



COMMONWEALTH LONG-TERM INTERVENTION MONITORING PROJECT:

STAGE 1 MID-TERM REVIEW AND EVALUATION



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Front cover photo: Freshwater meadow, Wimmera, Victoria, R. Butcher

EXECUTIVE SUMMARY

This report contains an independent ‘program level’ Mid-Term Review and Evaluation (MTRE) of the Commonwealth’s Long Term Intervention Monitoring (LTIM) Project undertaken by Prof Barry Hart (Director, Water Science Pty Ltd) and Dr Rhonda Butcher (Principal, Waters Edge Consulting).

The LTIM Project is the main program for addressing the Commonwealth Environmental Water Office (CEWO) requirements under the *Water Act 2007 (Cwlth)* and Murray-Darling Basin Plan. The LTIM Project commenced on-ground monitoring in June 2014, after an initial two-year scoping and development phase. The monitoring will occur over a five-year period, ending in June 2019.

The LTIM Project is world-leading in its scope, both spatially (the entire Murray-Darling Basin) and temporally (5 years), objectives and budget (over \$30 million over 5 years). It is seeking to achieve an outcome – assessment of the effectiveness of Commonwealth environmental water delivery in achieving local and Basin-scale ecological outcomes – that has never been attempted before anywhere in the world. It is a highly ambitious project.

The objectives of this MTRE are (in brief): to assess the structure of the LTIM Project; to review progress, effectiveness, achievements and outputs of the LTIM Project from the first three years of monitoring (2014-15 to 2016-17); to assess what is working well and what can be improved in the short and longer term; and to provide a series of recommendations and associated management responses related to the review findings for the CEWO’s consideration.

The evidence for this MTRE was obtained from two sources: first, from a review of relevant reports; and second from interviews with CEWO staff, the Murray Darling Freshwater Research Centre Director and Basin Matter leads; the leads of the seven Selected-Area teams and selected team members; and relevant staff from the Murray-Darling Basin Authority (MDBA).

LTIM PROJECT STRUCTURE

The LTIM Project structure is sound and does not need to be fundamentally changed. However, it appears that the LTIM Project has shifted emphasis with the focus on the Selected Area outcomes now occurring at the expense of the Basin-scale evaluation. This is a concern since this Project was established as the main program for assessing the CEWO requirements under the Murray-Darling Basin Plan, a Plan that is focused on improvements at a Basin-scale. The CEWO should review whether this apparent changed Project focus will impact on their capacity to report on the contribution of Commonwealth environmental water at a Basin-scale.

There are also a number of modifications that could be made over the next few months and in future iterations that would strengthen the Project. These are discussed fully below (with recommendations) and include: first, to review and clarify the Project objectives; second, to work to further improve the collaboration and coordination between the Selected Area teams and the Basin Matters team perhaps by establishing a *Project Steering Committee*; third, to review the LTIM Project Management arrangements, including consideration of desirability of establishing a *Science Leader* position; and fourth, to develop a *Program Evaluation Strategy* as part of the MERI process to assist in assessing the efficiency, effectiveness, relevance and sustainability of the LTIM Project.

PROGRESS

Area-scale evaluation – the Selected Area projects are generally being run effectively and appear largely to be on track to meet their stated objectives, with constraints relating to watering actions being responsible for most issues with achieving short term expected outcomes. Two areas were identified that need attention: first, objectives need to be reviewed to ensure they are SMART¹ or at least achievable and measurable; second, the ecological outcomes of each local-area watering action need to be more specifically addressed; third, the contribution of Commonwealth environmental water in meeting the objectives of the Basin Environmental Watering Plan need to be better accounted for; fourth, the scaling up of the Area-scale assessments and

¹ SMART objectives are: **Specific** – clear and unambiguous; **Measurable** – quantified, contain a measurable element that can be readily monitored to determine success or failure; **Achievable** – realistic and attainable; **Relevant** – considerate of temporal scale of response, resources available; and **Time** bound – specify a time scale in which the outcome is met/assessed.

evaluations to the entire Selected Area need more attention; and fifth, the short and long term evaluation questions need to be more specifically addressed. Additionally, this review has also identified issues with collaboration, reporting and review that need to be addressed (see below).

Basin-scale (Basin Matters) evaluation – this aims to use data being generated by the Selected Area teams to determine the contribution of Commonwealth Environmental Water (CEW) at the Basin-scale to achieving the Basin Plan Environmental Watering Plan objectives relating to biodiversity, resilience, water quality and ecosystem function. These learning's will be used to inform adaptive management. Each of the Basin Matter evaluation reports and the synthesis report has been assessed in terms of meeting the stated objectives and reporting requirements. Some Basin Matters are not meeting expectations because of data limitations (i.e. lack of wetland inundation data), lack of ecological response to base flows or freshes (i.e. stream metabolism) or simply require longer data sets to establish linkages to watering actions. Additionally, this review has also identified issues with quantitative Basin-scale modelling, the monitoring data management system, collaboration, reporting and review that need to be addressed (see below).

Adaptive management – this review found that while there is considerable attention on the capture of adaptive management learning's each year by the Selected Area teams, this could be done more systematically. We have identified two changes that could improve the situation: first, the many informal and formal discussions that lead to changes in planning and water delivery need to be captured and added to an accessible and searchable database; and second, there appears to be no report that captures and synthesises the way this increased knowledge is changing the way in which the CEWO delivery teams are managing environmental water.

POSSIBLE MODIFICATIONS TO THE PROJECT

Project structure

As noted above the LTIM Project structure is sound and does not need to be fundamentally changed, although we have identified a number of modifications that could be made over the next few months to strengthen the Project. First, the LTIM objectives and key evaluation questions need to be reviewed (**Recommendation 1**). The LTIM Outcome Framework was developed prior to the completion of the Basin Environmental Watering Strategy (BEWS) and as such there is a misalignment between the four Basin Matters in the BEWS (hydrology and connectivity, fish, vegetation and waterbirds) and the Basin Matters monitored under LTIM, in that waterbirds are not monitored as part of the LTIM Project. Additionally, the watering objectives underpinning the watering actions are not SMART. Second, to further improve the collaboration and coordination between the Selected Area teams and the Basin Matters team CEWO should consider perhaps by establishing a *Project Steering Committee* (**Recommendation 4**); third, the LTIM Project management arrangements should be reviewed, including consideration of desirability of establishing a *Science Leader* position (**Recommendation 5**); and fourth, a *Program Evaluation Strategy* as part of the MERI process should be developed to assist in assessing the efficiency, effectiveness, relevance and sustainability of the LTIM Project (**Recommendation 6**).

LTIM Objectives

Review and update LTIM objectives and Key Evaluation Questions (KEQ) – as part of the adaptive management of the LTIM Project, the objectives and KEQs needs to be refined using SMART criteria. In addition, the Area and Basin-scale evaluation needs to be aligned to the expected outcomes and targets set in the BEWS. Both these modifications are linked to the primary objective of LTIM to evaluate the contribution of CEW to meeting the objectives of the Basin Plan Environmental Watering Plan. The lack of the use of SMART criteria in setting objectives is pervasive throughout the water planning process right through to the LTIM project. Effective process and outcome evaluation cannot be achieved without establishing a baseline against which to assess trends. To move away from a purely narrative based output, some specific amendments or revisions to the objectives and KEQ are required (**Recommendation 1**).

Expectations from the Basin-scale evaluation – during the first three years of Project implementation many issues (some quite unexpected) have emerged and solutions had to be found at both the Selected Area and Basin-scale. This is not unexpected given the scope and experimental nature of this LTIM Project. However, the time taken to find solutions to these quite difficult issues has meant that some of the more long-term objectives have had less attention than was originally envisaged. Consequently, some of the initial expectations of the Basin-scale evaluation are unlikely to be met and need to be revised. These include: the Basin-scale quantitative models; and the inferring of the outcomes of Commonwealth environmental water in areas not monitored as part of the LTIM Project (**Recommendation 11**).

Assessment of the contribution of Commonwealth environmental water – many of the key evaluation questions being addressed at both the Area-scale and Basin-scale are focused on the contribution of the *Commonwealth* environmental water to key ecological outcomes, such as fish breeding, wetland vegetation community diversity and ecosystem diversity. This has caused problems with the reporting of ecological outcomes as a result of environmental watering events where the Commonwealth's contribution may be only part and sometimes a quite small part of the total environmental water delivered. This issue has now been partially resolved, although we believe this is still extremely open to interpretation as the KEQs do not have SMART objectives.

Improve the expected outcomes for large multiple-scale watering actions - the CEWO is increasingly moving toward coordinated large-scale watering actions that influence multiple assets and rivers, and the monitoring and evaluation process needs to be modified to ensure the adaptive management can be undertaken at this large scale (**Recommendation 2**).

Expected outcomes for key ecosystem types (Ecosystem Diversity) - the increased focus on multi-scale watering actions has implications for the ecological scale of expected outcomes; that is the need to consider ecosystems in addition to species and populations. There is a need to better understand how key ecosystem types influence Basin biodiversity, resilience, ecosystem function and water quality. The CEWO needs to develop 1-year and 5-year expected outcomes for ecosystem diversity (**Recommendation 3**).

Area-scale evaluations

This MTRE has identified four areas where there could be improvements in the Area-scale evaluations: first, meeting the stated objectives; second, interactions and collaboration; third, reporting; and fourth, initiating independent technical review of the annual reports. The assessment of progress towards meeting objectives was of necessity a high level evaluation and focused on the provision of services for evaluation, adaptive management and context as per the contracts with the Selected Area teams. Most Selected Area teams are not fully meeting the requirements – mainly in relation to failing to scale up to whole of Selected Area, cumulative evaluation of results and reporting on Basin-scale data collected at the Area-scale. Interaction and collaboration is a fundamental requirement of the LTIM project, this has been improved considerably with increased interaction between the Selected Area teams, but still requires work to improve collaboration between the Selected Area and Basin Matter teams. Improved reporting is also seen as critically important to the legacy of the LTIM Project, as is independent review of the science (**Recommendations 7, 8 and 9**).

Basin-scale evaluations

Meaning of Basin-scale evaluation – The concept of what constitutes a 'Basin-scale evaluation' or an 'integrated Basin-scale evaluation' is still poorly articulated. Presumably, a Basin-scale evaluation will be made up of the aggregation of subsets of the Basin; these may be large sub-regions (e.g. northern and southern Basins) or single catchments. But even the integration of the components making up a catchment is not a simple matter. We have recommended that CEWO establish a process to better define this term and to scope how a 'Basin-scale evaluation' would be undertaken (**Recommendation 10**).

Development of quantitative models – There is no clear plan for how the Basin Matters team will develop, test and implement quantitative models for fish, vegetation and metabolism in the 18 months to the LTIM Project's completion. There is an urgent need for a comprehensive *modelling development plan* to be developed (**Recommendation 11**).

MDMS QA/QC issues – Data quality control issues continue to impact on the ability of the Basin Matters team to complete their annual evaluations in a timely manner. We have recommended that resolution of this issue be one of the first tasks of the new Steering Committee (**Recommendation 12**).

More detailed hydrological information and improve inundation mapping - the availability of hydrological information relating to watering actions is highly variable and is limiting the assessments of hydrological outcomes and ecological responses. Equally, the high uncertainty about the fate of water in the landscape after it is released is also limiting Area-scale and Basin-scale evaluations. The volumes in storage and the rates and timing of delivery are well known, but the physical extent of water covering the land and the duration it persists in wetlands and on floodplains is much more poorly understood (**Recommendation 13**).

Collaboration

This review has identified a continuing need to support moves to improve collaboration between the Selected Area teams, and between the Selected Area teams and the Basin Matters team. The benefits of this improved collaboration needs to be assessed (**Recommendation 14**). Additionally, there is a need to provide a more formal collaboration component to the Project's structure for the remainder of the Project, perhaps by the establishment of a *Project Steering Committee* (**Recommendation 4**).

Reporting and communication

Reporting is a key product of the LTIM Project, but currently there is a lack of a strategy that outlines the objective(s), audience(s) and types of reports, fact sheets and web products to be produced annually. The Selected Area teams need to either: (a) more faithfully follow the terms of their contract regarding annual reports; or (b) perhaps produce two reports annually - a relatively short *general report* suitable for water managers and other stakeholders, and a detailed *science report* containing the information currently in the appendices, together with a synthesis of the scientific ecological outcomes for the Selected Area (and beyond if possible). Additionally, the Basin Matters and Synthesis reports need to be reviewed with a view to making them more accessible to a wider audience (**Recommendation 15**). A particular problem for the Synthesis reporting is the difficulty in accessing relevant data and information from other non-LTIM monitoring programs. There is an urgent need to consolidate these data into a central location (**Recommendation 14**). An effective science communicator(s) should be engaged to assist the Selected Area and Basin Matters teams with their reports (**Recommendation 17**).

Capture of adaptive management information

There are some excellent interactions between the Selected Area and CEWO Delivery teams that are resulting in a considerable number of learnings that are being translated into better management of the Commonwealth's environmental water. However, the capture of these adaptive management learnings could be improved and done more systematically. Two improvements were identified: first, better documentation of the many informal and formal discussions that lead to changes in water delivery, with this information recorded in an accessible and searchable database; and second, the production of an annual report that captures and synthesises the way this increased knowledge is changing the way in which the CEWO Delivery Teams are delivering environmental water (**Recommendation 18**).

Project Steering Committee

This review has identified the need for a more structured and collaborative approach to the running of the LTIM Project. We recommend the establishment of a Project Steering Committee composed of: the CEWO Project management team; the CEWO Delivery Team leads; the MDFRC Director; and the Selected-Area team lead. The CEWO and MDFRC Director would jointly chair the Steering Committee (**Recommendation 4**).

Independent Science Review Committee

This review has identified a significant lack of independent peer review of the LTIM Project. Some internal review is occurring within the Selected Area teams and (recently) between the Basin Matters and the Selected Area teams. The recommended Project Steering Committee will assist in strengthening these internal review processes. However, there is still need for independent peer review of the science. CEWO have commenced an independent review process with this current mid-term review and evaluation process. The next critical point will be to review the LTIM Program at its completion. CEWO should establish an *Independent Science Review Committee* to review the quality and relevance of the science (Selected Area and Basin Matters) and other aspects of the Project in year 5, and to make recommendations of modifications to the Project relevant to LTIM Phase 2 (**Recommendation 19**).

RECOMMENDATIONS

Recommendation 1: that the Basin-scale evaluation questions are reviewed to assess whether they are all still relevant, and the likelihood that they will be adequately addressed by June 2019. In light of this review to

the CEWO should make any modifications that would update the expectations of the Basin-scale evaluations.

Recommendation 2: that for multiple-scale watering actions, CEWO ensures the full range of expected ecological outcomes are determined and communicated to the appropriate LTIM Project teams.

Recommendation 3: that the CEWO develop expected outcomes for the ecosystem diversity Basin Matter.

Recommendation 4: that a LTIM Project Steering Committee be established, consisting of the CEWO, CEWO Delivery Teams, Selected Area team leads and the MDFRC Director. CEWO should also consider whether the MDBA should also be invited to join this Committee.

Recommendation 5: that the CEWO review the management of the LTIM Project with a view to identifying a single Program Manager and a Science Leader.

Recommendation 6: that the CEWO urgently develop an Evaluation Strategy for the LTIM Project.

Recommendation 7: that the Selected Area teams focus more attention in their annual reports on: addressing the key evaluation questions; the ecological outcomes of each local-area watering action, and scaling up the Area-scale assessment and evaluations to the entire Selected Area.

Recommendation 8: that consideration be given to requiring the Selected Area teams to produce two reports annually: first, a relatively short general report suitable for water managers and other stakeholders; and second, a detailed science report containing the information currently in the Appendices.

Recommendation 9: that the CEWO consider having a detailed independent peer review undertaken during 2018 of the quality of the science being reported by the Selected Area teams, with the focus being on the initial MEP, and the 2016-17 annual evaluation reports.

Recommendation 10: that the CEWO organise a process to clarify the scope and consistency of basin-scale evaluations, the process consisting of the preparation of a discussion paper, followed by a workshop with key researchers and managers to provide a sensible outcome.

Recommendation 11: that the MDFRC develop a comprehensive project modelling plan as a matter of urgency, and that this Plan be agreed to by the proposed Project Steering Committee. Additional funds or reallocation of existing funds may be required to ensure the development of the Plan, and the subsequent development and testing of the models, is achieved.

Recommendation 12: that the new Project Steering Committee be tasked with resolving the continuing issues associated data QA/QC and the MDMS.

Recommendation 13: that the need for improved hydrological data and information, and inundation mapping be urgently addressed.

Recommendation 14: that the proposed Project Steering Committee formally evaluate the benefits of this improved collaboration between the Selected Area and Basin Matters teams as one of its first tasks.

Recommendation 15: that a review of the annual Basin Matters and Synthesis reported be undertaken, with a view to restructuring them to make them more accessible to a wider audience.

Recommendation 16: that a common database be established to hold all relevant data relating to environmental water monitoring in the Murray-Darling Basin; this will require cooperation between CEWO, MDBA and state agencies to achieve.

Recommendation 17: that an effective science communicator(s) be engaged by CEWO or MDFRC to assist the Selected Area and Basin Matters teams to make their various reports more readable, and to assist CEWO to produce more structured and targeted information products related to the LTIM Project.

Recommendation 18: that the capture of adaptive management learning's be improved and done more systematically, in particular with the development of a accessible and searchable database to contain the learning's, and the production of an annual report that synthesises how this increased knowledge is changing the way in which environmental water is being delivered.

Recommendation 19: that an Independent Science Review Committee be established to review the quality and relevance of the science being developed by the Selected Area teams and the Basin Matters team.

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1 INTRODUCTION

This report contains an independent ‘program level’ Mid-Term Review and Evaluation (MTRE) of the Commonwealth’s Long Term Intervention Monitoring (LTIM) Project undertaken by Professor Barry Hart (Director, Water Science Pty Ltd) and Dr Rhonda Butcher (Principal, Waters Edge Consulting).

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The LTIM Project is world-leading in its scope, both spatially (the entire Murray-Darling Basin) and temporally (5 years), objectives and budget (over \$30 million over 5 years). It is seeking to achieve an outcome – assessment of the effectiveness of Commonwealth environmental water delivery in achieving Basin-scale ecological outcomes – that has never been attempted before anywhere in the world. It is a highly ambitious project.

The objectives of this MTRE are (in brief): to assess the structure of the LTIM Project; to review progress, effectiveness, achievements and outputs of the LTIM Project from the first three years of monitoring (2014-15 to 2016-17); to assess what is working well and what can be improved in the short and longer term; and to provide a series of recommendations and associated management responses related to the review findings for the CEWO’s consideration.

The evidence for this MTRE was obtained from two sources: first, from a review of relevant reports (Program Logic documents; Area-scale Monitoring and Evaluation Plans (MEP); Basin-Matter Evaluation Plans; and Area-scale and Basin-scale 2015-16 evaluation reports – see Appendix A); and second, from interviews with CEWO staff (project managers, Water Delivery Teams), the Murray Darling Freshwater Research Centre (MDFRC) Director and Basin Matter leads; the leads of the seven Selected-Area teams and selected team members; and relevant staff from the Murray-Darling Basin Authority (MDBA) (See Appendix C for discussion points). This review has been impressed with the large number of talented, highly skilled, experienced and committed scientists and water managers involved in the Project.

This MTRE report covers: the background to the LTIM Project; a review of the Project structure; a high level evaluation of the Project’s progress under three headings - Area-scale evaluation, Basin-scale evaluation, and Adaptive Management; possible modifications to the Project; some considerations for LTIM Phase 2; and finally a series of recommendation for CEWO’s consideration.

