform in the MDB as climate change and growing global demands for high value foods will inevitably increase pressure on the MDB's water resources and their governance. Leith et al. (2017) considers that this is a general problem in sustainability challenges and '*Left untreated, it could lead many areas of science to become increasingly impotent in policy and political debates*'. Over-politicisation of science is a potential threat to the science foundation for ongoing water policy reform.

7.2. Reimagining science–policy interactions for basin planning in the Murray-Darling

Ideally, a growing focus on the politicisation of science in water policy debates including in Cash Splash, the Open Letter, CGW21 and this response provides the trigger to reimagine interactions between science and policy in water planning. Over the coming years, the MDBA will lead a review of the Basin Plan with the opportunity to recommend changes to the Plan for consideration in the Australian parliament in 2026. There will be pressure for scientific input to this review with many emerging challenges, including climate change, an urgency to include First Nations values in water management, and the growth in permanent irrigated crops across the basin that demand a high level of water security (MDBA 2020a). This is an opportunity to consider lessons from the past decade including science-policy interactions during the development and implementation of the Basin Plan.

We propose some actions to mitigate the threat of over-politicisation of science in water reform. These actions address issues at the interface of science and policy making. This is consistent with Leith et al. (2017), who suggest that the remedies for over-politicisation of science lie in deliberate design of the social and institutional infrastructure that connects science, society and decision-making. This is different to CGW21's proposal for the Australian Council of Learned Academies to form an Independent Panel on Scientific Integrity. Such a panel may consider matters of scientific integrity, but it is unlikely to address the over-politicisation of science.

Firstly, there is a need for clarity on the Basin Plan's purpose and, more specifically, to free science from any expectation that it has a leading role in defining this purpose. The Water Act requires that the Basin Plan provides sustainable limits for water diversions, defined using '*scientific – especially biological, hydrological, hydraulic and ecological – assessments of the condition and functioning requirements of certain environmental features of the Basin's ecosystems and biodiversity*' (Walker 2019). Professor John Briscoe, at the time Director of the Harvard Water Program, described this as an expectation that *'science will determine what the environment needs and that the task for government (including the MDBA) is then just to 'do what science tells it to do'* (LSCARC 2011). Capon and Capon (2017) calls out this fallacy '*that science alone, without socio-economic and political considerations, can determine "how much is enough?" because what constitutes "enough" is inescapably dependent on subjective, value judgements'*. To the extent that the Water Act

gives science a controlling role in defining the Basin Plan's purpose, it is conflating science and politics, with the likely outcome that science will be increasingly politicised. As Professor Briscoe advised, it should be the role of governments to make decisions and be accountable for the necessary trade-offs involved, and the job of science is to make predictions about the consequences of alternate options (LSCARC 2011).

In addition, new forums are needed to support open engagement of scientists with policy makers to explore water policy options and performance. Other stakeholders should also be included in these forums, recognising that scientific knowledge needs to be integrated with other knowledge and views to inform decisions. These forums should support respectful, measured and research-informed debate and discussion across individuals and groups with opposing views and different knowledge about the policy context, to test and strengthen their own thinking. Respectful debate lies at the heart of scientific practice and indeed societal progression, and this should extend to engagement in policy advocacy. The need for such forums was highlighted in the recent Productivity Commission review of the National Water Initiative (PC 2021). The commission noted that '*few institutional mechanisms now exist to regularly bring water decision makers and researchers together, risking a disconnect between science and policy*' (P215).

Such forums would also provide the opportunity for thoughtful reflection on the source, nature and policy implications of uncertainties in Basin Plan assessments, particularly given they underpin contested science perspectives. Large uncertainties are unavoidable in basin analyses, considering the many interacting social, economic and environmental responses of a whole river basin. Whilst targeted research is important over the long-term, there are good reasons to be suspicious of the simple linear notion that more research will quickly lead to lower uncertainty and result in better decisions (Sarewitz 2004). It would be beneficial for basin scientists and policy makers to jointly explore the uncertainties in current and emerging knowledge, how these can be usefully communicated, and implications for basin water planning. It will be more productive to make transparent how assumptions shape the inference of Basin Plan performance, instead of ongoing prosecution of opposing views based on competing assumptions. As scientists engaged in water research, we would value the opportunity to discuss these matters with the authors of CGW21 and others. As we have argued in this paper, open and respectful debate will strengthen the science and its contribution to improved policy and management in the Murray-Darling Basin.

8. Conclusion

Based on a detailed analysis of CGW21, we find little to support their claims of possible administrative capture among the Open Letter signatories. Their arguments rely on selective interpretations of evidence and spurious arguments that are not related to administrative capture itself. CGW21 also conflates issue advocacy, an accepted and legitimate role for scientists in policy analysis with scientific integrity concerns related to administrative capture.