2 BACKGROUND

2.1 LTIM PROJECT OBJECTIVES

Since 2008, the Commonwealth has acquired environmental water with the aim of rebalancing the water resources of the Murray-Darling Basin (MDB) to ensure the environmental assets of the Basin are protected and where needed also restored. The Commonwealth Environmental Water Holder (CEWH) manages the Commonwealth’s environmental water portfolio. At the 31 January 2018, the portfolio totalled 1,836 GL (long-term average).²

The *Water Act 2007 (Cwlth)* requires the CEWH to perform its functions and exercise its powers consistently with and in a manner that gives effect to the Basin Plan (Commonwealth of Australia 2012). Specifically, the CEWH must ensure that Commonwealth environmental water is managed in accordance with the Basin Plan’s environmental watering plan (BWP; Commonwealth of Australia 2012) and the Basin-wide environmental watering strategy (BEWS; MDBA 2014). The CEWH is also expected to have regard to the Basin annual watering priorities as well. The Water Act (in part via the Basin Plan) places a number of obligations on the CEWH, including principles of monitoring, evaluation and reporting requirements.

In response to the requirements of the Water Act and the Basin Plan, the CEWO has established a Long Term Intervention Monitoring (LTIM) Project, with the aim of supporting improved decision making through the application of the principles of adaptive management, good governance and reporting.

² <http://www.environment.gov.au/water/cewo/about-commonwealth-environmental-water>

Intervention monitoring is one of three types of monitoring included in the CEWO Monitoring, Evaluation, Reporting and Improvement (MERI) Framework (CEWO 2013) - the other two being *operational* and *program* level monitoring. Intervention monitoring is a key step in the MERI process that underpins evaluation, reporting of outcomes and improved decisions, and future monitoring through the adaptive management process. The CEWO MERI Framework includes two types of intervention monitoring: *targeted monitoring* of selected watering actions, and *long-term monitoring* of Selected Areas.

The LTIM Project objectives, in order of priority, are (Gawne et al. 2014):

- Evaluate the contribution of Commonwealth environmental watering to the objectives of the Murray-Darling Basin Authority's (MDBA) Environmental Watering Plan;
- Evaluate the ecological outcomes of Commonwealth environmental watering at each of the seven Selected Areas;
- Infer ecological outcomes of Commonwealth environmental watering in areas of the Murray-Darling Basin not monitored;
- Support the adaptive management of Commonwealth environmental water;
- Monitor the ecological response to Commonwealth environmental watering at each of the seven Selected Areas.

The Outcomes Framework developed by MDFRC represents a hierarchy of expected outcomes based around the environmental watering objectives stated in the Murray-Darling Basin Plan (MDBA 2012). Expected outcomes are referred to as Basin Matters, which were identified as achievable:

- Within a one year timeframe (1 year expected outcomes);
- Within a one year to five year timeframe (5 year expected outcomes).

Table 1: Objectives relevant to Commonwealth environmental water management (CEWO 2013).

Basin Plan Reference	Basin Plan Objective	Short label
Environmental watering plan	"to protect and restore water-dependent ecosystems of the Murray-Darling Basin" (Basin Plan, Chapter 8, Part 2, 8.04(a))	Biodiversity
	"to protect and restore the ecosystem functions of water-dependent ecosystems" (Basin Plan, Chapter 8, Part 2, 8.04(b))	Ecosystem function
	"to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats" (Basin Plan, Chapter 8, Part 2, 8.04(c))	Resilience
Water quality and salinity management plan	"to ensure water quality is sufficient to achieve the above objectives for water-dependent ecosystems, and, for Ramsar wetlands, sufficient to maintain ecological character" (Basin Plan, Chapter 9, Part 3, 9.04 (1) & (2))	Water quality

2.2 LTIM PROJECT DEVELOPMENT

The LTIM Project commenced in 2012 with the awarding of a contract to the MDFRC to lead the Project's development. The MDFRC, under the previous director (Dr Ben Gawne), assembled a team of experts who spent two years (2012-2014) in developing a detailed logic and rationale for the project and providing technical advice to the Selected Area teams during the development of the Monitoring and Evaluation Plans (MEP). The process undertaken is well documented in Gawne et al. (2013).

In brief, the LTIM Project development involved five steps:

1. Establishing the scientific rationale that would allow prediction of the likely ecological outcomes of Commonwealth environmental water use

This involved in integration of four major inputs:

- A hierarchy of Basin Plan Environmental Water Plan (EWP) objectives that classifies these objectives in a way that is helpful for environmental water managers, practitioners and scientists, and also sets out the scientific basis of how delivery of environmental water will contribute to meeting EWP objectives;

- A suite of conceptual models (cause-effect diagrams) that use the best available science to link EWP objectives to changes in flow;
- The ecological roles of the major hydrological flow types described in the Basin Plan (i.e. base flows, freshes, bank full and overbank flows) and their influence on biodiversity, ecosystem function, resilience and water quality; and
- The range of possible water availability scenarios over the course of five years.

These inputs were then used to develop a generic set of expected outcomes over both less than 1-year and 1 to 5-year periods at each of the seven LTIM 'Selected Area' sites (discussed below).

2. Determining the scope of the LTIM Project

The LTIM Project was established at seven 'Selected Area' sites. These are (with the major water-related assets in brackets):

- Edward–Wakool river system (in-stream and fringing wetlands);
- Goulburn River (in-stream and fringing wetlands);
- Gwydir River system (in-stream, wetlands and floodplains);
- Lower Lachlan River system (in-stream and fringing wetlands);
- Murrumbidgee River system (in-stream, fringing wetlands and floodplains);
- Lower Murray River (in-stream, connected wetlands, floodplain and temporary non-connected wetlands);
- Warrego- Darling River system.

The CEWO engaged consortium-monitoring teams, led by research institutions, to develop and implement the 5-year MEP for each of the seven Selected Areas. The focus of each MEP is to determine whether Commonwealth environmental water is achieving the outcomes expected of it at the local-scale, but to also capture data, which would contribute to basin scale evaluation of the influence of Commonwealth environmental water.

The seven areas included in the LTIM Project were selected to cover areas where Commonwealth environmental watering occurs and to complement, rather than duplicate, monitoring activities by other organisations/programs such as asset scale monitoring by Basin states under Long Term Watering Plans. For example, a number of high profile wetland areas (e.g. the Coorong and Lower Lakes; Barmah-Millewa Forest; Hattah Lakes and Macquarie Marshes) were not included as these were assumed to be adequately covered in The Living Murray or state-based programs.

3. Identifying and prioritising the monitoring indicators

A three-stage process was undertaken to identify a range of both *effect* indicators (that provide information relevant to reporting against objectives) and *causal* indicators (that help to explain the effects), including:

- Stakeholder workshops in each Selected Area to provide a local perspective on ecological values and management priorities;
- Prioritising the objectives against: whole of Basin reporting obligations; the potential for the monitoring indicators to help in evaluating ecological outcomes in non-monitored areas; and the value of the indicators in helping with adaptive management of the Commonwealth's environmental water;
- Prioritising the causal indicators based on their potential importance in assisting decision-making by the CEWO Delivery Teams.
- This process identified 18 monitoring priorities and 40 priority indicators, with a subset of the indicators identified as priorities in all seven Selected Areas; these included hydrological connectivity, ecosystem diversity, vegetation condition, vegetation diversity, fish population condition, fish community diversity, water quality and river channel metabolism. The tenth indicator was a generic category to cover responses by high value species such as threatened and endangered species.

It is understood that waterbirds were also considered as an indicator, but were not recommended as either a Selected Area or Basin-scale indicator, because of funding limitations and the fact that other waterbird monitoring programs are operative.

Consideration was also given to the standardisation of methods, sampling design and analysis. However, there was considerable resistance to this from the Selected Area teams, and a compromise was reached that saw three categories of indicators developed, these being (Hale et al. 2014):

- Category I – mandatory indicators and standard protocols to be used in Basin-scale evaluation;
- Category II – optional indicators with mandatory standard protocols; and
- Category III – optional indicators with Selected Area specific protocols and mandatory reporting requirements.

4. Deciding on the evaluation process

Evaluation of the monitoring results is required to identify change due to environmental watering and to support possible adaptive management of the monitoring programs. Outcomes evaluation of the LTIM Project is undertaken each year at multiple spatial and temporal scales; broadly, the evaluation is focused on assessing:

- The outcomes of the Commonwealth environmental watering against the expected outcomes for each Selected Area, which is addressed in each of the Selected Area (Area-scale) annual evaluation reports;
- The contribution of the Commonwealth environmental watering to the objectives of the Basin Plan, which is addressed in the Basin Matter (Basin-scale) annual evaluation and synthesis reports.

5. Determining how adaptive management could be incorporated into the LTIM Project

Gawne et al. (2014) noted that *‘Effective adaptive management requires processes (to be developed) to generate, communicate, assimilate and apply new knowledge to improve monitoring, evaluation, system understanding and future interventions’*, and further that the *‘LTIM will include the development of statistical models that will facilitate the generation, assimilation and application of knowledge to future management decisions’*. They suggested that the information being collected through the LTIM Project could contribute to the development of (a) species population models, and (b) simple ecosystem models. To date (February 2018) no models have been developed. However, there has been some progress on the development of quantitative large-scale models for fish, vegetation and metabolism that is discussed in Section 4.2.2.

2.3 LTIM PROJECT DELIVERY

As noted above, the primary aim of the CEWO LTIM Project is to evaluate the ecological response of Murray-Darling Basin water-related assets to the added Commonwealth environmental water. This is to be achieved by evaluating these ecological responses at two scales: the Area-scale and the Basin-scale.

The *Area-scale evaluations* are provided by the seven Selected Area teams. Each Selected Area team was required to provide a detailed MEP before they commenced. The MEP were developed using a standard template, and with technical advice from the technical advisory group led by MDFRC. Each Selected Area team was required to draft a MEP using the standard methods developed through the program logic design phase undertaken by MDFRC. The MEP were reviewed by the technical advisors and feedback provided to CEWO on each of the MEP.

We provide a ‘high level’ assessment of these MEP’s and the Selected Area 2015-16 annual evaluation reports in Section 4.1 below, but have not undertaken a detailed review of the various programs, the data collected, the analysis of these data, or the interpretation (evaluation) of the data. Such a detailed review should be undertaken.

The ‘Basin Matters’ team led by the MDFRC provide the *Basin-scale evaluations*. The development of the Basin-scale evaluation is described in the LTIM Project Logic and Rationale document (Gawne et al. 2013) and the Basin Evaluation Plan (Gawne et al. 2014). Six ecological indicators, Basin Matters, underpin the Basin-scale evaluation:

- **Ecosystem diversity** – the aquatic ecosystem types (e.g. wetlands, rivers, streams) that benefited from Commonwealth environmental water;
- **Hydrology** – river flow and wetland water regimes modeled with and without Commonwealth environmental water;

- **Stream metabolism and water quality** – rates of in-stream primary productivity and decomposition, salinity and pH;
- **Vegetation diversity** – plant species' responses with respect to extent, diversity and condition;
- **Fish** – short- and long-term responses of fish with respect to movement, condition, abundance and diversity; and
- **Generic diversity** – effects on diversity of all biota from monitoring and observations.

The Basin-scale reports are based on the data and evaluations contained in the Selected Area reports (Gawne et al. 2014) and on Category I indicator data collected by the Selected Area teams. Those for 2015-16 are reviewed in Section 4 below.

Finally, the information in the Basin Matters evaluation reports is brought together in a 'Basin-scale Synthesis Report' that provides an integrated assessment across the three themes of the Basin Plan: biodiversity, ecosystem function and resilience (Gawne et al. 2013). Basin-scale evaluations are done annually (to date done for 2014-15 and 2015-16) and for the cumulative 5-year period (to date done for 2014-16) (Gawne et al. 2017).

3 REVIEW OF LTIM PROJECT STRUCTURE

3.1 LOGIC AND RATIONAL - ALIGNMENT WITH THE ENVIRONMENTAL WATERING PLAN OBJECTIVES/REQUIREMENTS

The Basin Plan was released (November 2012) and the Basin-wide Environmental Watering Strategy (BEWS) was completed in 2014 (MDBA 2014). The BEWS, a part of the Environmental Watering Plan (Chapter 8 of the Basin Plan), is intended to help environmental water holders and waterway managers plan and manage environmental watering at a *Basin-scale*, and over the long term to meet the environmental objectives (MDBA 2014). Expected outcomes by 2024 for four components of the Basin's water-dependent ecosystems are the focus of the BEWS; these include river flows and connectivity; native vegetation; waterbirds; and native fish (MDBA 2014). The BEWS is the means by which the Environmental Watering Plan objectives are assessed.

Annual environmental watering priorities for the Basin are prepared to inform annual planning and prioritisation of environmental watering across the Murray–Darling Basin. They are developed to meet the long-term outcomes in the [BEWS](#) and aim to deliver the Basin Plan's objectives of protecting and restoring the Basin's rivers, wetlands and floodplains (MDBA 2017).

3.2 IMPLEMENTATION

As outlined in Section 2, the structure of the LTIM Project was developed over a two-year period (2012-2014) by the CEWO in collaboration with a team of technical advisors coordinated by the MDFRC. Activities over a five-year period (2014-2019) will include:

- **Area-scale evaluation** – monitoring and evaluation of the ecological response of water-related assets to Commonwealth environmental water (CEW) in the seven Selected Area sites;
- **Basin-scale evaluation** – aggregation and integration of this area-scale data and knowledge to provide Basin-scale evaluation of the ecological response of water-related assets to CEW;
- **Temporal evaluation** – both the Area-scale and Basin-scale evaluations are done annually, and will also be done cumulatively over 1-5 years as the program is rolled out;
- **Adaptive management** – the LTIM Project is built around the assumption that there will be a number of 'learnings' as the project is rolled out, and that these need to be captured and used to modify technical and decision-making aspects of the Project during time, as well as inform water planning decisions (see definition of adaptive management as per Basin Plan in Section 5).

The Project structure is logical and has been very well planned (see Figure 1). Additionally, the LTIM Project objectives are well focused and sensible (see Section 2.1), although adequately addressing them in five years will be challenging.

The three main structural components of the Project are (Figure 1): the seven Selected Area teams, the Basin Matters team, and the CEWO Water Delivery teams. The seven Selected Area teams are contracted to collect data in their areas for two purposes:

- First, to provide data of relevance to the Basin-scale evaluations, i.e. addressing the first objective above. Largely standard methods (Category I indicators) are being used for this monitoring, with these data being analysed and use by the Basin Matters team in their Basin-scale evaluations, with some input from the Selected Area teams (see also below);
- Second, to provide data and analyses of more relevance at the local scale, and to address the second LTIM objective above. For this purpose, Category II and III indicators are being monitored and evaluated.

Additionally, the Selected Area teams are all interacting closely with the CEWO water delivery teams (and their various Stakeholder Advisory Groups) in planning annual environmental water delivery regimes, and in reporting back to these groups on the ecological outcomes of each particular environmental watering event. This aspect is covered in more detail in the Adaptive Management section below (Section 4.3).

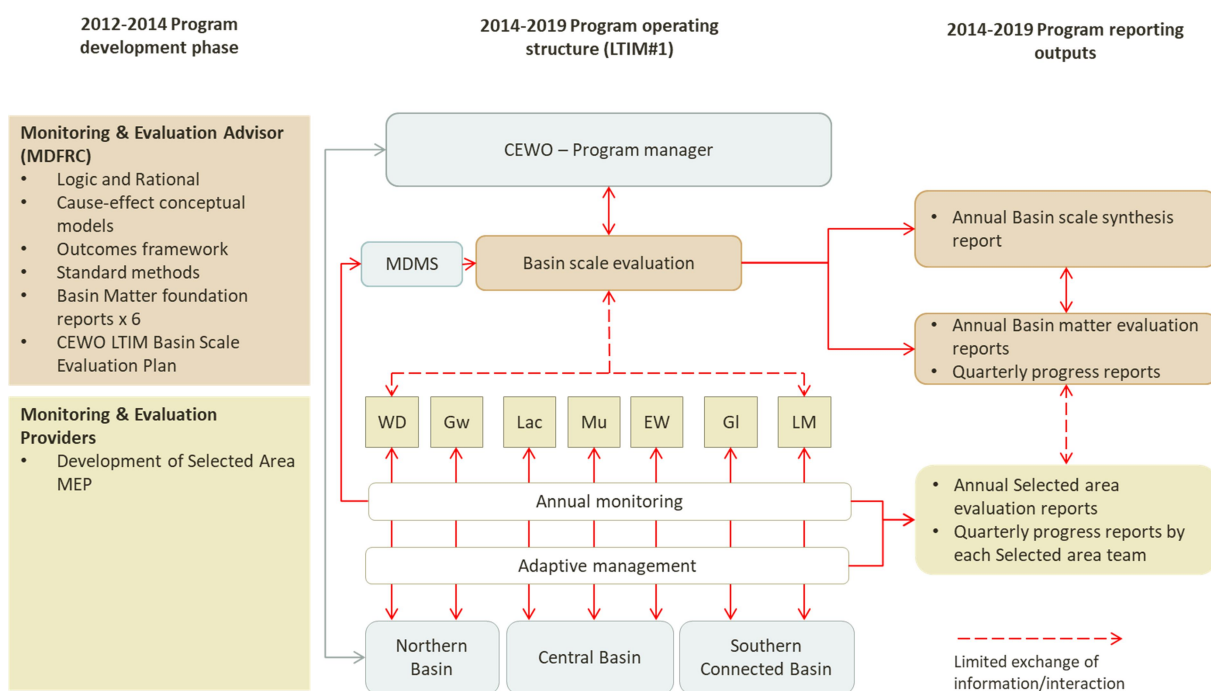


Figure 1: Schematic of LTIM Project development and output phases and operating structure

3.3 DISCUSSION

It is clear that the original development of the LTIM Project structure was rather ‘top down’ with little interaction between the MDFRC development team and the Selected Area teams. This was understandable given the logic at that time, where the Selected Area teams were seen as ‘providers’ (or ‘contractors’) of the necessary data, with the Basin Matters team doing the analysis and evaluation at the Basin-scale.

This ‘top down’ approach created considerable resentment in the Selected Area teams who felt their involvement would have resulted in a more collaborative LTIM Project and also improved the selected indicators and monitoring and analysis methods adopted. The Project has become more collaborative, although this has taken some time to achieve and has taken valuable time away from the main game. This is a key lesson for those planning the continuation of the LTIM Project (we will refer to this potential new project as LTIM 2).

The original intent of the LTIM Project was to focus on the Basin-scale evaluation with the input at the Selected Areas being the smaller component of the program. In the early scoping phase it was anticipated that approximately 70% of the funding would be targeted at the Basin-scale outcomes and evaluations as per the requirements to contribute to Basin-scale evaluation under the Basin Plan and BEWS. The project appears to have shifted emphasis with the focus on the Selected Area outcomes now occurring at the expense of the Basin-scale evaluation. We are not aware of the reasons for this changed focus, but note first that the LTIM Project was established as the main program for assessing the CEWO requirements under the Water Act 2007

and the Murray-Darling Basin Plan, and second that the Basin Plan is focused on improvements at a Basin-scale. We urge CEWO to review whether this apparent changed Project focus will impact on their capacity to report on the contribution of Commonwealth environmental water at a Basin-scale.

We were also somewhat surprised to discover that there was no single manager of the LTIM Project, but that management was spread between four groups within CEWO – these being: the CEWO Aquatic Ecosystems & Science Section who are responsible for coordinating the management of the LTIM Project³, and the three CEWO delivery teams who are responsible for the Selected Area team contracts. We are not aware of the internal coordination linkages within CEWO, but our experience suggests that such a dispersed project management system is unlikely to be efficient and effective.

In addition to the desirability that the LTIM Project has an agreed and recognisable Project Manager, we believe it would be of value to the Project if there was also an agreed and recognised Science Leader. This is further discussed in Section 5.3.

3.4 FINDINGS

The LTIM Project structure is sound and does not need to be fundamentally changed. There are, however, a number of modifications that could be made over the next few months and in future iterations that would strengthen the Project.