CGW21 and the Open Letter scientists generally take different approaches to policy analysis, which we broadly describe here as idealistic and pragmatic, respectively. CGW21 appears to have misinterpreted the pragmatic approach, which involves working closely with policy agencies, as 'capture'. This claim, by CGW21, that scientists with alternate views or those who take a pragmatic approach are captured, indicates that the science used in water planning is becoming over-politicised. This trend places the usefulness of science to support future policy reform in jeopardy.

We suggest attention is needed to improve science-policy engagement in basin planning, to promote constructive debate over contested views and avoid over-politicisation of water science. There is a need to free science from any expectation that it has a leading role in defining the purpose of the Basin Plan. If science is required to define the Basin Plan's purpose, it is likely to be politicised. In addition, new forums are needed to support constructive policy discussions including scientists, policy makers and other stakeholders holding a variety of values, perspectives and knowledge. There is also a need for independent review of existing controls on the quality of science used in basin planning.

Acknowledgments

We gratefully acknowledge thoughtful reviews provided by the journal's editor, Katherine Daniell, and reviewers, John Madden, Steve Morton and Roger Pielke Jr.

Disclosure statement

The authors are amongst the researchers who Colloff et al. (2021a; 2021b) claimed are subject to administrative capture. In this context, we acknowledge our strong interest and that of our institutions in questioning the veracity of these claims. We highlight that we have prepared this response with the encouragement of the Journal editor, to provide an alternate view of this case.

Many of the authors have: been remunerated by one or more Basin governments for participation in advisory committees; received payments from one or more Basin governments for consultancies; received research funding from Basin governments, agricultural industry organisations or companies that have contributed to irrigation modernisation; and/or been employed directly by Basin government agencies.

Funding

No direct funding was provided to support this research.

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Marcia Langton AM is an anthropologist and geographer, and since 2000 has held the Foundation Chair of Australian Indigenous Studies at the University of Melbourne. She has produced a large body of knowledge in the areas of political and legal anthropology, Indigenous agreements and engagement with the minerals industry, and Indigenous culture and art. Her role in the Empowered Communities project under contract to the Department of Prime Minister and Cabinet and as a member of the Expert Panel on Constitutional Recognition of Indigenous Australians are evidence of Professor Langton's academic reputation, policy commitment and impact, alongside her role as a prominent public intellectual. Her 2012 Boyer lectures titled: The Quiet Revolution: Indigenous People and the Resources Boom is one of her recent contributions to public debate, and have added to her influence and reputation in government and private sector circles. In 1993, she was made a member of the Order of Australia in recognition of her work in anthropology and the advocacy of Aboriginal rights. Professor Marcia Langton is a Fellow of the Academy of Social Sciences in Australia, a Fellow of Trinity College, Melbourne and an Honorary Fellow of Emmanuel College at The University of Queensland. In 2016 Professor Langton is honoured as a University of Melbourne Redmond Barry Distinguished Professor. As further recognition as one of Australia's most respected Indigenous Academics, in 2017 Professor Marcia Langton is appointed as the first Associate Provost at the University of Melbourne.

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Fran Sheldon is Professor and Dean (Learning and Teaching) in the Griffith Sciences group at Griffith University and a Research Member in the Australian Rivers Institute. Her research explores the relationships between hydrology, physical geomorphology and ecology in river systems, particularly large dryland rivers such as those of the Murray-Darling Basin and the Lake Eyre Basin. She has been the project lead or project member on several significant projects including two ARC Linkage projects on stream ecosystem health and riparian restoration in Southeast Queensland, the "Ecology of Low Flows" project for the National Water Commission, the "Northern Basin Sustainable Diversion Limits Revision" project for the Murray-Darling Basin Authority. She was a member of the CSIRO Water for a Healthy Country Ecological Responses to Altered Flow Regimes Cluster and more recently was involved in a technical review of the Barwon-Darling Water Sharing Plan for the NSW Natural Resources Commission and was a member of the Scientific Expert Panel investigating the 2019 fish deaths in the lower Darling River. Fran has a strong research track record, with an h-index of 38, an i10-index of 72, and over 5000 citations.

Ross Thompson is foundation Director of the Centre for Applied Water Science and co-Director of the Institute for Applied Ecology at the University of Canberra. His research is in the area of community and ecosystem ecology, with a particular interest in how human impacts may be reduced within heavily managed ecosystems. Professor Thompson co-leads the Basin-scale Flow Monitoring Evaluation and Research program funded by the Commonwealth Environmental Water Office. Over the last decade he has been heavily engaged at the science-management-policy interface, working with land and water managers and state and federal government. Professor Thompson has published over 110 peer-reviewed papers in the broad area of water science ranging from highly conceptual contributions to

quantitative biophysical studies. These have included detailed reviews of the role of science in the development of the Murray Darling Basin Plan.