These are fully discussed in Section 5.1 (with recommendations) and include: first, to review and clarify the Project objectives; second, to work to further improve the collaboration and coordination between the Selected Area teams and the Basin Matters team perhaps by establishing a *Project Steering Committee*; third, to review the LTIM Project Management arrangements, including consideration of desirability of establishing a Science Leader position; and fourth, to develop a Program Evaluation Strategy as part of the MERI process to assist in assessing the efficiency, effectiveness, relevance and sustainability of the LTIM Project

4 EVALUATION OF LTIM PROJECT PROGRESS

4.1 AREA-SCALE

The CEWO has contracted seven teams, largely associated with research institutions, to undertake monitoring and evaluation in the seven Selected Areas, these being: Edward–Wakool River; Goulburn River; Gwydir River; Lower Lachlan River; Murrumbidgee River; Lower Murray River; and Warrego- Darling River system.

Our review of their progress has been based on: *review* of the M&E Plans, the 2015-16 Annual Reports, and a selection of Quarterly Reports; and *interviews* with the team leads, other team staff and the CEWO delivery teams. It would have been useful to have also had the 2016-17 Annual Reports for review, but these are not yet available.

4.1.1 FINDINGS

Meeting stated objectives:

This review has found that the Selected Area projects are generally being run effectively. A detailed assessment of progress of each Selected Area project is provided in Appendix G. Table 2 below provides a high level assessment of the level to which each Selected Area project is on track to meet the LTIM project objectives.

³ Management of: LTIM finances; LTIM contractual issues; the LTIM Monitoring Data Management System; and management of advice, coordination of issues, cross project coordination and consistency.

Table 2: Assessment of Selected Area progress against LTIM Project objectives as per CEWO contracts. Green – evaluation on track to be achieved; Yellow – evaluation has possibility of being achieved but dependent on watering conditions or other constraint; Red – objectives not adequately addressed or evaluation not on track to be achieved.

Selected Area	1. Contribute to objectives of the MDBA EWP	2. Evaluation of CEW at Area-scale	3. Infer to non-monitored areas	4. Adaptive management	5. Monitor response to CEW
Edward-Wakool	Yellow	Red	Red	Green	Green
Goulburn	Yellow	Red	Red	Green	Green
Gwydir	Green	Red	Red	Green	Green
Lower Lachlan	Yellow	Red	Red	Green	Green
Lower Murray	Yellow	Red	Red	Green	Green
Murrumbidgee	Yellow	Red	Red	Green	Green
Warrego-Darling	Green	Red	Red	Green	Green

Our assessment has highlighted several areas that need attention at the area-scale to meet the stated LTIM project objectives, including:

- To evaluate ecological outcomes of Commonwealth environmental watering at each Selected Area the expected outcomes need to be SMART⁴, or at the least *achievable* and *measurable*. In some cases the local-area watering action objectives and/or expected outcomes are not able to be adequately addressed as the objective originally developed by the CEWO delivery teams are not SMART. For example, the Warrego-Darling evaluation report lists ‘salinity’ as the expected outcome (as per Commonwealth of Australia 2014), but this provides no guide as to what the expected response to watering should be. There is also concern that the LTIM short and long term key evaluation questions are also not SMART.
- There are only two Selected Areas that attempt to account for the contribution of Commonwealth environmental water to meeting the objectives of the Murray Darling Basin Authority’s Environmental Watering Plan – the Gwydir and Warrego-Darling. All other Selected Area evaluation reports focus on the Area-scale outcomes linked to area watering. This reflects the shift in focus of the LTIM project from Basin scale reporting to Area-scale reporting.
- There is inadequate attention to the requirement to scale up the Area-scale assessment and evaluations to the entire Selected Area. The majority of the results presented focus on the reach, zone, river or wetland scale, but in most cases do not make clear statements for the entire Selected Area. For example, the Lower Lachlan evaluation report (Dyer et al. 2016) refers to catchment outcomes for some matters, but it is not clear if this refers to the entire Selected Area or the larger Lachlan catchment. Occasionally the counterfactual – inferring outcomes to non-watered area – is included in the evaluation reports, but this is not consistently done across the Selected Area reports.
- In general, the Area-scale evaluation reporting requirements are not fully met (see Appendix G). In addition to the points made above, there is inconsistency across the Selected Areas as to the degree that both short and long term evaluation questions are addressed, not all of the key evaluation questions listed in the MEP are included (most are, but not all), and the requirement to provide cumulative evaluation of data has not been addressed adequately, if at all.

The observations made above have to be made in the context that only two years of data have been collected and that had a third round of evaluation reports may present a different picture. Also we are aware that there have been some modifications to the Monitoring & Evaluation Plans since the commencement of the Project. We have been told that no changes have been made to the original evaluation questions, but that there have been some changes to M&E Plans along the way. These changes fall into three categories:

- Changes to Category I monitoring – these are initiated and managed by the Basin Matters team, with the CEWO ensuring any changes are reflected in updated M&E Plans;

⁴ SMART objectives are: **Specific** – clear and unambiguous; **Measurable** – quantified, contain a measurable element that can be readily monitored to determine success or failure; **Achievable** – realistic and attainable; **Relevant** – considerate of temporal scale of response, resources available; and **Time bound** – specify a time scale in which the outcome is met/assessed.

- Changes from Category I to Category III monitoring – these changes, for example for larval fish data, were initiated by the Selected Area teams and approved by CEWO to allow ‘preferred’ (opposed to Category I) methods to be used Selected Area teams. This had consequences for the Basin evaluation; and
- Changes to Category III monitoring – Selected Area teams sometimes request changes such as change of schedule due to flooding, a revised cost structure due to sickness, or the introduction of new technology in place of old technology. These need to be approved by the CEWO.

Overall, the very clear positive outcome of the LTIM Project at the Area-scale is the significant contribution being made to the adaptive management of water planning and delivery at the Area-scale. This is the overwhelming opinion of all involved that this aspect of the project has had considerable benefits for the management of Commonwealth environmental water.

Interactions and collaboration:

Interactions between the Selected Area teams and the CEWO Water Delivery Teams are very good. We heard from the Delivery Teams that the researcher involvement in the annual water deliver planning, and additionally in suggesting potential modifications to specific watering events, is excellent and has resulted in the Delivery Teams having essentially real-time scientific information upon which to base their decisions. These interactions are an excellent example of the ‘active’ adaptive management described by Horne et al. (2017) and O’Donnell and Garrick (2017).

Interactions between the Selected Area teams and their Stakeholder Advisory Committees are also very good. We heard that researchers have been prepared to provide up-to-date and understandable information on the ecological outcomes that have been achieved as a result of particular watering events, and when needed they are also prepared to speculate on what outcomes might be expected from modified watering events.

Interactions between the Selected Area teams and the CEWO LTIM project management team (Aquatic Ecosystems & Science Section) have also been very effective. The Selected Area teams indicated to us that these interactions have been very professional, and that the CEWO staff have a keen appreciation of some of the difficulties being experienced, and have worked hard to seek practical solutions to these issues.

Interaction and collaboration between the seven Selected Area teams is a requirement of their contracts, however it has been recognised within the Selected Area teams (and the CEWO) that increased collaboration would lead to better Project outcomes. To this end the CEWO provided additional funds (\$400,000) in 2017 to the MDFRC to support additional activities aimed at improving collaboration within the LTIM Project.

Until recently, the collaboration between the Basin Matters and Selected Area teams has been poor, although it has improved in recent times. These teams are benefitting from this funding by being able to review each other’s annual reports and to hold one or two workshops each year on topics of their choosing (see also Section 5.6).

Reporting:

The Selected Area annual evaluation reports are overly detailed and often not written in a way that addresses the intent of their contracts. The contracts require an annual report with three sections: an executive summary (1-2 pages); a stand-alone main body suitable for a water managers and interested audience (containing context, evaluation and adaptive management components – around 20 pages); and separate appendices for any detailed results and methods suitable for a technical or academic audience.

It is the main body of the reports in particular that needs attention. In most cases they are too long, overly complex, and many cases do not directly/adequately address the key evaluation questions. We address this issue in more detail in Section 5.7.

Appendix G presents a summary of the progress of each Selected Area in meeting the reporting requirements as specified in the contracts. Some of the issues identified have been mentioned above; however another key finding is that there is no consistency in how each Selected Area report the key ‘take home’ messages. It was quite a time consuming task to find the information to check against each of the reporting requirements – some reports did this exceptionally well, others less so.

Review:

There appears to be no documented process for reviewing Selected Area projects or their annual reports, such as the Program Evaluation Strategy developed for the Environmental Water Knowledge Research (EWKR) project (Hodge et al. 2015).

We were told that CEWO staff comment on the Selected Area draft annual reports, but currently there is no process for peer review (independent or otherwise) of the technical components (i.e. the technical appendices) of the annual reports. The technical appendices have not been reviewed in detail as part of this review, although we have needed to partially review the 2015-16 appendices to be able to evaluate the main reports. We were told that most Selected Area teams have a process where teams members are involved in the review of the more technical aspects of the annual reports (the appendices), but we have no evidence of the extent or rigor of these reviews.

We have also been informed that from late 2017, the Basin Matter team members (Sam Capon, Mike Grace and Rick Stoffels) will review certain sections of the Selected Area annual reports.⁵ The objectives and scope of these reviews will be:

- Obtain an overview of Selected Area ecological response to flows prior to and up to the current Basin-scale reporting period. This overview will help to place Basin scale quantitative analyses in context, while at the same time providing the necessary foundation for qualitative synthesis of managed flow outcomes at the Basin scale;
- Strengthen collaboration between the Selected Area and Basin matter teams, by achieving a shared understanding of the collective challenges in interpreting the monitoring data;
- Strengthen the quality of LTIM reporting by gaining a shared understanding of the inferences concerning flow impacts that are emerging from the monitoring, and how to strengthen those inferences;
- Identify common issues and challenges that may require targeted discussion at the LTIM Annual Forum;
- Determine whether the information required for Basin-scale synthesis is within Selected Area reports and, if not, identify additional material that could be included, stating the reasons it is required; and
- Identify any issues with the manner in which material is presented within the Selected Area reports, and suggest possible improvements, towards achieving more accessible and cogent reporting.

The introduction of the Basin Matter team review of the Selected Area annual reports is a welcome addition. However, we believe it is imperative that a more formal, independent review of the quality of the science in these technical reports is undertaken before the completion of this phase of the LTIM Project (see also Section 5.9). Such an independent review is crucial to ensuring the credibility of the LTIM Project - it is after all a science-based project.

4.2 BASIN-SCALE

4.2.1 GENERAL

The Basin-scale component of the Project is being run through the MDFRC, who have contracted a team of experts to conduct Basin-scale evaluations using six Basin Matters (Gawne et al. 2017):

- hydrology – river flow and wetland water regimes modeled with and without Commonwealth environmental water;
- ecosystem diversity – the aquatic ecosystem types (e.g. wetlands, rivers, streams) that benefited from Commonwealth environmental water;
- stream metabolism and water quality – rates of in-stream primary productivity and decomposition, salinity and pH;
- vegetation diversity – plant species' responses with respect to extent, diversity and condition;
- fish – short- and long-term responses of fish with respect to movement, condition, abundance and diversity;
- generic diversity – effects on diversity of all biota from monitoring and observations.

The development of the Basin-scale evaluation is described in the LTIM Project Logic and Rationale document (Gawne et al. 2013) and in the Basin Evaluation Plan (Gawne et al. 2014a, b). The Selected Area teams are using standard methods to collect data on fish, vegetation and metabolism, with these data (and Area-scale evaluations) then used by the relevant Basin Matters team member to provide an integrated analysis across the Basin.

⁵ R. Stoffels, personal communication, 2 Nov 2017

Annually, the Basin Matters team produce reports addressing each of the Basin Matters (see Appendix B for references). The Basin-scale evaluation aims and evaluation questions being addressed by each of the Basin-Matters are listed in Table 3.

Table 3: Key evaluation questions (KEQ) for each Basin Matter (from Gawne et al 2014 Evaluation plan). Each KEQ begins with the wording “What did Commonwealth environmental water contribute to...?”

Basin Matter	1 year KEQ	1-5 year KEQ
Hydrology	<ul style="list-style-type: none"> • Restoration of the hydrological regime • Hydrological connectivity 	<ul style="list-style-type: none"> • Restoration of the hydrological regime • Hydrological connectivity
Ecosystem diversity	None identified	None identified
Stream metabolism and water quality	<ul style="list-style-type: none"> • Patterns and rates of decomposition • Patterns and rates of primary productivity • pH levels • Turbidity regimes • Salinity regimes • Dissolved oxygen levels 	<ul style="list-style-type: none"> • Patterns and rates of decomposition • Patterns and rates of primary productivity • pH levels • Turbidity regimes • Salinity regimes • Dissolved oxygen levels
Vegetation	<ul style="list-style-type: none"> • Vegetation species diversity • Vegetation community diversity 	<ul style="list-style-type: none"> • Vegetation species diversity • Vegetation community diversity
Fish	<ul style="list-style-type: none"> • Sustaining native fish reproduction • Sustaining native larval fish growth and survival • Sustaining native fish survival 	<ul style="list-style-type: none"> • Sustaining native fish populations
Generic diversity	<ul style="list-style-type: none"> • Other vertebrate species diversity • Other vertebrate populations 	<ul style="list-style-type: none"> • Other vertebrate populations

The Selected Area data are added to a Monitoring Data Management System (MDMS), which is then available for use by both the Selected Area and Basin Matters teams. It was recognised early in the LTIM Program development that such a data management system was imperative given the reliance on multiple stakeholders and contractors contributing data towards reporting and evaluation obligations. Considerable effort went in to ensuring that data being collected was of high quality, complete, compatible and available to data users in consistent and standardised formats to meet reporting and evaluation needs (Brooks and Wealands 2013a, b).

It is intended that the Basin-scale evaluation will seek to predict what would have happened in the absence of environmental watering. Currently, this is being done using conceptual models that relate watering characteristics and antecedent conditions to ecological outcomes. The intent is to develop quantitative predictive models to do this within the 5-year timeframe of the LTIM Project. These quantitative models will also be used in assessing the ecological outcomes in areas where watering actions are unmonitored, and to assist in addressing the third objective above.

The final stage of the annual Basin-scale evaluation requires an estimation of the overall outcomes across the Basin, and then a judgement of their significance to the objectives of the Basin Plan. This process involves synthesising the evaluations from the Selected Areas and then linking these to the Basin Plan objectives by translating local or site-scale outcomes to the three high level Basin Plan objectives – biodiversity, ecosystem function, and resilience. This analysis is currently reported in the Basin-scale evaluation synthesis reports (e.g. for 2015-16 see Gawne et al. 2017).

4.2.2 FINDINGS

Our review of the progress of the Basin-scale evaluations has been based on: review of Foundation Reports, Basin-Matters Foundations Reports, the 2015-16 Basin Matters and Synthesis Reports, and a selection of Quarterly Reports; and interviews with the MDFRC Director and Basin Matter leads, Selected Area leads and CEWO staff. The evaluation of the progress of the Basin-scale evaluations is presented in Appendix F.

Meeting stated objectives:

In this section we review progress of the Basin-scale component of the LTIM Project in meeting objectives 1, 3 and 4 above.

Objective 1 (*Evaluate the contribution of Commonwealth environmental watering to the objectives of the Basin Environmental Watering Plan*)

This objective is being addressed annually through the six Basin Matters reports and the integrated Synthesis report (Gawne et al. 2017). Our assessment on whether the Basin Matter (and Selected Area) team is on track to achieve this objective by June 2019 is summarised in Table 9, with more detail given in Appendix F.

Table 4: Assessment of progress of each Basin Matter against LTIM Project objectives. Green – evaluation on track to be achieved; Yellow – evaluation has possibility of being achieved but dependent on watering conditions or other constraint; Red – objectives not adequately addressed or evaluation not on track to be achieved.

Basin Matter	1. Contribute to objectives of the MDBA EWP	3. Infer to non-monitored areas	4. Adaptive management
Hydrology	Inundation data limitations		
Ecosystem diversity	Need expected outcomes to be specified		
Stream metabolism and water quality	Water quality; flow constraints for metabolism outcomes; model development		
Vegetation	Model development		
Fish	Model development		
Generic diversity	Some data limitations		

We noted earlier that because the LTIM Project is not monitoring waterbirds it cannot fully address this first objective since the BEWS is focused around four key components of river hydrology and connectivity, fish, vegetation and waterbirds. As discussed further in Section 5.1, aligning the Basin-scale evaluation with BEWS is seen as desirable.

We find that the Basin Matters reports for 2015-16 are somewhat inconsistent in how they address this primary objective. The hydrology report directly addresses the annual watering priorities for the 2015-16 watering year and the specific priorities as stated in the BEWS. Four of the Basin Matter evaluation reports provide a summary section at the end of the report.

In addition there is some inconsistency in how water quality is addressed within the LTIM Project. Water quality is identified in the Logic and Rational document as a Level 1 objective, and a Basin Plan objective in the Outcomes Framework (Table 2, Gawne et al. 2013), yet it is not included as a theme in the Synthesis report. We would recommend that consideration be given to including Water Quality as a theme so as to match the Outcomes Framework and Logic and Rational. This would be captured under the Recommendation 1 – see Section 5.2.5.

The 2015-16 Synthesis report makes a real attempt to integrate and synthesise the Basin-scale information from both the LTIM Project, and to some degree, other sources (e.g. TLM, MDBA fish monitoring, Joint Venture M&E Program, State agency monitoring) (Gawne et al. 2017). We were told that this collation and evaluation of monitoring data from water-related assets that receive Commonwealth environmental water, but are not part of LTIM, has proved to be very difficult because there is no central repository for this monitoring data, and in some cases is not easily accessible. This is particularly evident in the Generic Diversity Basin Matter report, as there is very little data from the northern basin included.

Some of the findings made in regards to the Selected Area evaluations also apply to the Basin-scale evaluation; most notably those relating to a lack of SMART evaluation questions and failure to fully address the evaluation reporting requirements. A further issue for the Basin-scale evaluation reports is a lack of consistency in language used relating to objectives. The different Basin Matter reports variably use *Basin objectives*, *Basin Plan objectives*, *Basin Plan environmental objectives*, *the environmental objectives contained within the Environmental Watering Plan*, *longer term objectives of the Environmental Watering Plan*, and so on. Improved review processes for Basin-evaluation reports should address these issues.

Objective 3 (*Infer ecological outcomes of Commonwealth environmental watering in areas of the Basin that are not monitored*)

We found that little is occurring to address this objective. Inferring ecological outcomes in other areas will largely depend upon the development of the quantitative predictive models. Progress with the model development is a concern and is addressed below and in Section 5.5.1.

Objective 4 (*To support the adaptive management of Commonwealth environmental water*)

Our review of progress in addressing this objective is covered in Section 4.3 below.

The main finding from our review of progress in meeting the Basin-scale objectives is that it seems unlikely that the objectives will be fully met by June 2019. Thus, we suggest that CEWO needs to manage expectations, and modify the existing objectives where necessary to make the outputs more realistic and achievable.

Quantitative Basin-scale modelling:

Three of the Basin Matters team, covering fish, vegetation and metabolism, are contracted to develop and implement quantitative predictive models by June 2019. A high level summary of what these models will look like has been reported in the relevant Foundation Basin Matter reports (Stoffels et al. 2015; Grace 2015; Capon et al. 2015).

A summary of the progress to date with these three models is provided below:

- *Fish model*⁶

The Basin Matters fish team have outlined a comprehensive approach to the development of quantitative models to predict the effects of flow event on fish spawning, recruitment and movement, fish populations and fish community structure at both an area-scale (both within and outside the LTIM Project) and Basin-scale (Stoffels et al. 2015). A timeline for these activities is also provided.

Using the first two years of data (2014-16), models that relate the probability of fish spawning to flow and temperature at both Selected Area-scale and Basin-scale have been reported for Golden Perch, Silver Perch, Murray Cod, Australian Smelt, Bony Herring, and Carp Gudgeon (Stoffels et al. 2017).

However, over the past three years there have been a number factors that have resulted in the fish modelling component being less well advanced than expected. These include: time spent in resolving fish sampling issues; loss of Category I larval fish sampling; issues with data added to MDMS; and some shift in focus to assist Selected Area in modelling the effects of flow and temperature on the movement of Golden Perch and Murray Cod.

In view of the above, we believe it unlikely that the original fish modelling program can be completed by the end of the LTIM Project. Therefore, we recommend that the fish Basin Matters team provide, as part of the Modelling Plan recommended below, a revised plan for the fish models that will be developed and tested by the end of the Project.

- *Vegetation model*⁷

The Basin Matters vegetation team are contracted to develop quantitative model(s) for predicting vegetation responses to environmental water delivery. It is intended that *“The model response variables will include the presence and abundance of selected species (e.g. key representatives of each functional group) and a range of metrics used to characterise vegetation community responses in the aggregated analysis (i.e. species richness, total cover, functional diversity)”* and that Bayesian hierarchical models will be used (Capon et al. 2015).

It is expected that the development of these models will be complicated by the different data collection approaches in different regions; the sampling design program will result in data collected at multiple scales across the Selected Areas. As a result predictor variables will come from sampling unit and point scale (e.g. soil characteristics, distance from stream channel), as well as the reach/zone and Selected Area scale (e.g. recent and long term hydrology). These constraints will require tailored statistical models to be developed, to ensure the estimated eco-hydrological relationships are robust and transferable to areas beyond the monitoring locations. We were told that the models to be developed should have the capacity to account for relationships between response variables and predictor variables at the finest unit of observation at each Selected Area (e.g. quadrat or transect), and that these relationships should be able to be scaled up to levels that are useful for management

⁶ R. Stoffels, personal communication, January 2018.

⁷ B. Stewart-Koster, personal communication, February 2018.

decision making (e.g. river reaches, sub-catchments or even catchments). A hierarchical approach to modelling will facilitate the development of cross-scale models, while the Bayesian approach provides a framework to predict outside the sampling domain while accounting for predictive uncertainty.

However, it appears that this model development has not yet commenced, and that there is no timeline for completion, meaning that there must be concern that the original vegetation modelling program can be completed by the end of the LTIM Project. Therefore, we recommend that the vegetation modelling team provide, as part of the Modelling Plan recommended below, a revised plan for the vegetation models that will be developed and tested by the end of the Project.

- *Metabolism model*⁸

The Basin Matters metabolism team are contracted to develop a reach-scale model for estimating primary production and ecosystem respiration as a function of flow. A statistical model (BASE – Bayesian Stream Metabolism Estimation) has already been developed for this purpose (Grace 2015).

In the latter part of 2017, the current BASE metabolism model was independently validated (by Dr Jim Thomson, ARI) and its implementation simplified. The updated model and user notes are expected to be available to Selected Area teams by the end of February 2018. Presumably this will also address the concern expressed by a number of the Selected Area teams regarding the overly conservative acceptance criteria for data fit to the BASE model.

The metabolism team is currently developing a new metabolism metric – the amount of organic carbon created (by photosynthesis) or consumed per river km per day. From this it should be possible to estimate the amount of potential food created at the base of the food web, which in turn may also be related to fish carrying capacity (and potentially whether the native fish populations are resource limited or not). This will require an estimate of the cross-sectional area as a function of flow for each logger site, which is currently being provided by the hydrology Basin Matters team.

It seems progress towards the development of reach-scale metabolism models that relate flow to various stream metabolic indicators (and perhaps also organic carbon produced and consumed) is on target to provide useful outputs by the end of the LTIM Project. However, we have no information on what is planned or indeed feasible regarding area-scale, catchment-scale or Basin-scale metabolism models.

We recommend that the metabolism Basin Matters team provide, as part of the Modelling Plan recommended below, a detailed plan for the metabolism models that will be developed and tested by the end of the Project, including a timeline with milestones.

This review has found that while some discussions have occurred regarding predictive model development, there is little evidence that much progress has been made to date (February 2018). Thus, there is concern regarding the capacity of these teams to develop, test and implement these quantitative models in the 18 months before LTIM is completed.

We have recommended in Section 5.5.1 that the Director MDFRC and the relevant Basin Matters team members urgently develop a Modelling Plan (see also Recommendation 11). This should contain: the types of models that will be developed; the scale (area, catchment, Basin) the model(s) will focus on; what data will be used to populate the models; what the model outputs will be; who will develop the models; how they will be tested; how uncertainty will be handled; and a timeline for their development (with milestones).

It may be that additional funds need to be found to resource the development of the Modelling Plan and the subsequent model development and testing. We urge CEWO to make every attempt to find these funds if they are needed, because these models will play a vital role in predicting the area-scale ecological outcomes of different watering regimes, and the ecological outcomes in non-monitored assets.

Monitoring Data Management System:

The data collected by Selected Areas monitoring is used to evaluate local outcomes from watering and also to contribute to the analysis and evaluation of Basin-scale objectives.

All Selected Area teams have a contractual obligation to upload their data onto the MDMS. However, rather than entering data directly into MDMS, the teams use their own data management systems and export a copy

⁸ M. Grace, personal communication, February 2018.

in the required formats to the MDMS (see also below). There is some disquiet within the Selected Area teams regarding the difficulties in using the MDMS.

The MDMS is the main source of data for the Basin Matters team evaluations, and is also the long-term archive of data for the CEWO. The MDMS aggregates the seven Selected Area data sets into a single data set for each indicator (Category I or Category III data is entered in a standard format) for Basin-scale evaluation, which is a very useful function. However, it is not clear to us how much the Selected Area teams use the MDMS for their reporting rather than using their own data management systems.

Even if the Selected Area teams do not use the MDMS in generating their evaluation reports, the fact they are required to add their data to this system has advantage in that the automatic QA/QC function is able to highlight data issues (some but not all) so they can be corrected before the Basin Matter teams even see the data. However, we were not able to assess whether this data checking function assisted the Selected Area teams since we suspect the Selected Area teams using their own data management systems and not the MDMS.

We were told⁹ that the current system is flexible enough to keep inputting data for future iterations of LTIM, and that in the future other researches (outside LTIM) are also expected to have access to the data, which will add to its usefulness.

However, we have been made aware of some issues with the current MDMS, including:

- The interface is outdated, overly complex, not user friendly, and only works on a PC and not on a Mac. In practice only one person per Selected Area team has learned how to operate the system, with most people finding it a chore to use. For the Basin Matters team, Shane Brooks acts as the data manager and extracts data and passes it onto the relevant team member;
- As noted above, the Selected Area teams use their own data management systems and export a copy in the required formats to the MDMS, which makes QA/QC checking challenging. We understand that finding and fixing errors in the exported data sets is currently quite time consuming. The database has the technical ability to do this checking, with controls slowly being tightening up. The expectation is that the QA/QC checking will be more effective and less onerous in the near future;
- As the number of data sets increases, extracting these large data sets will be challenging as apparently it has been in 2017. We understand that the software provider is currently working on an improved 'data extraction tool', which should help.

We have been told¹⁰ that in terms of risks and cost/time blowouts for the Basin Matter reporting, these MDMS and QA/QC issues continue to have a major impact, entailing literally weeks to months in delays each year before the Basin Matters team can commence their actual evaluations. While some of the issues with the MDMS are software (or IT) related the main problem appears to be problems associated with the input of data from the Selected Area teams to the MDMS (people problems). It seems that stronger data governance is required, perhaps by the CEWO developing more robust QA/QC procedures that include a data manager to ensure compliance.

We have recommended that resolution of this issue should be one of the first tasks of the new Project Steering Committee.

Collaboration:

Collaboration between the Selected Area and Basin Matters teams has been poor, but is improving. We have been told of a number of recent changes that have been instituted to improve the situation, including: the Selected Area teams now have an opportunity to comment on drafts of the Basin Matters annual reports; the Basin Matters team have an opportunity to comment on drafts of the Selected Area annual reports; and the two groups are able to get together at the Annual Forum. The CEWO have made additional funds available to assist various collaborative activities to occur (see above).

However, despite the changes outlined above, we believe there is still inadequate collaboration. We suggest there would be value in changes that would permit the Selected Area team members to work with the relevant Basin Matters team member from the early stages of the Basin Matters annual reports, and where appropriate be recognised as joint authors. This change would improve collaboration and also likely lead to higher quality reports.

⁹ S Brooks, Personal Communication, 19 January 2018

¹⁰ Prof Nick Bond, MDFRC, Personal communication, 1 March 2018

We have also sought to assess the adequacy and effectiveness of the collaboration between Basin Matters team members. The evidence we have gathered suggests that interaction is minimal, largely due to budget constraints. We are aware that the Basin Matters team recently had a two-day meeting in Melbourne (December 2018) to discuss collaboration and the production of the 2016-17 Basin Matters and Synthesis Reports. A further Basin Matters team meeting is to be held in May or June 2018.

Our finding is that collaboration within the Basin Matters team has significantly improved over the past 6 months, that the Basin Matters team members are all very committed to LTIM, and that collaboration opportunities have been limited because of a lack of funds. The CEWO should determine if this additional funding to the Basin Matters team is required to increase the opportunities for collaboration.

Reporting:

There appears to be a lack of clarity as to the audience for these annual Basin Matter reports. Presumably, they contribute to the annual reports the CEWO provide to the MDBA addressing their requirements under the Basin Plan (Note: we have not seen any of these reports or discussed with the MDBA their assessment of the quality of the reports). The audience (or audiences) for these Basin Matters reports and the Synthesis report needs to be better articulated. Improvements would include short (10 page) easy to read summaries of each of the Basin Matters reports that would be suitable for publication on the CEWO and MDFRC web sites. The MDFRC should consider engaging a science communicator to assist with this process. This is further covered in Section 5.7 below.

Review:

We are aware that CEWO staff comment on the draft annual Basin Matters reports, but we are not aware that any independent science review of these reports occurs. We believe there would be advantage if this occurred (see Sections 5.5 and 5.9 below).

4.3 ADAPTIVE MANAGEMENT

4.3.1 GENERAL

The fourth LTIM objective is *'to support the adaptive management of Commonwealth environmental water'*. Arguably, the most important part of the LTIM Project leading to adaption of the management of Commonwealth environmental water has been the very close working relationships established between the seven Selected Area teams and the three CEWO Delivery Teams. We have outlined above how this is working very well.

The three CEWO Water Delivery Teams (Northern Basin, Central Basin and Southern Basin) all told us that their close interaction with the relevant Selected Area teams was providing practical scientific information and advice on the relationships between various flow components and possible ecological outcomes in a timely manner (and mostly well ahead of formal reporting). This had resulted in improved decision-making regarding particular environmental watering events.

Webb et al. (2017) identified two particular advantages in the management of environmental water that flow from these science-manager partnerships. *'First, researchers have better access to ongoing and up-to-date information on forecasted flows from the water and catchment management authorities to target sampling periods. Second, practitioners see field verification of management intentions.'*

It should be noted that there are two aspects of adaptive management within the LTIM project. The first, improving environmental water management has been covered above. The other is the adaption that has occurred with the management of the LTIM Project, and this has been significant and most impressive. We have discussed earlier the transformation from a very 'top down', perhaps 'command and control', Project at the start, to a more collaborative Project. This has not occurred without some angst and with considerable adaption by all parties. We believe there would be considerable advantage if this journey was written up and published so that the legacy is not lost.

4.3.2 FINDINGS

Capture of the relevant learning's

Information relating to the relevant learning's that are contributing to adaptive management of the Commonwealth's environmental watering is being reported at three levels:

- The individual Selected Area teams are required to provide a section in their annual evaluation report and Quarterly reports where relevant adaptive management information has been generated and recorded;
- The CEWO process – annual water planning process, portfolio management plans, and acquittal reports;
- The annual Basin Matters Synthesis Report also attempts to synthesize information from the Selected Area annual reports. The 2015-16 Synthesis Report (Gawne et al. 2017, Section 4) captures many of the science learning's related to flow-biota relationships, namely: the way timing of water delivery affects the outcomes for biota; the importance of rate of fall for vegetation; the variation in the spawning response of flow-cued spawners (e.g. golden perch) to freshes; and the importance of variable water regimes in maintaining (and restoring) biodiversity (vegetation, waterbirds) at both wetland and landscape scales.

Our review found that while there is considerable attention on the generation and use of adaptive management learning's each year by the Selected Area and Basin Matters teams, this could be done more systematically. We have identified two changes that could improve the situation:

- First, the many informal and formal discussions that lead to changes in water delivery need to be captured and added to an accessible and searchable archive system so they are not lost and can be called upon at a later time by multiple users; and
- Second, there appears to be no report that consolidates these learning at an appropriate scale, nor is the way this increased knowledge is changing the way in which the CEWO delivery teams are delivering environmental water being adequately captured, although this may in part be captured in acquittal reporting.

We suggest that the adaptive management outcomes are central to showcasing the long-term success of the LTIM Project. Therefore, a mechanism by which the learning's are accessible to managers and the public is needed (see Sections 5.7 and 5.8 for more discussion).

5 POSSIBLE MODIFICATIONS TO THE PROJECT

Before addressing some possible modifications aimed at improving the LTIM Project, we believe it important to reiterate our earlier conclusion that this Project is world-leading in its scope, both spatially (the entire Murray-Darling Basin) and temporally (5 years), objectives and budget (over \$30 million over 5 years). It is a highly ambitious project that it is seeking to achieve an outcome – assessment of the effectiveness of Commonwealth environmental water delivery in achieving local and Basin-scale ecological outcomes – that has never been attempted before anywhere in the world.

5.1 PROGRAM STRUCTURE

The LTIM Project structure is sound and does not need to be fundamentally changed. There are, however, a number of modifications that could be made over the next few months and in future iterations that would strengthen the Project.

First, the LTIM objectives and key evaluation questions need to be reviewed. The LTIM Outcome Framework (CEWO 2013) was developed prior to the completion of the BEWS and as such there is a misalignment between the four Basin Matters in the BEWS (hydrology and connectivity, fish, vegetation and waterbirds) and the Basin Matters monitored under LTIM, in that waterbirds are not monitored as part of the LTIM Project. Additionally, the watering objectives underpinning the watering actions are in general not SMART.

Second, while collaboration between the Selected Area teams and the Basin Matters team has improved, more still needs to be done in the final two years of the Project to cement this necessary collaborative approach. We have recommended that consideration be given to the establishment of a *Project Steering Committee* to assist with improving Project coordination and collaboration (see Section 5.3 below).

Third, we noted above our surprise that there was no single manager of this LTIM Project, with the management largely with the CEWO Aquatic Ecosystems & Science Section, but also involving the three CEWO Delivery Teams. While this aspect is not part of our terms of reference, we urge CEWO to review whether this is the most efficient and effective way to run this very important and complex project, and whether there is a need for an identifiable single Program Manager and a Science Manager.

Fourth, the LTIM Project lacks a clearly defined Program Evaluation Strategy as part of its MERI process to assist in assessing the efficiency, effectiveness, relevance and sustainability of the Project. The CEWO should urgently develop such a strategy and could consider using the evaluation strategy being used by the Murray-Darling Basin Environmental Water Knowledge and Research (MDB EWKR) project (Hodge et al. 2015) as a guide.

5.2 LTIM OBJECTIVES

This Section covers the need to review the current expectation from the Basin-scale evaluations, assessment of the contribution of the CEW, and the updating (or setting) of objectives for multi-scale watering events and key ecosystem types.

5.2.1 EXPECTATIONS FROM THE BASIN-SCALE EVALUATION

The expectations for this Project were set in 2013-14. There has now been three years of Project implementation, during which time many issues (some quite unexpected) have emerged and solutions had to be found at both the Selected Area and Basin-scale. This is not unexpected given the scope and experimental nature of this LTIM Project.

However, the time taken to find solutions to these quite difficult issues has meant that some of the more long-term objectives have had less attention than was originally envisaged. Consequently, some of the initial expectations of the Basin-scale evaluation are unlikely to be met. These include: the Basin-scale quantitative models; and the inferring of the outcomes of CEW in areas not monitored as part of the LTIM Project.

We have recommended that the Basin-scale evaluation questions are reviewed for their relevance and feasibility, and modified if need to ensure the expectations of this Project can be adequately met by June 2019 (**Recommendation 1**). A review of how water quality is treated in the Basin-scale evaluation should be included in this process.

5.2.2 ASSESSMENT OF THE CONTRIBUTION OF COMMONWEALTH ENVIRONMENTAL WATER

We note that many of the key evaluation questions being addressed at both the Area-scale and Basin-scale are focused on the contribution of the *Commonwealth environmental water* to key ecological outcomes such as fish breeding, wetland vegetation community diversity and ecosystem diversity.

We were told that this particular Commonwealth focus, while understandable, has caused some problems with the reporting of ecological outcomes as a result of environmental watering events where the Commonwealth's contribution may be only part, and sometimes a quite small part, of the total environmental water delivered.

This difficulty has been largely addressed by the CEWO who have broadened the interpretation to focus on assessing the outcomes for all environmental water, and where possible assess the contribution of Commonwealth's water, as documented below¹¹:

What does 'with and without Commonwealth environmental water' mean for evaluation purposes?

The issue of what 'with/without CEW' means for LTIM evaluation purposes has come up, and specifically what the contract means when it says that Providers must: 'quantify to the fullest extent possible the marginal benefit of Commonwealth environmental water and other held environmental water delivered in conjunction with Commonwealth environmental water' (Schedule 3, Clause 4).

The overarching purpose of the LTIM Project is to monitor and evaluate the contribution of Commonwealth environmental water to Basin Plan environmental objectives. Nonetheless, the reality is that CEW is often only part of the picture, and delivered in conjunction with other held or planned environmental water or on the back of natural flows for example.

*The question of when Providers should try and separate the relative contribution of CEW to the overall outcome of a watering action with multiple water sources will invariably depend on **what the management objective is**.*

¹¹ Personal communication, Sam Roseby, CEWO, 23 January 2018

In situations where multiple water sources are delivered, it may be appropriate to separate the relative contribution of CEW to the overall outcome. A hypothetical example may include where CEW is being delivered following a State watering or natural event to extend the duration of wetland inundation in support of water bird breeding. The CEW component has a specific objective here that can be separated from the overall outcome – to extend the duration of inundation for a certain period of time/water level/recession rate etc so that the waterbirds can successfully finish their breeding activity. Understanding exactly what CEW is contributing to a hydrograph may also be important when mapping biotic samples to flows from upstream tributaries.

Conversely, it may be inappropriate to separate the relative contribution of CEW to the overall outcome of a watering action with multiple water sources. In those circumstances, CEW is only part of the picture, and we monitor and evaluate the effects of environmental watering as a whole - given that the action design (and thus expected outcomes or watering objective) would likely have been different, had the additional non-Commonwealth water not been available. An example may include where TLM, VEWH and CEW is being delivered in conjunction to achieve a fresh which a distinct hydrograph shape to trigger golden perch spawning. Under such circumstances, Providers should be looking to assess the outcome of the watering action as a whole - recognising as important context the multiple sources and volumes of water that contributed to it.

5.2.3 IMPROVE THE EXPECTED OUTCOMES FOR LARGE MULTIPLE-SCALE WATERING ACTIONS

The 2015-16 Synthesis Report (Gawne et al. 2017) noted that the CEWO is increasingly moving toward coordinated large-scale watering actions that influence multiple assets and rivers, and that it is important for the monitoring and evaluation process to be modified to ensure the adaptive management can be undertaken at this larger scale.