Rob Vertessy is an Honorary Enterprise Professor in the School of Engineering, University of Melbourne. He has a PhD from the Australian National University (1990) and is widely published in the field of hydrology. He has had a distinguished career in water research leadership, serving as Chief Executive of the Cooperative Research Centre for Catchment Hydrology (2002–2004) and then Chief of CSIRO's Land and Water Division (2004–2007). In late 2006, Rob was seconded to the Department of Prime Minister and Cabinet to design a national water information strategy as part of the Australian government's National Plan for Water Security. He then joined the Bureau of Meteorology in 2007 to oversee its implementation as a new Bureau service, forming and then leading the Climate and Water Division (2007-2011). Rob served as CEO of the Bureau of Meteorology (2011-2016), introducing a number of significant initiatives that strengthened the organization. After retiring from the Australian Public Service in April 2016, Rob took up a part-time role at the University of Melbourne as an Enterprise Professor in Water Resources. Rob heads Global Change Advisory, a consulting company focused on environmental intelligence. On behalf of the Australian Water Partnership, he has provided strategic advice on water reform and water information to several governments in Asia and the Middle East. In 2019 he led a panel of experts who undertook the Independent Assessment into the Fish Deaths in the Lower Darling River 2018-19 at the request of the Australian Government. Rob's other significant governance roles include Murray Darling Water and Environment Research Program (Chair), MDBA Advisory Committee on Social, Economic and Environmental Sciences (Chair) and the Reef Restoration and Adaptation Program (Chair). Rob is an elected Fellow of the Australian Academy of Technology and Engineering (ATSE).

Glen Walker was a research scientist, studying groundwater and salinity processes, with CSIRO for over thirty years before retiring in 2014. Since then, he has set up a part-time consultancy, Grounded in Water and has been a member of the Independent Scientific Expert Committee on Coal Seam and Large Coal developments, MDBA Independent Audit Group for Salinity and the University of Melbourne project team providing an Independent Expert Assessment on return flows for the MDBA.

QJ Wang is a professor of hydrological forecasting at The University of Melbourne. His educational qualifications include BE from Tsinghua University and MSc and PhD from National University of Ireland, Galway. He has worked as an academic and researcher at universities and government organisations. QJ's research interests include statistical hydrology, hydrological modelling and optimisation, irrigation, regional planning and ensemble hydro-climate forecasting. QJ led the 2018 independent expert review on potential impacts of groundwater Sustainable Diversion Limits and irrigation efficiency projects on river flow volume under the Murray-Darling Basin Plan.

Skye Wassens is an internationally recognised ecologist specialising in the ecology and conservation of wetland dependant amphibians. Her research on the responses of amphibians to environmental flooding and amphibian water requirements has led the way for the inclusion of amphibians into environmental flooding programs throughout the Murray-Darling Basin. Her research on wetland dependent frogs currently underpins environmental flooding strategies in the Lowbidgee floodplain and Yanga National Park, the Murrumbidgee Water Sharing Plan and management of wetlands in the Mid Lachlan River. She has lead a number of major field based research projects on the relationship between flooding and amphibian dispersal, tadpole ecology, the relationship between native and introduced freshwater fish and amphibian recruitment during wetland flooding, temporal activity patterns of wetland dependant frogs and large scale drivers of amphibian habitat occupancy in regulated rivers and floodplain wetlands. She is leader of the Monitoring Evalucation and Research - Murrumbidgee FlowMER Website.

Robyn Watts is a Professor of Environmental Science at Charles Sturt University where she teaches and leads interdisciplinary research projects on the ecology, management and restoration of river ecosystems. Her current research focuses on ecosystem responses to environmental flows in the Murray-Darling Basin. She works in partnership with biophysical scientists, social scientists, natural resource managers, practitioners and the community to integrate research findings with knowledge from other sources to improve outcomes for river systems and communities. Robyn serves on several committees relating to environmental flows, river operations and water quality in the Murray-Darling Basin. She has co-authored over 100 publications and has supervised 20 PhD and 15 Honours students.

Angus Webb is a quantitative ecologist within the Water, Environment and Agriculture Program at the University of Melbourne. His research focuses on the study of landscape-scale impacts of human-induced disturbances on freshwater systems, and what can be done to restore these systems. In recent years, his work has focused on environmental flows in the Murray Darling Basin. Angus has been leading the monitoring and evaluation of Basin Plan environmental flows in the Goulburn River, Victoria, since 2012. He has published 2 books and over 50 journal papers and book chapters on different aspects of environmental flows science and management.

Andrew Western has more than twenty-five years experience in catchment and waterway research, teaching and consulting. He has experience in the fields of hydrology, water resources, hydraulics and related disciplines and has worked as a researcher for the Centre for Environmental Applied Hydrology, Technical University of Vienna, The CRC for Catchment Hydrology and eWater CRC. He is now Head of the Department of Infrastructure Engineering at the University of Melbourne. Prof Western has expertise in field monitoring, physically-based and conceptual catchment and river modelling, catchment water quality, catchment analysis and remote sensing and has concentrated on integrating these areas to support catchment system understanding and management. He has undertaken major field programs in Australia and New Zealand investigating catchment behaviour.

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