The delivery of environmental water to local assets is complex enough without the need to determine (and deliver) ecological outcomes at multiple scales. Currently, the communication of the expected outcomes from the multiple-scale watering actions is imperfect so that the full range of expected outcomes that have guided the multiple-scale environmental water delivery may not be clear to monitoring teams. This can reduce the effectiveness of evaluation and limit the ability of the LTIM Project teams to provide advice on adaptive management of environmental water. Accordingly, we have recommended that this issue be addressed (**Recommendation 2**).

5.2.4 EXPECTED OUTCOMES FOR KEY ECOSYSTEM TYPES (ECOSYSTEM DIVERSITY)

The 2015-16 Synthesis Report (Gawne et al. 2017) also noted that the increased focus on multi-scale watering actions has implications for the ecological scale of expected outcomes; that is there is a need to consider ecosystems in addition to species and populations.

It has been argued that there is a need to better understanding how key ecosystem types influence Basin biodiversity, resilience, ecosystem function and ecosystem services. Delivering Commonwealth environmental water for ecosystem objectives will require that the LTIM Project move beyond counting the ecosystem types watered or whether some types have had watering targets met. There will be a need, for example, to ‘shape’ flow regimes so that patterns of spatio-temporal variability along a river are preserved, or perhaps to deliver water at critical times to maintain life forms or ecosystem processes.

The CEWO currently does not have documented 1-year or 5-year expected outcomes for ecosystem diversity¹² and needs to develop these (**Recommendation 3**). CEWO delivery teams often plan to link ecosystem types to water availability scenarios, such as directing water to maintain permanent water systems in dry years, or augmenting overbank flows to the floodplain in wet years, but these actions rarely have explicit ecosystem outcomes.

5.2.5 RECOMMENDATIONS

Recommendation 1: *that the Basin-scale evaluation questions are reviewed to assess whether they are all still relevant, and the likelihood that they will be adequately addressed by June 2019. In light of this review to*

¹² Note that several of the Selected Area teams have key evaluation questions regarding ecosystem diversity in their MEP.

the CEWO should make any modifications that would update the expectations of the Basin-scale evaluations.

Recommendation 2: *that for multiple-scale watering actions, CEWO ensure the full range of expected ecological outcomes are determined and communicated to the appropriate LTIM Project teams.*

Recommendation 3: *that the CEWO develop expected outcomes for the ecosystem diversity Basin Matter.*

5.3 PROJECT MANAGEMENT

This review has identified the need for a more structured and collaborative approach to the running of the LTIM Project. To this end we recommend that the CEWO consider three modifications to the Project.

5.3.1 PROJECT STEERING COMMITTEE

The CEWO should consider the establishment of a Project Steering Committee composed of: the CEWO Project Management team; the CEWO Delivery Team leads; the MDFRC Director; and the Selected-Area team lead. The CEWO Project Manager and the MDFRC Director would jointly chair the Steering Committee. CEWO should also consider whether the MDBA should also be invited to join this Committee. We suggest the Steering Committee meet two monthly, with two meetings per year face-to-face and the others via Skype or video link.

5.3.2 MANAGEMENT OF THE PROJECT

We noted above our surprise that there was no single program manager of this LTIM Project, with program management spread between four CEWO groups. While this aspect is not part of our terms of reference, we urge CEWO to review whether this is the most efficient and effective way to run this very important and complex project.

Additionally, we have raised the possibility that a project *Science Leader* be identified and recognised. This we believe would be of value to the Project for two reasons: first, it would highlight the fact that this is an innovative science-based project, and second, it would provide leadership to ensure that the science underpinning this Project is of the highest quality.

5.3.3 PROGRAM EVALUATION STRATEGY

The LTIM Project lacks a clearly defined Program Evaluation Strategy as part of its MERI process. Evaluation, in this sense, is defined as a systematic and objective assessment of an ongoing or completed project, program or policy, from its design and implementation through to results. The aim is to assess the efficiency and effectiveness in achieving the stated objectives and intended outcomes/results. Evaluations also assess the relevance and sustainability of outputs in terms of their contribution to short, medium and long-term outcomes. Evaluation provides the basis for adaptive management, via distillation of lessons learnt and from sharing of knowledge.

Ideally, such an Evaluation Strategy would have been developed prior to this MTRE; however it is recommended that such a strategy be urgently developed to enable the scope of the end of LTIM Phase 1 evaluation to be defined prior to the completion of the project.

Recommendation 4: *that a LTIM Project Steering Committee be established, consisting of the CEWO, CEWO Delivery Teams, Selected Area team leads and the MDFRC Director. CEWO should also consider whether the MDBA should also be invited to join this Committee.*

Recommendation 5: *that the CEWO review the management of the LTIM Project with a view to identifying a single Program Manager and a Science Leader.*

Recommendation 6: *that the CEWO urgently develop an Evaluation Strategy for the LTIM Project.*

5.4 AREA-SCALE EVALUATION

This review has found the Selected Area projects are generally being run effectively (see Section 4.1). However, we have identified four areas where there could be improvements:

- Meeting the stated objectives – there is a need for Selected Area teams to focus more attention in their evaluation reports on: first, addressing all the key evaluation questions listed in the MEP (and these need to be better stated so they are at least achievable and measurable); second, assessing the ecological outcomes of each local-area watering action and also how these meet the objectives of the Basin Environmental Watering Plan, third, to scaling up the Area-scale assessment and evaluations to the entire Selected Area; and fourth, providing a cumulative evaluation of the data.
- Interactions and collaboration – interactions between the Selected Area teams and between the Selected Area teams and the CEWO Delivery Teams, stakeholder groups are very good. Collaboration between the Selected Area teams and the Basin Matters teams is improving, but still requires attention.
- Reporting – the current Selected Area annual reports are overly detailed and not written in a way that addresses the intent in the contracts. We have made recommendations aimed at improving these reports.
- Review – there is no documented process for reviewing the Selected Area projects or their annual reports. From later 2017 we understand that the Basin Matter team will take a larger role in reviewing these reports, which is welcome. However, more is needed and we have recommended that a more detailed independent review be undertaken.

Recommendation 7: *that the Selected Area teams focus more attention in their annual reports on: addressing the key evaluation questions; the ecological outcomes of each local-area watering action, and scaling up the Area-scale assessment and evaluations to the entire Selected Area.*

Recommendation 8: *that consideration be given to requiring the Selected Area teams to produce two reports annually: first, a relatively short general report suitable for water managers and other stakeholders; and second, a detailed science report containing the information currently in the Appendices.*

Recommendation 9: *that the CEWO consider having a detailed independent peer review undertaken during 2018 of the quality of the science being reported by the Selected Area teams, with the focus being on the initial MEP, and the 2016-17 annual evaluation reports.*

5.5 BASIN-SCALE EVALUATION

This review has identified four areas where more effort is needed to ensure the stated LTIM Project outcomes are achieved: better definition of what is meant by ‘basin-scale evaluation’; the development and use of the quantitative models; upgrading the Monitoring Data Management System; more detailed hydrological information; and improved inundation mapping.

5.5.1 MEANING OF ‘BASIN-SCALE EVALUATION’

There is no consistent agreement of what constitutes a ‘Basin-scale evaluation’ or an ‘integrated Basin-scale evaluation’. Three types of analysis were identified in the initial LTIM Basin Evaluation Plan (Gawne et al. 2014): aggregative analysis; qualitative analysis; and quantitative analysis. Conceptually, the idea is to synthesize ‘*observed outcomes (at the Selected Area or local scale) in order to evaluate their contribution to achieving Basin Plan objectives at a larger spatial or longer temporal scale*’ (Gawne et al. 2014, p6). However, currently there is a lack of detail on how this aggregation or integration will be undertaken.

In fact, it is difficult to see how a single assessment of the Basin as a very large and complex system could be undertaken. More sensibly, a Basin-scale evaluation will be made up of the aggregation of subsets of the Basin; these may be large sub-regions (e.g. northern and southern Basins) or catchments. But even the integration of the components making up a catchment is not a simple matter.

We recommend that a process be established to better define this term and what it actually means to undertake a ‘Basin-scale evaluation’. This is also of relevance to the MDBA who have commenced with addressing Basin-scale evaluation in their recent 2017 Basin Plan Evaluation Reports¹³. The process we

¹³ <https://www.mdba.gov.au/publications/mdba-reports/2017-basin-plan-evaluation-reports>

suggested would involve: first, the preparation of a discussion paper; and second, the running of a workshop of key researchers and managers to provide a sensible outcome (**Recommendation 10**).

5.5.2 DEVELOPMENT OF QUANTITATIVE MODELS

We have documented above (Section 4.2.2) our concern regarding the capacity of the Basin Matters team to develop, test and implement quantitative models for fish, vegetation and metabolism in the 18 months to the LTIM Project's completion.

We believe there is an urgent need for a comprehensive *modelling development plan* to be developed to better define: the types of models that will be developed; what data will be used to populate the models; what the model outputs will be; who will develop the models; how they will be tested; how uncertainty will be handled; and a timeline for their development (with milestones).

We have recommended that this plan should be developed by the MDFRC (and perhaps approved by the recommended new Project Steering Committee), and needs to be done within the next few months (**Recommendation 11**). Additional funds or reallocation of existing funds may be required to ensure the development of this Plan, and the subsequent development and testing of the models, is achieved.

5.5.3 MONITORING DATA MANAGEMENT SYSTEM

MDMS and QA/QC issues continue to have a major impact, entailing literally weeks to months in delays each year before the Basin Matters team can commence their actual evaluations. We have recommended that resolution of this issue be one of the first tasks of the new Steering Committee (**Recommendation 12**).

5.5.4 MORE DETAILED HYDROLOGICAL INFORMATION

The 2015-16 Synthesis Report (Gawne et al. 2017) noted that the availability of hydrological information relating to watering actions is highly variable and is limiting the assessments of hydrological outcomes and ecological responses.

This is particularly serious when attempting to predict responses to environmental watering at places (assets) that are not monitored. The hydrological information on the key aspects of the water regime that are important to target biota, include: depth and duration of inundation, and rates of rise and fall at both sites where monitoring data are collected and unmonitored sites. We have recommended that this issue be urgently addressed (**Recommendation 13**).

5.5.5 IMPROVE INUNDATION MAPPING

The 2015-16 Synthesis Report (Gawne et al. 2017) and the Joint Venture (JVSC 2017) have noted that the ability to evaluate the contribution of Commonwealth environmental water to achieving objectives of the Basin Plan is currently limited by high uncertainty in the fate of water in the landscape after it is released. The volumes in storage and the rates and timing of delivery are well known, but the physical extent of water covering the land and the duration it persists in wetlands and on floodplains is much more poorly understood.

The initial planning for Basin evaluation was contingent on good floodplain inundation data both with and without Commonwealth environmental water being available (Gawne et al. 2014). The lack of good inundation mapping is limiting the Basin-scale evaluations for several Basin Matters (e.g. Ecosystem Diversity, Vegetation Diversity, Generic Diversity).

The Joint Venture Monitoring & Evaluation Program members held a workshop in June 2017 to discuss the need for reliable and accessible inundation mapping in the Basin (JVSC 2017). The workshop focused on inundation maps derived from remotely sensed Landsat satellite observations because they can be used to monitor inundation extents in near-real time. Similarly, the long-term archive means a time series of inundation maps can be used to manage flow regimes, develop inundation models as well as to validate inundation model outputs.

The inundation mapping workshop concluded that there is a compelling need for reliable and accessible Basin-wide inundation mapping, and that the most significant benefit would be to increase the efficacy of jurisdictional monitoring, evaluation and reporting obligations. The Workshop also recommended further

investment to meet the identified need for Basin-wide accessible and reliable inundation mapping. We have recommended that this issue be urgently addressed (**Recommendation 13**).

Recommendation 10: *that the CEWO organise a process to clarify the scope and consistency of basin-scale evaluations, the process consisting of the preparation of a discussion paper, followed by a workshop with key researchers and managers to provide a sensible outcome.*

Recommendation 11: *that the MDFRC develop a comprehensive project modelling plan as a matter of urgency, and that this Plan be agreed to by the proposed Project Steering Committee. Additional funds or reallocation of existing funds may be required to ensure the development of the Plan, and the subsequent development and testing of the models, is achieved.*

Recommendation 12: *that the new Project Steering Committee be tasked with resolving the continuing issues associated data QA/QC and the MDMS.*

Recommendation 13: *that the need for improved hydrological data and information, and inundation mapping be urgently addressed.*

5.6 COLLABORATION

We have identified a need to continue to support moves to improve collaboration between the Selected Area teams, and between the Selected Area teams and the Basin Matters team. The improvements that have occurred over the past three years have not been lead centrally, but have emerged largely through individual actions by Selected Area team members.

There is a need to provide a more formal collaboration component to the LTIM Project's structure for the remainder of the Project. One mechanism that would achieve this more collaborative approach would be to establish a *Project Steering Committee* (**Recommendation 4**). We also recommend that one of the first tasks for the Steering Committee should be to formally evaluate the benefits of this improved collaboration between the Selected Area and Basin Matters teams.

Recommendation 14: *that the proposed Project Steering Committee formally evaluate the benefits of this improved collaboration between the Selected Area and Basin Matters teams as one of its first tasks.*

5.7 REPORTING AND COMMUNICATION

Effective reporting is a key product of the LTIM Project, but currently there is a lack of a strategy that outlines the objective(s), audience(s) and types of reports, fact sheets and web products to be produced annually.

Our review of the Selected Area annual reports (Section 4.1.1) found that there would be value in modifying the structure of the current reporting guidelines. In particular, the main body of the reports, aimed at water managers and interested non-technical audiences, are generally too long and overly complicated. The CEWO should consider requiring the Selected Area teams to produce two reports annually: first, a relatively short *general report* suitable for water managers and other stakeholders; and second, a detailed *science report* containing the information currently in the appendices, together with a synthesis of the scientific ecological outcomes for the Selected Area (and beyond if possible) (**Recommendations 7 and 8**).

Additionally, a strong theme in the interviews was the need for improved communication in a number of key areas of the LTIM Project. We suggest that the engagement of an effective science communicator(s) to assist the Selected Area teams in the writing of their general reports would result in positive improvements in the reporting.

The Basin Matters and Synthesis reports need to be reviewed with a view to making them more accessible to a wider audience (**Recommendation 15**). A particular problem for the Synthesis reporting is the difficulty in accessing relevant data and information from other non-LTIM monitoring programs. This additional data is held by the MDBA, The Living Murray (TLM) monitoring and the state agencies. There is an urgent need to consolidate this data into a central location (**Recommendation 16**).

We have also recommended that the CEWO or MDFRC (or both) engage an effective science communicator(s) for two reasons: first, to assist the Selected Area and Basin Matters teams in producing reports that are more

readable for the target audience, and second, to assist CEWO in producing better information products related to the LTIM Project (**Recommendation 17**).

Recommendation 15: *that a review of the annual Basin Matters and Synthesis reports be undertaken, with a view to restructuring them to make them more accessible to a wider audience.*

Recommendation 16: *that a common database be established to hold all relevant data relating to environmental water monitoring in the Murray-Darling Basin; this will require cooperation between CEWO, MDBA and state agencies to achieve.*

Recommendation 17: *that an effective science communicator(s) be engaged by CEWO or MDFRC to assist the Selected Area and Basin Matters teams to make their various reports more readable, and to assist CEWO to produce more structured and targeted information products related to the LTIM Project.*

5.8 CAPTURE OF ADAPTIVE MANAGEMENT INFORMATION

This review found (Section 4.3) that there are some excellent interactions between the Selected Area and CEWO Delivery teams. These are resulting in a considerable number of learning's that are being translated into better management of the Commonwealth's environmental water.

However, we also identified that the capture of these adaptive management learning's could be improved, particularly if it was done more systematically. Two improvements were identified: first, better documentation of the many informal and formal discussions that lead to changes in water delivery, with this information recorded in an accessible and searchable database; and second, the production of an annual report that captures and synthesis the way this increased knowledge is changing the way in which the CEWO Delivery Teams are delivering environmental water.

Recommendation 18: *that the capture of adaptive management learning's be improved and done more systematically, in particular with the development of a accessible and searchable database to contain the learning's, and the production of an annual report that synthesises how this increased knowledge is changing the way in which environmental water is being delivered.*

5.9 INDEPENDENT SCIENCE REVIEW COMMITTEE

We have identified a significant lack of independent peer review of the LTIM Project science. There is some internal review occurring within the Selected Area teams and (recently) between the Basin Matters and the Selected Area teams. The recommended Project Steering Committee will assist in strengthening these internal review processes.

However, there is still need for overall independent peer review of the science. CEWO have commenced a independent review process with this current mid-term review and evaluation process.

The next critical point will be to review the LTIM Program or close to at its completion. CEWO should establish an *Independent Science Review Committee* to review the quality and relevance of the science (Selected Area and Basin Matters) and other aspects of the Project in year 5, and to make recommendations of modifications to the Project relevant to LTIM Phase 2.

Recommendation 19: *that an Independent Science Review Committee be established to review the quality and relevance of the science being developed by the Selected Area teams and the Basin Matters team.*

6 SOME CONSIDERATIONS FOR LTIM PHASE 2

6.1 EVALUATION LTIM PROJECT PHASE 1

An independent reviewer (or review team) should be contracted to undertake an end-of-Project evaluation of LTIM Project Phase 1. This will not be a fast process and may take several months. CEWO will also need to give consideration to having an interim plan for the 2019-2020 watering year to ensure monitoring data continues to be captured. This may require a 12-month extension for some elements of LTIM Phase 1.

6.2 UPDATE PROGRAM LOGIC AND STRUCTURE FOR LTIM PHASE 2

The LTIM Phase 1 evaluation should also provide comment on the possible structure, governance, logic and rationale of LTIM Phase 2. Our review has identified four key issues that will need to be addressed in settling the form of LTIM Phase 2

The first issue will be to review the overall objectives of the Project so that they are more closely aligned with the updated BEWS (to be done in 2019) and also with major programs such as the MDB EWKR. Additionally, there is a need to better manage expectations about what can (and cannot) be achieved with Commonwealth environmental water. For example, in many catchment it is not possible to use environmental water to reconnect floodplains either because of a lack of water to achieve the high flows needed, or of policy or political constraint on over-bank flows.

The second issue will be to review the advantages and disadvantages of the current structure with separate Area-scale and Basin-scale evaluations. Our view is that the current structure is perhaps overly emphasising the area-scale projects over the Basin-scale evaluations. This may have occurred as a result of the Project governance, where with the Selected Area teams are contracted to and managed by the Water Delivery Teams, who have a largely site or local focus. However, it should be remembered that the main reason LTIM was established was to address the CEWO's requirements under the Basin Plan, and these are Basin-scale.

The third issue will be to map the monitoring efforts being undertaken by the MDBA and the Basin states to look for sources of complementary data, identify knowledge gaps and to help prioritise selection of areas and indicators to be included in LTIM 2. Monitoring of the Long Term Watering Plans will come on line post 2019, and should greatly increase the potential data sources.

The fourth issue will be to achieve better alignment between LTIM 2 and other environmental watering monitoring programs, particularly those being undertaken by MDBA and the state agencies.

There are also two other concepts that those planning LTIM Phase 2 might consider:

- *Emerging new concepts in flow restoration* – Thomson et al. (2017) have reviewed recent papers on responses to flow restoration in the Murray–Darling Basin and complemented this with inferences from the global literature. They found that ecological responses to flow restoration are often inconsistent, site and taxon specific and difficult to detect. They have proposed a conceptual model for understanding responses to flow restoration that incorporates key factors influencing the size of ecological responses to restoration, including: existing ecological condition, legacy impacts of past change, interactions with other variables, life-history traits of taxa and broad-scale and long-term trends due to climate or land-use change.
- *Assessment of rivers as social-ecological systems* – Parsons and Thoms (2017) and Parsons et al. (2016) have suggested that the assessment of river health in Australia should go beyond the current bioassessment, and monitoring the resilience of rivers as social-ecological systems.

7 SUMMARY OF RECOMMENDATIONS AND MANAGEMENT RESPONSE REQUIRED

A summary of the recommendations arising from our review are presented in Table 5 along with some suggested responses and timeframe in which action is required.

Table 5. Summary of recommendations and suggested management response/actions and timing

Recommendation	Suggested management response/action	Timing
1. That the Basin-scale evaluation questions are reviewed to assess whether they are all still relevant, and the likelihood that they will be adequately addressed by June 2019. In light of this review to the CEWO should make any modifications that would update the expectations of the Basin-scale evaluations.	Establish working group from Selected Area and Basin Matter team to develop SMART objectives and KEQ. Seek Project Steering Committee approval of updated objectives and KEQ Working group to liaise with delivery teams to develop SMART objectives	Immediately
2. That for multiple-scale watering actions, CEWO ensure the full range of expected ecological outcomes are determined and communicated to the appropriate LTIM Project teams.	Project management by the CEWO water delivery teams	Annual/ongoing
3. That the CEWO develop expected outcomes for the ecosystem diversity Basin Matter.	CEWO in collaboration with relevant Basin Matter team members	Within 6 months
4. That a LTIM Project Steering Committee be established, consisting of the CEWO, CEWO Delivery Teams, Selected Area team leads and the MDFRC Director. CEWO should also consider whether the MDBA should also be invited to join this Committee.	Approval by Project Steering Committee CEWO management	Immediately
5. That the CEWO review the management of the LTIM Project with a view to identifying a single Program Manager and a Science Leader.	CEWO in collaboration with MDFRC Director	Immediately
6. That the CEWO urgently develop an Evaluation Strategy for the LTIM Project.	Outsource to independent contractor – needs to be independent from current project staff Oversight of development of Terms of Reference by Project Steering Committee	Within 6 months
7. That the Selected Area teams focus more attention in their annual reports on: ecological outcomes of each local-area watering action, and scaling up the area-scale assessment and evaluations to the entire selected area.	CEWO management in collaboration with Selected Area team leaders Approval by Project Steering Committee	Immediately/ongoing
8. That consideration be given to requiring the Selected Area teams to produce two reports	CEWO management in collaboration with	For next set of Annual

Recommendation	Suggested management response/action	Timing
annually: first, a relatively short general report suitable for water managers and other stakeholders; and second, a detailed science report containing the information currently in the Appendices.	Selected Area team leaders	Evaluation Reports
9. That the CEWO consider having a detailed independent peer review undertaken during 2018 of the quality of the science being reported by the Selected Area teams, with the focus being on the initial MEP, and the 2015-2016 and 2016-17 annual evaluation reports.	CEWO management	In the second half of 2018
10. That the CEWO organise a process to clarify the scope and consistency of basin-scale evaluations, the process consisting of the preparation of a discussion paper, followed by a workshop with key researchers and managers to provide a sensible outcome.	CEWO in collaboration with MDFRC	In the second half of 2018 Could be done in conjunction with the 2018 Annual Forum
11. That the MDFRC develop a comprehensive project modelling plan as a matter of urgency, and that this Plan be agreed to by the proposed Project Steering Committee. Additional funds or reallocation of existing funds may be required to ensure the development of the Plan, and the subsequent development and testing of the models, is achieved.	MDFRC Director and relevant Basin Matters team members Consider need for independent peer review of the modelling plan by recognised world leader(s) in the field	Immediately
12. That the new Project Steering Committee be tasked with resolving the continuing issues associated data QA/QC and the MDMS.	Project Steering Committee with input from Shane Brooks	One of the first tasks
13. That the need for improved hydrological data and information, and inundation mapping be urgently addressed	Collaborate with MDBA and other data suppliers (e.g. NSW OEH) to coordinate progress at the Basin scale – possibly via a working group	Initiate discussion and identify stakeholders within 6 months
14. That the proposed Project Steering Committee formally evaluates the benefits of this improved collaboration between the Selected Area and Basin Matters teams as one of its first tasks.	Project Steering Committee	One of the first tasks
15. That a review of the annual Basin Matters and Synthesis reports be undertaken, with a view to restructuring them to make them more accessible to a wider audience.	MDFRC Director with CEWO management	During 2018
16. That a common database be established to hold all relevant data relating to environmental water monitoring in the Murray-Darling Basin; this will require cooperation between CEWO, MDBA and state agencies to achieve.	Establish a working group to resolve (CEWO, MDBA, state agencies)	During 2018
17. That an effective science communicator(s) be engaged by CEWO or MDFRC to assist the Selected Area and Basin Matters teams to make their various reports more readable, and to assist CEWO to produce more structured and targeted information products related to the LTIM Project.	CEWO in collaboration with MDFRC Director Establish a Communications strategy for	During 2018

Recommendation	Suggested management response/action	Timing
	LTIM Phase 1 outcomes – to be rolled out over final two years	
	Oversight by Project Steering Committee	
18. That the capture of adaptive management learning's be improved and done more systematically, in particular with the development of a accessible and searchable database to contain the learning's, and the production of an annual report that synthesises how this increased knowledge is changing the way in which environmental water is being delivered.	Project Steering Committee	During 2018
19. That an Independent Science Review Committee be established to review the quality and relevance of the science being developed by the Selected Area teams and the Basin Matters team.	CEWO management	Early in 2018

8 ACKNOWLEDGEMENTS

We wish to sincerely thank all who participated in the interviews for this review. We were able to tap a huge knowledge pool, to obtain insightful comments on what was working well and not so well with this Project, and to discuss possible modifications to the Project. An outstanding feature of these discussions was the widespread enthusiasm for the LTIM Project.

9 REFERENCES

9.1 REFERENCES CITED

- Borja, A., Elliott, M., Andersen, J.H., Berg, T., Carstensen, J., Halpern, B.S., Heiskanen, A.-S., Korpinen, S., Lowndes, J.S.S., Martin, G., and Rodriguez-Ezpeleta, N. (2016). Overview of Integrative Assessment of Marine Systems: The Ecosystem Approach in Practice. *Frontiers in Marine Science* 3. doi:10.3389/fmars.2016.00020.
- Brooks, S. and Wealands, S. (2013a). *Functional Requirements for LTIM Data Management*, Murray Darling Freshwater Research Centre, Wodonga, 8 pp.
- Brooks, S. and Wealands, S. (2013b). *Commonwealth Environmental Water Long Term Intervention Monitoring Project: Data Standard*, Publication 29.3/2013, Murray Darling Freshwater Research Centre, Wodonga, 54 pp.
- Butcher R., Hale J. and Cottingham P. (2014). Integrated environmental monitoring and evaluation at different spatial scales: a review of Australian and international case studies. Peter Cottingham & Associates report to the Murray darling Basin Authority.
- Capon S, Campbell C, Stewart-Koster B (2015) Long Term Intervention Monitoring Basin Matter – Vegetation Diversity foundation report. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 68/2015, May, 15 pp.
- CEWO (2013). *Commonwealth Environmental Water – Monitoring, Evaluation, Reporting and Improvement Framework V1.1, December 2013*, Commonwealth Environmental Water Office, Canberra.
- Commonwealth of Australia (2009). *NRM MERI Framework: Australian Government natural resource management monitoring, evaluation, reporting and improvement framework* p 40.
- Commonwealth of Australia (2012). *Murray-Darling Basin Plan*, Federal Register of Legislative Instruments, F2012-L02240, Canberra.
- Commonwealth of Australia (2014) *Commonwealth environmental water use options 2014–15: Northern Unregulated Rivers*, Commonwealth Environmental Water Office, Canberra.
- Doolan, J.M., Ashworth, B. and Swirepik, J. (2017) Planning for the Adaptive Management of Environmental Water (Chapter 23), In: Horne, A., Stewardson, M., Webb, J.A., Richter, B.D. and Acreman, M. (eds), *Water for the Environment: From policy and science to implementation and management*, Elsevier Publishing, New York, 539-561.
- Gawne, B., Brooks, S., Butcher, R., Cottingham, P., Everingham, P., Hale, J., Neilson, D., Stewardson, M. and Stoffels, R. (2013). *Long Term Intervention Monitoring Project: Logic and Rationale Document (Final Report)*, Publication 01/2013, Murray Darling Freshwater Research Centre, Wodonga, 109 pp.
- Gawne, B., Roots, J., Hale, J. and Stewardson, M. and Stoffels, R. (2014). *Long Term Intervention Monitoring Project: Basin Evaluation Plan*, Publication 42/2014, Murray Darling Freshwater Research Centre, Wodonga, 55 pp.
- Gawne, B., Hale, J., Brooks, S., Campbell, C., Capon, S., Everingham, P., Grace, M., Guarino, F., Stoffels, R. and Stewardson, M. (2017). *2015-16 Basin-scale Evaluation of Commonwealth Environmental Water – Synthesis Report*, Publication 141/2017, Murray Darling Freshwater Research Centre, Wodonga, 47 pp.
- Gawne B, Everingham P, Le Busque K (2015). *Long Term Monitoring Project Annual Forum: Outcomes 2015*, Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 83/2015, August, 46 pp.

- Gawne B, Everingham P, Busuttil R, Williams M, Stoffels R, Capon S, Stewardson M, Grace M and Brooks S (2016). *Long Term Monitoring Project Annual Forum: Outcomes Report 2016*, Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 127/2016, August, 39 pp.
- Gawne B, Everingham P, Busuttil R, Williams M, Stoffels R, Capon S, Stewardson M, Grace M, Bond N, Gorman, R and Brooks S (2017). *Long Term Monitoring Project Annual Forum: Outcomes Report 2017*, Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 165/2017, October, 32 pp.
- Gawne, B., Hale, J., Butcher, R., Roots, R., Brooks, S., Cottingham, P., Stewardson, M. and Everingham, P. (2014a). *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Evaluation Plan*. Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 29/2014, January, 61 pp.
- Gawne B, Roots J, Hale J (2014b). *Commonwealth Environmental Water Office Long– Term Intervention Monitoring Project: Basin Evaluation Plan – Part B: Implementation*. Report prepared for the Commonwealth Environmental Water Office by the Murray–Darling Freshwater Research Centre, MDFRC Publication 35/2014, August, 35pp.
- Grace M, (2015) Long Term Intervention Monitoring Basin Matter - Stream Metabolism and Water Quality foundation report. Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 69/2015, 9 pp.
- Hale, J., Stoffels, R., Butcher, R., Shackleton, M., Brooks, S., Cottingham, P., Gawne, B. and Stewardson, M. (2014). *Long Term Intervention Monitoring Project: Standard Methods*. Publication 29-2/2014, Murray Darling Freshwater Research Centre, Wodonga, 175 pp.
- Hodge, W., Gomez-Bonnet, F. and Alexandra, L. (2015). *Evaluation Strategy for the Murray-Darling Basin Environmental Water Knowledge and Research (MDB EWKR) project*, Report prepared by ARTD Consulting for MDFRC and CEWO, MDFRC, Wodonga, 55 pp.
- Horne, A., Stewardson, M., Webb, J.A., Richter, B.D. and Acreman, M. (eds) (2017). *Water for the Environment: From policy and science to implementation and management*, Elsevier Publishing, New York.
- JVSC (2017). Report on outcomes and recommendation for the next steps on the need for accessible and reliable inundation mapping in the Murray–Darling Basin, Joint Venture Steering Committee, ????, June 2017, 10 pp.
- MDBA (2014). Basin-wide environmental watering strategy, MDBA Publication No 20/14, Murray–Darling Basin Authority, Canberra.
- MDBA (2017). Basin environmental watering priorities – Overview and technical summaries, June 2017, MDBA Publication No 19/17, Murray–Darling Basin Authority, Canberra.
- O'Donnell, E. and Garrick, D.E. (2017). Defining Success: A Multi-criteria Approach to Guide Evaluation and Investment (Chapter 26). In: Horne, A., Stewardson, M., Webb, J.A., Richter, B.D. and Acreman, M. (eds), *Water for the Environment: From policy and science to implementation and management*, Elsevier Publishing, New York, 625-644.
- Parsons, M., Thoms, M.C., Flotemersch, J.E. and Reid, M. (2016). Chapter 10: Monitoring the resilience of rivers as social-ecological systems: A paradigm shift for river assessment in the twenty-first century, In Gilvear, D.J. et al. (eds), *River Science: Research and Management for the 21st Century*, John Wiley & Sons, New York, 27 pp.
- Parsons, M. and Thoms, M.C. (2017) Assessment of rivers as social–ecological systems: a response to ‘The imperative need for nationally coordinated bioassessment of rivers and streams’, by Susan J. Nichols et al., *Marine and Freshwater Research* 68, 2179–2183.
- Thompson, R.M., King, A.J., Kingsford, R.M., MacNally, R. and Poff, N.L. (2017). Legacies, lags and long-term trends: Effective flow restoration in a changed and changing world, *Freshwater Biology* 1-10, DOI :10.1111/fwb.13029.
- Webb, J.A., Arthington, A.H. and Olden, J.D. (2017). Models of Ecological Response to Flow Regime Change to Inform Environmental Flow Assessments (Chapter 14). In: Horne, A., Stewardson, M., Webb, J.A., Richter, B.D. and Acreman, M. (eds), *Water for the Environment: From policy and science to implementation and management*, Elsevier Publishing, New York, 287-312.

Webb, J.A., Watts, R.J., Allan, C. and Warner, A.T. (2017). Principles of Monitoring, Evaluation and Adaptive Management of Environmental Flow Regimes (Chapter 25), In: Horne, A., Stewardson, M., Webb, J.A., Richter, B.D. and Acreman, M. (eds), *Water for the Environment: From policy and science to implementation and management*, Elsevier Publishing, New York, 599-622.

9.2 PEER REVIEWED PAPERS RESULTING FROM/LINKED TO LTIM

Bino, B., Wassens, S., Kingsford, R.T., Thomas, R.F. and Spencer, J. (2018) Floodplain ecosystem dynamics under extreme dry and wet phases in semi-arid Australia. *Freshwater Biology* 63, 224–224.

Grace, M.R., Giling, D.P., Hlady, S., Caron, V., Thompson, R.M. and Mac Nally, R. (2015) Fast processing of diel oxygen curves: Estimating stream metabolism with BASE (Bayesian Single-station Estimation). *Limnology and Oceanography: Methods* 13, 103-114.

JVSC (2017). Report on outcomes and recommendation for the next steps on the need for accessible and reliable inundation mapping in the Murray-Darling Basin, Joint Venture Steering Committee, June 2017, 10 pp.

Ocock, J., G. Bino, S. Wassens, J. Spencer, R. Thomas & R. Kingsford, 2017. Identifying Critical Habitat for Australian Freshwater Turtles in a Large Regulated Floodplain: Implications for Environmental Water Management. Environmental management. Published online: 09 March 2017. <https://link.springer.com/article/10.1007/s00267-017-0837-0>

Stoffels, R.J., Bond, N. and Nicol, S. (2017) Science to support the management of riverine flows. *Freshwater Biology* 63, 1-15.

Thompson, R.M., King, A.J., Kingsford, R.M., MacNally, R. and Poff, N.L. (2018) Legacies, lags and long-term trends: Effective flow restoration in a changed and changing world. *Freshwater Biology* 63, 1-10.

Thompson, R.M., Bond, N., Poff, N.L. and Byron, N. (2018) Towards a systems approach for river basin management - Lessons from Australia's largest river. *River Research and Applications*, 1-10.

Vietz, G.J., Lintern, A., Webb, J.A. and Straccione, D. (2017) River Bank Erosion and the Influence of Environmental Flow Management. *Environmental Management*, 1-15.

Shamsi, S., A. Turner & S. Wassens, 2017. Description and genetic characterization of a new *Contracaecum* larval type (Nematoda: Anisakidae) from Australia. *Journal of Helminthology*. Published online: 05 May 2017. <https://doi.org/10.1017/S0022149X17000360>.

Song, C., Dodds, W.K., Trentman, M.T., Euegg, J.R. and Ballantyne, F. (2016) Methods of approximation influence aquatic ecosystem metabolism estimates. *Limnology and Oceanography: Methods* 14, 557-569.

Stewardson, M. and Guarnio, F. (2018). Basin-scale environmental water delivery in the Murray-Darling, Australia: A hydrological perspective, *Journal?*,

Stoffels R., Bond N., Pollino C., Broadhurst B., Butler G., Kopf R.K., Koster W., McCasker N., Thiem J., Zampatti B., Ye Q. (2016) Long Term Intervention Monitoring Basin Matter - Fish foundation report. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 65/2015, May, 37 pp.

Wolfenden, B. J., S. Wassens, K. M. Jenkins, D. S. Baldwin, T. Kobayashi & J. Maguire, 2017. Adaptive Management of Return Flows: Lessons from a Case Study in Environmental Water Delivery to a Floodplain River. *Environmental Management*. Published online: 04 May 2017 <https://link.springer.com/article/10.1007/s00267-017-0861-0>

APPENDIX A: MTRE OBJECTIVES

Table 6. Objectives of LTIM MTRE

Number	Objective
1	<p>To assess overall progress towards meeting the stated LTIM Project objectives as specified in the foundation documentation (noting that independent review of foundation documents occurred at time of publication). The approach will be to:</p> <p>1a Review program logic and design in terms of meeting requirements under Water Act (2007) and Murray-Darling Basin Plan, in particular mapping against Basin Wide Environmental Watering Strategy (MDBA 2014);</p> <p>1b Review individual area-scale projects (at high level, see also 2a below) and assess their contribution to meeting LTIM Project objectives.</p>
2	<p>To assess implementation and effectiveness of the LTIM Project at the program level. The approach will be to:</p> <p>2a Assess individual area-scale projects (based on area-scale MEP and 2015-2016 evaluation reports) to establish if they are on track to meeting stated objectives for each region;</p> <p>2b Identify any risks to the successful implementation of area-scale projects;</p> <p>2c Assess whether the LTIM Project is on track to meeting stated objectives - establish what is working (combines outputs from 2a);</p> <p>2d Identify any risks to the LTIM Project outcomes - establish what is not working (combines outputs from 2b).</p>
3	<p>To review the effectiveness of the LTIM Project's current approach to adaptive management.</p> <p>3a Identify what adaptive management processes have occurred, and what changes have been implemented;</p> <p>3b Identify any challenges and how they were addressed;</p> <p>3c Areas to be considered include management arrangements, work planning (in relation to sharing of data), project-level monitoring and evaluation systems, and reporting.</p>
4	<p>To provide a review and evaluation report of the LTIM Project containing:</p> <p>4a Recommendations for improvement of the current program;</p> <p>4b Recommendations for consideration in determining the scope of LTIM Stage 2;</p> <p>4c Recommend possible management responses to the MTRE report (e.g. presentation/workshop with CEWO and suggestions on who does what and by when?).</p>

APPENDIX B: DOCUMENTS REVIEWED IN MTRE

The main documents reviewed for the MTRE are listed below.

FOUNDATION DOCUMENTS

Environmental Water Outcomes Framework	CEWO (2013). <i>Commonwealth Environmental Water – The Environmental Water Outcomes Framework</i> , Commonwealth Environmental Water Office, December 2013 V1.0, Commonwealth Environmental Water Office, Canberra.
Logic and Rationale	Gawne, B., Brooks, S., Butcher, R., Cottingham, P., Everingham, P., Hale, J., Neilson, D., Stewardson, M. and Stoffels, R. (2013). <i>Long Term Intervention Monitoring Project: Logic and Rationale Document (Final Report)</i> , Publication 01/2013, Murray Darling Freshwater Research Centre, Wodonga, 109 pp.
Basin Evaluation Plan	Gawne, B., Roots, J., Hale, J. and Stewardson, M. and Stoffels, R. (2014). <i>Long Term Intervention Monitoring Project: Basin Evaluation Plan</i> , Publication 42/2014, Murray Darling Freshwater Research Centre, Wodonga, 55 pp.
Standard Methods	Hale, J., Stoffels, R., Butcher, R., Shackleton, M., Brooks, S., Cottingham, P., Gawne, B. and Stewardson, M. (2014). <i>Long Term Intervention Monitoring Project: Standard Methods</i> . Publication 29-2/2014, Murray Darling Freshwater Research Centre, Wodonga, 175 pp.
Ecosystem diversity	Brooks, S. (2015). <i>Long Term intervention Monitoring Basin Matter – Ecosystem diversity foundation report</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 74/2015, May, 9pp.
Hydrology	Stewardson, M., Guarino, F., and Gawne, B. (2015). <i>Long Term Intervention Monitoring Basin Matter – Hydrology foundation report</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 66/2015, May, 9pp.
Stream metabolism and water quality	Grace, M. (2015). <i>Long Term Intervention Monitoring Basin Matter - Stream Metabolism and Water Quality foundation report</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 69/2015, May, 9pp.
Vegetation	Capon, S., Campbell, C., and Steward-Koster., B. (2015). <i>Long Term Intervention Monitoring Basin Matter – Vegetation Diversity foundation report</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 68/2015, May, 11pp.
Fish	Stoffels, R., Bond, N., Pollino, C., Broadhurst, B., Butler, G., Kopf, R.K., Koster, W., McCasker, N., Thiem, J., Zampatti, B., and Ye, Q. (2016). <i>Long Term Intervention Monitoring Basin Matter - Fish foundation report</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 65/2015, May, 11pp.
Generic diversity	Baumgartner, L., Hale, J., and Gawne, B. (2015). <i>Long Term Intervention Monitoring Basin Matter – Aggregation of Selected Area biodiversity outcomes (generic diversity) foundation report</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater

Research Centre, MDFRC Publication 67/2015, May, 5pp.

AREA-SCALE MONITORING AND EVALUATION PLANS

Edward-Wakool	Watts, R.J., McCasker, N., Baumgartner, L., Bond, N., Bowen, P., Conallin, A., Grace, M., Healy, S., Howitt, J.A., Kopf, R.K., Scott, N., Thiem, J., and Wooden I. (2014). <i>Monitoring and Evaluation Plan for the Edward-Wakool Selected Area</i> , Commonwealth of Australia 2014.
Goulburn	Webb, A., Sharpe, A., Koster, W., Morris, K., Pettigrove, V., Grace, M., Vietz, G., Woodman, A., Earl, G., and Casanelia, S. (2014). <i>Long-Term Intervention Monitoring Project for the lower Goulburn River: Final Monitoring and Evaluation Plan</i> . Commonwealth of Australia 2014.
Gwydir	Frazier, P., Ryder, D., Garraway, E., and van der Veer, N. (2015). <i>Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Gwydir River System Selected Area Monitoring and Evaluation Plan</i> . Commonwealth of Australia 2014.
Lower Lachlan	Dyer, F., Broadhurst, B., Thompson, R., Jenkins, K., Brandis, K., Driver, P., Saintilin, N., Bowen, S., Packard, P., Gilligan, D., Thiem, J., Asmus, M., Amos, C. Hall, A., Martin, F., and Lenehan, J. (2015). <i>Long Term Intervention Monitoring and Evaluation Plan Lachlan River system</i> , Commonwealth of Australia 2014.
Lower Murray (version 2 2016)	SARDI, University of Adelaide, CSIRO, EPA, DEWNR and In Fusion (2016). <i>Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Lower Murray River Selected Area Monitoring and Evaluation Plan</i> . Version 2, Commonwealth of Australia 2016.
Murrumbidgee	Wassens, S., Jenkins, K., Spencer, J., Thiem, J., Bino, G., Lenon, E., Thomas, R., Kobayashi, T., Baumgartner, L., Brandis, K., Wolfenden, B., Hall, A. , and Scott, N. (2014). <i>Murrumbidgee Monitoring and Evaluation Plan</i> , Commonwealth of Australia 2014.
Warrego-Darling	Frazier, P., Ryder, D., Southwell, M., and Southwell, E. (2015). <i>Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area</i> , Commonwealth of Australia 2014.

AREA-SCALE EVALUATION REPORTS 2015-2016

Edward-Wakool	Watts, R.J., McCasker, N., Howitt, J.A. Thiem, J., Grace, M., Kopf, R.K. Healy, S. and Bond, N. (2016). <i>Commonwealth Environmental Water Office Long-Term Intervention Monitoring Project: Edward-Wakool River System Selected Area Evaluation Report 2015-16</i> . Report prepared for Commonwealth Environmental Water Office. Commonwealth of Australia.
Goulburn River	Webb, A., Baker, B., Casanelia, S., Grace, M., King, E., Koster, W., Lansdown, K., Lintern, A., Lovell, D., Morris, K., Pettigrove, V., Sharpe, A., Townsend, K., and Vietz, G. (2016). <i>Commonwealth Environmental Water Office Long-Term Intervention Monitoring Project – Goulburn River Selected Area evaluation report 2015-16</i> . Report prepared for the Commonwealth Environmental Water Office

Gwydir	Southwell, M., Frazier, P., Hancock, P., Martin, B., Burch, L., van der Veer, N., Frost, L., Ryder, D., Tsoi, W.Y., Butler, G., Spence, J., Bowen, S., and Humphries, J. (2016). <i>Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Gwydir River System Selected Area – 2015-16 Draft Evaluation Report</i> , Commonwealth of Australia 2016.
Lower Lachlan	Dyer, F., Broadhurst, B., Tschierschke, A., Thiem, J., Thompson, R., Driver, P., Bowen, S., Asmus, M., Wassens, S., and Walcott, A. (2016). <i>Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Lower Lachlan river system Selected Area 2015-16 Monitoring and Evaluation Synthesis Report</i> . Commonwealth of Australia, 2016.
Lower Murray	Ye, Q., Giatas, G., Aldridge, K., Busch, B., Gibbs, M., Hipsey, M., Lorenz, Z., Mass, R., Oliver, R., Shiel, R., Woodhead, J. and Zampatti, B. (2017). <i>Long-Term Intervention Monitoring of the Ecological Responses to Commonwealth Environmental Water Delivered to the Lower Murray River Selected Area in 2015/16</i> . A report prepared for the Commonwealth Environmental Water Office, 2016.
Murrumbidgee	Wassens, S., Spencer, J., Thiem, J., Wolfenden, B. Jenkins, K., Hall, A., Ocock, J., Kobayashi, T., Thomas, R., Bino, G., Heath, J., and Lenon, E. (2016). <i>Commonwealth Environmental Water Office Long-term Intervention Monitoring project Murrumbidgee River System Selected Area evaluation report</i> , Commonwealth of Australia 2016.
Warrego-Darling	Frazier, P., Ryder, D., Southwell, M., Butler, G., van der Veer, N., Burch, L., Martin, B., Frost, L., and Cawley, R., and Tsoi, W.S., (2017). <i>Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area – 2015-16 Final Evaluation Report</i> , Commonwealth of Australia 2017.

BASIN MATTER EVALUATION REPORTS 2015-2016

Ecosystem diversity	Brooks, S. (2017). <i>2015–16 Basin-scale evaluation of Commonwealth environmental water – Ecosystem Diversity</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 144/2017, May, 45pp.
Hydrology	Stewardson, M.J., and Guarino, F. (2017). <i>2015–16 Basin-scale evaluation of Commonwealth environmental water — Hydrology</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 142/2017, October, 45pp., plus annex
Stream metabolism and water quality	Grace, M. (2017). <i>2015–16 Basin-scale evaluation of Commonwealth environmental water — Stream Metabolism and Water Quality</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 143/2017, October, 58pp.
Vegetation	Capon, S., and Campbell, C. (2017). <i>2015–16 Basin-scale evaluation of Commonwealth environmental water – Vegetation Diversity</i> . Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 145/2017, August, 87pp.

Fish	Stoffels, R.J., Bond, N.R., and Guarino, F. (2017). <i>2015–16 Basin-scale evaluation of Commonwealth environmental water – Fish</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 146/2017, October, 72pp.
Generic diversity	Hale, J. (2017). <i>2015–16 Basin-scale evaluation of Commonwealth environmental water – Generic Diversity</i> . Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 147/2017, September, 61pp.
CEWO watering actions	CEWO (n.d.) 2015–16 Basin-scale evaluation of Commonwealth environmental water – Environmental watering actions.
Synthesis Report	Gawne, B., Hale, J., Brooks, S., Campbell, C., Capon, S., Everingham, P., Grace, M., Guarino, F., Stoffels, R., and Stewardson, M. (2017). <i>2015–16 Basin-scale evaluation of Commonwealth environmental water – Synthesis Report</i> . Final report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 141/2017, October, 47 pp.

APPENDIX C: INTERVIEW APPROACH AND KEY RESPONSES

APPROACH

Each LTIM Project team member and stakeholder interviewed was sent a short introduction to the MTRE and a list of questions. The questions related to the program strategy, progress towards results, implementation, adaptive management, reporting, future planning and key lessons.

The interviews focused on what's working well and what's not, adaptive management processes and practices, reporting and interactions between the various key team groups (i.e. Selected Area teams, Basin Matter teams, CEWO project managers and the CEWO water delivery teams). Not all questions were addressed in the interviews.

A set of summary notes from the interview were sent to each of the interviewees with the option of clarifying points, and or adding more comments. From these notes the key responses have been distilled into the following main topics:

- LTIM Program as a whole – approach, foundation documents, design, strategy, progress etc.
- Project specific responses either for Selected Areas or Basin Matter evaluation covering implementation, reporting, adaptive management
- CEWO interaction – project management and water delivery teams
- Key lessons
- Future planning

PARTICIPANT RESPONSES

Abbreviations used in responses:

BM – Basin Matter

CEW – Commonwealth environmental water

EWAG – Environmental Watering Advisory Group

MEP – Monitoring and evaluation plans

SA – Selected Area

TAG – Technical Advisory Group

CEWO STAFF

Bruce Campbell (Director, Central Basin Delivery Section) – 22 January

Some preliminary thoughts:-

1. A discussion about complexity would be worthwhile. Ben Gawne presented to River symposium several years ago on “Complicated” versus “Complex” systems. He referred to the Space Shuttle being Complicated – whilst it was a sophisticated machine, every part had a known purpose. LTIM#1 has been designed to meet a complex problem (some unknown unknowns).

a. To the extent that LTIM#1 will inform some responses to environmental watering that have not been previously understood, there is scope to reduce the “Complex” system scope in LTIM#2.

b. Theoretically this should result in a dividend (no need to repeat investment in those relationships to the same extent). The next issue is “where to invest a dividend from LTIM#1”. There are discrete options:

i. Reduce the investment in M&E effort – design a program to meet “Complicated” system needs (use the knowledge from LTIM#1 to infer outcomes based on less intensive data collection);

ii. Continue to invest at a similar scale to determine additional complex responses; and

iii. Change the scope of the activity (refer 2. below).

2. *Regardless of the M&E objectives and the scale relative to LTIM#1 there is a need to include far greater science communication effort in LTIM#2. I would be guided by others' knowledge of contemporary practice but up to 10% of overall budget is probably a useful start to get the program up to best practice science communication. There is enormous, mostly untapped potential to increase public information to inform what it is that the CEWH/CEWO is trying to do. We should not be limited to explaining to a (mostly) scientific audience what it is that has been achieved to 95%ile confidence limits years afterwards.*

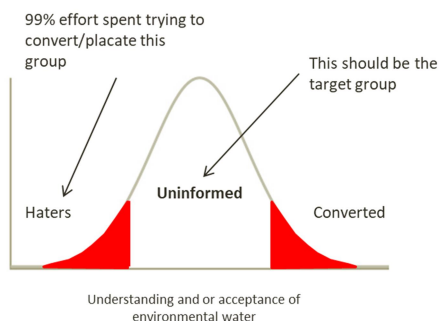
LTIM Program

- What's working well:
- *Re program strategy:* Big picture - not convinced needs are being met in terms of communications – we have invested in rigorous method of achieving best possible science but we need to tell the story better in a different way – to a rigorous standard.
- Knowledge transfer – in a contemporary program should probably invest at least 10% effort into communications – and recognise this is a different skill set. The initial intent was to focus on adaptive management – didn't have the communication needs in mind. Another argument is the capacity one – CEWO do not have the skills to do the knowledge exchange – since Kelly White left we have no formal communications function.
- A possible solution is to harness the capacity of the research institutions – to expand the contracts where feasible to include standalone knowledge exchange capacity within the existing teams. Need to look beyond just the needs within CEWO – need to consider what is best for LTIM#2. Another argument for this to be done is that LTIM is very complex – with many unknowns and we need help in communicate what we are doing now – the 2 year delays in the synthesis relying on known responses is not useful.
- Rather than investing hypothesis testing need to focus more on Basin-scale and being more predictive. Overall the outcomes in terms of investment and adaptive management is not well aligned – we are having to explain a fair bit to the SA in terms of what we need.
- *RE the program logic and rational:* Can't plan in advance over a 5 year timeframe for water delivery – too many unknowns. The project started with the SA teams acting as herded cats – standard methods were to be applied at 7 SA – this is often limiting for example in the Lower Lachlan adaptive management led to different reaches being targeted for watering, compared to the location of LTIM M&E effort. STIM or optional LTIM resources were not available to apply M&E to the adapted watering targets. Hence the LTIM project needs to be more flexible.
- Basin annual watering priorities – sometimes dependent on hydrologic conditions – but still need local scale watering events. An example of one of my frustrations with the Basin-scale approach is what constitutes a Basin-scale response – for example in 2016-17 at Booligal Wetlands we had the largest colonial waterbird nesting event in the Basin (according to Kate Brandis it was the biggest event since the 1980s) with at least 500 000 Straw necked ibis – yet we only spent a very limited amount of money understanding the event. The event was unusual – it bucked all previous trends pointing to a national decline in colonial nesting waterbird numbers. So clearly a Basin-scale response – but investigation efforts were higher at far smaller colonial nesting sites (selected based on historical trends, not contemporary).
- *How much interaction have you had with other teams?* The Water Delivery Teams get together – we integrate our knowledge – the delivery staff do a formal presentation to the CEWH annually – but other discussions occur as well. The teams all sit together so it's organic – particularly for southern connected basin there is overlap. Portfolio management comes into play – no drought so no loss of watering events. With the northern team it's less structured. Presentations from Paul Frazier or Mark Southwell, Angus Webb – everyone goes along – only been a few presentations, few from the SA providers that Central team deals with. Interactions could be better structured and a bit more frequent than just annual.
- Some occasions where we have technical advisory groups which inform operations but also inform/used in planning – e.g. TAG meetings – both Robyn and Ben W regularly involved, Fiona too.
- *Thoughts on program leadership:* Ben Gawne has a huge depth of knowledge and I hope that his knowledge and skill can continue to play a role in some way – recognising that that role might be a different one.
- *Comments on adaptive management:* Adaptive management efforts are meeting our needs – but only to a degree. Our hypotheses are not stable enough to refine what we need. Undertaking adaptive management at a course scale is still a new game. This will likely change in the future, as if we get a non-response then we might need to change the hypothesis. *BH: are the adaptive management/hypotheses captured?* LTIM is not the only source of information we use to make decisions – for example Clayton's and Rick's fish work–

the hydrograph in the Lower Lachlan was very similar to the Goulburn (where a strong response occurred) suggested the Lower Lachlan would be right for a response but none observed (although some question re the presentation of some key temperature data – operational data showed temperature actually on higher side of target range in target reach, not below as summarised). *BH: sources of knowledge?* Very much expert based – ourselves, fisheries, NSW OEH, Iain Ellis, Sam Davis, and others – they draw on knowledge from elsewhere. These discussions often occur outside the EWAG – noting that the Lachlan EWAG is very low on local stakeholders. Having said that most watering proposals are developed internally, with few from external stakeholders (lower Murrumbidgee an exception). *BH: how is this interaction captured?* The process has matured – used to develop discrete watering actions for the CEHW's approval, don't need to do this now. We ask for approval of an umbrella set of proposals – the CEWH approves a broader seasonal package – decisions then come down to the directors to approve/endorse. The Water Delivery Team doesn't have a specific conversation of what LTIM has told them over time, but we use it as well as other sources. Often State coordinated TAG meetings are used to workshop watering proposals but these are not well documented.

Selected-Area projects

- What's working well:
- *Implementation – dealing with constraints:* In the Edward-Wakool for example landholders have agreed to relax the constraints from 600 to 800 ML/d, but this represents an extremely limited degree of influence – so if we want to see a realistic result it will require much more water – therefore can't get an outcome in LTIM (e.g. metabolism). *BH: not just an Edward-Wakool problem.* Need an honest review if getting value for money out of the 7 SA (DN: capture point). Given the constraints in the Edward-Wakool we are only able to do limited things for example with blackwater events, which do have huge impacts. Are we asking the critical questions and getting value for money?
- Comments on reporting:
- *Comments on adaptive management:* From operation meetings recording only the actions for operational matters – there will be an email chain summarizing the discussions but not much else. Fiona Dyer mentioned a Mark Burgman presentation – came up to me and said 'did you know that all expert opinion is wrong? But opinion workshopped by a group of experts is almost always right'. Documentation could be done across a number of perspectives, not just CEWOs – and then be used for justification of a decision (DN: capture point).
- For example the wetland breeding event at Booligal – nothing much was being mentioned in the public forums – so we fought hard to get a drone to capture imagery and loaded it on our website – very proud of this outcome as it had more hits than the Department's Great Barrier Reef activities routinely get. I'm passionate about this – that there needs to be a significant effort put into converting the uninformed. For example – using a bell curve, the left 1% are the haters, the right 1% are the lovers/converted – the vast majority being the uninformed. However we target 99% of our efforts into the haters (who are largely ideologically motivated) and assume that the lovers/converted are on the same page (a poor assumption). The take home messages are there are not enough good stories – we need to promote the program with enthusiasm – and we need to invest effort in those who would be supportive so that they are informed (DN: capture point).



Interaction with LTIM teams

- Interaction with the BM team is mainly via Enzo as he sits within CEWO so interaction with Mike Stewardson. Recently Rick presented on fish progress – really encouraging and positive. Nick Bond presented on metabolism – take home was less positive – that this is a very challenging area. We saw Ben

a fair bit – couple of times a year – which was good, although the focus was more on the conceptual aspects. No interaction with the vegetation theme.

Key lessons over the 3 years

- LTIM#2 needs to review investment and rearrange structure.
- Need to be more flexible and able to respond to events as they arise.
- Science communication – concept of complex versus complicated – need more communication about what we are trying to do in real time. 12-24 months after a watering actions is not good enough – it won't get more support for the program, either internally or externally. Need to get others/CEWO and external to identify with the value of the project. To achieve this we need to maximise use of the pool of talent already within the LTIM project. LTIM SA teams have the capacity to include as part of the service provision (or can recruit) knowledge exchange/brokers – should be a requirement.
- Future planning comments:
- Undertake a review of the indicators – birds in particular – these are considered a surrogate for the food chain – consider this a missed opportunity.

David Straccione (Assistant Director, Southern Basin Delivery Section) – 22 January

Text in italics provided prior to phone interview – comments mainly in reference to Goulburn SA.

LTIM Program

- *What's working well: Adaptive Management and Access to Real-Time Results and Scientific / Expert Advice* – extremely valuable and building strong relationships. Done via emails, phone, across multiple themes including contact before and after a watering event to help shape the hydrograph. We have been using this approach over the past few years – this is the bit that's unique to LTIM (DN: capture point).
- Helped that the WDT were overseeing the contracts – more worthwhile as it allows for regular interaction with the selected area lead and theme leaders. If WDTs were not managing the selected areas, it is unlikely that the relationships would have developed to the mature and very beneficial stage they are at now (DN: capture point). WDTs run the day to day of the contracts – Paul and Sam have oversight of the whole program (DN: capture point). The BM team is not contracted via the WDTs so for the Goulburn the interaction with the BM team could be strengthened.
- Using information gained in the adaptive management cycle we can adjust the timing, duration, location, frequency and amount of environmental water that is provided during a watering action.
- The partnerships established under LTIM have two particular advantages for flow management. First, researchers have better access to ongoing and up-to-date information on flows from water managers to plan their sampling regimes. Second, water managers get a measure of success against management intentions.
- Ecological monitoring in the Murray–Darling Basin is not new, and has been shaping flow management for some time. However, the findings are typically considered retrospectively, and there are often delays between the delivery of environmental water and the results of those actions. The LTIM project is uniquely underpinned by the more real-time transfer of information between the researchers, CEWO and other environmental water managers throughout the year (vs. just a backward looking annual report).
- This highly effective and collaborative relationship established between government and the scientific community allows for an immediate response by water managers throughout the year to both enhance environmental outcomes, and mitigate unintended adverse impacts.
- The project has evolved over the last 3 years and positive changes in sampling techniques, methodology, reporting and information exchange have occurred. We will seek to employ these approaches as required for the remainder of the program, noting though that the project is now 'bedded in' and going well.
- *Re program strategy*: Only assessing watering actions that have a CEW volumetric contribution is not realistic, if CEW is involved in the management of a delivery (even if it is not e-water), then any outcomes should still be assessed and attributed to 'e-water management' vs that actual e-water component (see comments in italics on adaptive management below). Should change the wording of the questions/objectives to focus on assessing what events CEW is involved in. By looking at a contribution assessment it could skew the analysis (DN: capture point). For example when delivering inter valley transfers (IVT) the operational teams have changed a lot – when GMW are going to do an IVT out of the Goulburn they will involve water holders and the catchment management authority to see if there is any

way in which it can be used to benefit the environment (i.e. work with us to the best of their ability to shape the hydrograph in a way that promotes e-benefits)

- Having the CMA involved in the SA is also very good – not on the outside looking in.
- RE the program logic and rational
- *How much interaction have you had with other teams?* Need to have better collaboration with the BM team – partly a temporal issue as the results are temporarily and spatially different to our day to day needs – slow to ramp up at the Basin-scale – so automatic response is to focus on the SA scale. Also an element of too early to comment fully on Basin-scale.
- *Thoughts on program leadership?* Idea posed by BH that CEWO leads project management and Nick the intellectual lead – wouldn't disagree / makes sense. *BH: what about an oversight group?* Internally would be hard pressed to create such a group due to competing priorities and challenges re resourcing– not convinced as yet that another layer of governance would be of value – if it was to be supported then it should be at the Basin-scale and could lead forums which were thematically themed.
- *Comments on adaptive management:* Consideration should be given to adjusting the project objectives in relation to evaluation of Commonwealth environmental watering. This is because quite often for environmental water delivery outcomes, the CEWO may concede channel capacity to other e-water holders and/or operational flows (e.g. Inter-valley Transfers – IVT) from a portfolio management perspective. This is because other water holders / managers may have a need to use their water as a priority that outweighs CEW use, and if we agree, we will actively choose to scale back our deliveries, or not to deliver CEW at all at times. However, the resulting hydrograph is still shaped in such a way as to achieve the desired ecological outcomes / benefits (i.e. the environmental need has been met by other means) - that would have been delivered with CEW if we did not concede.
- Therefore, the project objectives could be amended to evaluate environmental watering and management (not CEWO-specific) as the current LTIM monitoring program has already adjusted their approach in this respect and are evaluating the outcomes of e-watering actions, irrespective of the water source. (DN: check if this will meet the BP requirements).
- Finally, it is worth noting that there was some initial confusion by monitoring providers at the inception of LTIM in 2014-15, as some thought were only meant to attribute ecological outcomes to the CEW component of the hydrograph – which is not a true reflection of reality in the river...the fish, veg, macros, etc. don't care who is providing the water.
- The contracts are structured to allow changes in sampling approach if agreed by all parties, which is valuable and has been applied. For example, some of the initial monitoring approaches, despite best efforts to bed them down at the start, required adjustment. The flexibility built into the contracts allowed for such changes. (DN: capture point)
- Also, the option to access additional funds for Short-Term Intervention Monitoring for a specific theme / parameter / outcome (not captured by the LTIM project) has been very beneficial and utilised a number of times (e.g. black bream monitoring in the Coorong, Lower Darling Native Fish, SARDI flow connectivity).
- There have also been times when agreement has been reached regarding the delay or rescheduling of planned sampling trips so as to maximise the benefit of the data collected (i.e. changing to a more appropriate time for sampling in response to changing conditions in the river and/or e-water deliveries).
- Goulburn fish monitoring was change, it was agreed to reduce the number of light traps for larvae / eggs for flow dependent spawners such as Golden and Silver Perch as drift nets were found to be a more effective sampling technique. This decreased sampling effort and saved project expenditure so that the funds could be used more effectively elsewhere on the project.
- Change to vegetation sampling protocol – timing was adjusted to better align with historical data from other projects to promote a longer / continuous data set.
- A strong governance model has been established and continues via regularly scheduled working group meetings (quarterly) that contain a project status update (e.g. progress against milestones, planned and completed deliveries, financial management, risks, issues arising and mitigation / resolution, etc.), monitoring results to date and other project info. (DN: capture point – re process evaluation)

Selected-Area project

- *What's working well:* Most of the time we go through Angus, but often we are considering multiple outcomes, trying to find the balance, so for example may approach Kay and ask her opinion re veg impacts (or Wayne for fish and Geoff Vietz re geomorphology) of a certain strategy – then we adjust to find the best balance re impacts – i.e. informs how we manage the hydrograph.

- *Implementation:* There is shared responsibility in the WDTs, each SA looked after by subleads – if there were changes to be made to the standard methods / SOPs / contracts these were checked with Sam and Co as most delivery leads weren't involved with the project from inception – this is especially true if changes had implications for Basin-scale (DN: check if a log of changes were kept – decision and justification – transparency).
- There is good collaboration between the WDTs – in particular Southern and Central as there is spatial overlap. We tend to ticktack with Central. North is so different both spatially and operationally so not as much overlap.
- Ideally, we would be able to better communicate the results, but this may be constrained by current resources.
- Possibly infer the Goulburn results to similar areas, where appropriate, to leverage our knowledge base and inform effective water management elsewhere.
- *Comments on reporting:* Typical messaging in the final reports – Good recommendations from the thematic leads – e.g. Wayne always really good, but in 16-17 report the data are showing that timing and temperature thresholds as well as magnitude are influential in golden perch responses – this will be captured in planning for the next year.
- We get varying feedback from the other WDTs – reports from the Goulburn are really good and have been developed via requests for change. Some teething issues for example there were no practical results to report in the first year – but the reporting was too cautious in the beginning – overall the SA team is more comfortable with the annual reporting now. In the early part of the project the report was very technical so shifted that all to the technical appendix – much improved. Added value with a synthesis chapter which has been really valuable. Would suggest this is a really good template (DN: capture point).
- The year 3 report is really starting to document trends / findings and provides some tangible / practical recommendations to inform future planning and deliveries e.g.:
 - bank erosion – CEW can continue delivering as planned as we are not having a negative geomorphological impact;
 - fish – in addition to flow-dependent spawners needing a sharp pulse to stimulate breeding events, the time of year is becoming increasingly apparent as spawning success will increase with higher water temperatures later in spring.
- As previously mentioned, the adaptive management and collaborative information exchange is working very well.
- Initially the annual reports were quite technical and a bit unwieldy for e-water managers to effectively use to inform future planning and implementation. However, a significant and effective effort has been undertaken by the monitoring providers and the selected area lead to distil the relevant outcomes for managers in a clear and concise format upfront in the report (while still maintain the robust science that underpins the outcomes – this has been shifted to the technical appendices now in the annual report).
- *Does the reporting address the objectives?* In short, yes. CEWO have developed a checklist that helps assess if the reporting requirements have been met.
- Although, I'm not sure that objective 3 (inferring Goulburn outcomes to other areas) has been addressed as the reports focus on the Goulburn selected area (DN: capture point).
- The authors and selected area lead have invested a lot of effort in enhancing the value of the reports and synthesising the results across themes.
- The impact of the reporting has meant being able to effectively communicate our outcomes and use the recommendations for future water planning and delivery (noting the comments above whereby we receive a lot of benefit via the real-time ongoing reporting throughout the year, vs. just the annual report).
- Some delays have been experienced in meeting milestone reporting requirements at times due to the high workloads. However, these delays were always communicated ahead of time and managed well, with the end products always to a high standard...so very acceptable and a good outcome. Each individual theme leader writes their own chapter and then the selected area lead collates and checks for consistency, edits, synthesises results etc.
- Operating as consortium means the reporting can be a challenge – as individual thematic chapters are drafted by various authors. This then presents a challenge to the selected area lead to edit and bring all of the findings together. However Angus does a great job linking outcomes across themes via a dedicated synthesis section of the report.
- *Comments on adaptive management:* Capturing adaptive management – in addition to emails we are also doing some case studies 2013-2015 which show adjustments made to the hydrograph and are annotated

as to why. These are mainly used internally and kept on our records management system and there is line of sight for others in the CEW to the records management system. Annual acquittal reports also capture the main adaptive management issues. (DN: see example sent by DS on 22/01/18). Angus and Geoff Vietz have published on the process in the Goulburn (DN: see paper sent by DS on 22/01/18).

Interaction with LTIM teams

- Very limited interaction with the other teams.

Key lessons over the 3 years

- Need to be flexible in the contracts – enables the teams to find the values that need to be focused on.
- Communications need to be improved – need to get the message out there. The SA are required to do communications as part of their contracts – needs to improve (DN: note wording in contract may not equate with expectations). To date this space has been very confused as the protocols around who can say or do anything re comms needs clarity.
- The collaborative information exchange is working very well and key to successful adaptive management. Access to near real-time information allows us to adjust our management approach to enhance benefits, and avoid potential negative outcomes.
- Allow some flexibility in the way contracts and monitoring plans are structured, while still maintaining robust science and ensuring longevity of monitoring data.
-
- Future planning comments:
- Currently there is a disconnect between EWKR and LTIM – EWKR is doing research to inform the why things happen, not what happened, LTIM is assessing what happened. Currently there is no (obvious) interaction between the programs – the research should be answering why things have or haven't been working. This has been acknowledged already in the CEWO and there are plans to better align / integrate these 2 programs during the next phase
- For LTIM 2 it would be good to have better alignment with the Environmental Water Knowledge and Research project (research-focus). This is because we might know what outcome was achieved via LTIM monitoring, but at times there are gaps as to why, or why not, and the EWKR project might be able to answer some of these questions to further inform water management (DN: capture point).
- It would be good to have an enhanced / dedicated communications and engagement component with clear direction / agreed protocol about who can disseminate outcomes, when and how...there have been teething issues here from both a governance perspective and a resourcing one.

Nerida Sloane (Assistant Director, Northern Basin Delivery Section) and Adam Flanagan (Northern Basin Delivery Section) – 23 January

Nerida – Warrego-Darling with recent move to Gwydir, Adam – Gwydir.

LTIM Program

- *What's working well:* Good to have monitoring to demonstrate outcomes from ewater – good outcomes.
- Highly useful for adaptive management, with considerable range of data to justify what we are doing – can point to evidence of impact.
- *What's not working well:* An objective of the LTIM program is to monitor a number of catchments with the view there would be findings, outcomes, lessons that would be transferrable to other catchments. To date we have seen very little of this. Need to communicate findings/research/lessons from different selected areas in a non- time consuming way – need to get the best answers quickly. Something like the MDB fish forum was a relatively short way of getting key outcomes from a range of studies/research and working out if there are any that are relevant to follow up. May be other options. This is an area of LTIM that hasn't worked as yet. Improve ability to get preliminary information/discussions prior to finalisation of reports to inform future deliveries, planning etc. By the time the evaluation reports are out, planning and delivery have often already commenced for next water year. While this often works within selected areas through meetings etc, there is limited learning between selected areas.

- Whole of basin reporting was to bring together the science – haven't paid as much attention to these (DN: capture point).
- The adaptive management of the project – the tweaking hasn't occurred – monitoring is done because it is scheduled but in some cases it makes sense to vary the schedule (responsive to events, rivers dry (fish). Having flexibility to vary monitoring in a sensible way would be useful.
- *Re program strategy:* More monitoring in unregulated, northern, systems is needed. For example undertake monitoring in the Narran system – fish and birds – look at identifying unregulated triggers (DN: capture point).
- *RE the program logic and rational*
- *How much interaction have you had with other teams?*
- *Thoughts on program leadership?*
- *Comments on adaptive management:* The LTIM projects have informed adaptive management in both selected areas. *BH: would having a database to capture adaptive management be useful?* It was suggested that this may not be necessary or use of resources (time to build, work required to fill it in, whether people use it) – our watering approvals approach and cross –delivery section conversations on environmental flows could be improved, but a new system is unlikely to be the most efficient way to increase shared learnings

Selected-Area projects

- *What's working well:* Interaction with ELA team –working very well. They are available and willing to provide advice and expert opinion in a timely way which helps inform environmental water use. *BH: is it worth having WD in LTIM?* Yes, it's been worth it – important to have a handle on what CEW is doing in that system – we don't have much information on that type of system so it's important to build that knowledge and highlight the outcomes in that system (DN: capture point). Whilst building an ecological baseline the program is also collecting data in response to CEW.
- *Implementation:* Need to consider funding extra capacity to do stuff – 20-30% contingency. Also remove some of the stringency so not as locked down – this would have generated better outcomes.
- *Comments on reporting:* Not really sure how much the reports are read.
- *Comments on adaptive management:* Planning meetings happen twice a year – discuss progress and water available for use and how it might be distributed for use. If LTIM suggests a new course of action then this is raised and discussed in terms of what the EAC thinks in terms of pursuing them – feeds into decisions – then there is an open committee vote leading to a motion, which is an endorsement of a particular approach, the CEWH makes the decision to use Commonwealth environmental water.
- Having LTIM SA team members in the EAC meetings is a bonus – works well. Formal reporting is not a negative, can participate at same time – with any new information is shared in the teleconferences.
- Warrego-Darling is a bit different as no formal committee – We have a decision tree for use at Toorale. We tend to get on the phone and talk to relevant people (ELA, NPWS, OEH etc) about demands, priorities, what is happening on the floodplain and the river to inform our decision making about where to prioritise use of environmental water. If we want to modify actions, try something new then we seek input to inform that decision (e.g. Warrego fish flow 2016-17). This responsiveness in Warrego-Darling is very important – but ELA are very willing to be available which is a really good thing – a reflection of the goodwill of the ELA team. *BH: planning advice is it captured?* For the Gwydir the key components are captured in the meeting minutes, feeds into OEH planning and CEWO portfolio plan – these are drafted so they are consistent – then generation of water use minutes – so overall would argue that a lot of the information is being captured at different levels as you progress through the planning phase – e.g. water operations are in the water minutes, actual management of the event is also captured.
- LTIM outcomes are captured in the evaluation reports but we also use internal acquittal reports – not publically available, but we do make them available to MDFRC. LTIM prompts automatic rethink based on

the monitoring information – not as formal in the Warrego-Darling but still works due to the people involved.

Interaction with LTIM teams

- Interaction with ELA is very good – includes emails, phone calls, teleconferences a few times a year to get an overview – also connects us with management partners all participating in the planning committee – they come to meetings (e.g. EACOAC). Also have good interaction with OEH as doing vegetation work together with ELA. Involves lots of agencies which have input into management decisions / best course of action. CEWH makes final decisions, but overall a very consultative approach with the EAC endorsing the actions. Since LTIM there has been a noticeable improvement in coordination – gives us more clout at the table.

Key lessons over the 3 years

- Working well – getting what I need to do the planning – the way that the ELA SA team has engaged in the public relations is over and above expectations – really great – lots of added value – shouldn't under value this as not all SA have this. This PR role should be contracted in LTIM#2. ELA contribute to a whole range of things – participation in committees, EWAGS, representations as well as communication material such as ELA newsletters – this all illustrates the strength of having locals who have a good reputation run the program – huge value to CEWO/program. It's all about relationships.
- To be able to just ring up and get an honest opinion – don't have to wait for something to be published.
- For the Warrego-Darling – for such a remote area having baseline monitoring occur; to just get some data is so good – contribute significant knowledge. There can be lots of challenges with a scheduled sampling program so perhaps LTIM#2 could be a bit more flexible (indicators, timing) to enable to be more responsive and meet needs in different selected areas. Need to have flexibility but also be sensible – recognise that not all SA are the same. Need a balance between getting enough baseline/standard monitoring is required at specific points in time whilst being able to respond to watering events or unregulated events. For example, it would be useful to have flexibility to undertake some optional and/or responsive monitoring e.g. to monitor western floodplain/Warrego during or after events; or unregulated events in other unregulated catchments; fish/bird breeding events.
- *Future planning comments:*
- LTIM#2 to continue and include areas such as Warrego-Darling – huge knowledge gaps need to be addressed but also potential changes if DAWR's infrastructure modification go ahead, it is important to be able to see what the impact of this is on environmental use and outcomes.
- It's important to get the establishment phase right – the guidelines set up meant LTIM#1 was too prescriptive about when and how to do things – need to consider labor intensity and distribute more effectively across most useful indicators.
- Scale of thinking – SA could be better addressed – also allow to monitor other areas in response to conditions – still within the themes, but taking advantage of unplanned events to improve knowledge base.

Damian McRae (Assistant Director, Central Basin Delivery Section) – 24 January

LTIM Program

- *What's working well:* Fundamentally important to demonstrate the value in the catchments – EWKR being combined into CEWO means it's very lucky to have such a significant investment into monitoring and evaluation – so many other programs don't have this type of investment – so very lucky to have the program. Not just the science, but also water is very political. Need to be able to defend it rigorously – water will be a significant issue over the next 20-50 years in the context of population growth and climate change so very important to have started now.

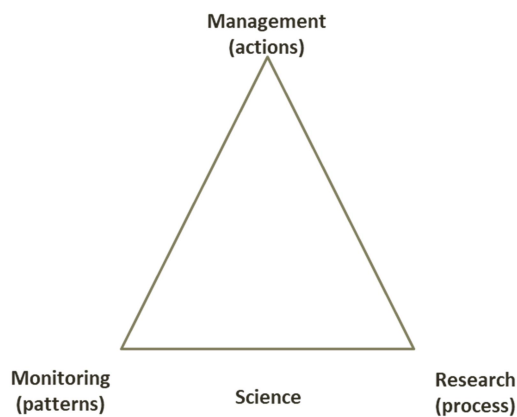
- *Re program strategy* See comment below re maintain, improve, increase. There is no line of sight from SA to the BM scale.
- In early years of LTIM Robyn was very frustrated about limited capacity to deliver larger flows (above constraints) into Edward-Wakool system. The issue of achieving environmental outcomes while working within system constraints, avoiding potential 3rd party impacts from e-water use and adhering to the CEWH's good neighbor policy is an important consideration for the CEWO. This is why proposals to trial flows in these systems, with community support, to test, monitor and revise existing constraints are critical. .
- RE the program logic and rational
- How much interaction have you had with other teams?
- *Thoughts on program leadership?* The fact that collaboration funding had to be supplied indicates there was a problem. However the reviews of the SA reports by the BM team were positive – Fiona indicated it was good to get feedback from outside the team. BH: Steering committee idea – membership from all groups – thoughts? Not sure it would work – look at the LTIM annual forum – have these worked – probably not/not effective so I don't go to them. If you have a forum you need to appeal to the audience – has to address two needs – updates on the science and provision of knowledge. Discussed how the USA is able to bring key people together at a forum to discuss ideas and produce journal publications from the same process to add to broader science community discussion and learning - why not do this in Aus? (DN: capture point but not the USA example is funded). Might want to encourage or allow the SA leads to choose who should lead the forums – not just the BM leads. Before introducing another SC why not ask Paul Marsh or John Foster why EWSAP was dissolved – need to consider how another SC would be different/better.
- I would be very surprised if among the female scientists on LTIM there isn't already drivers and commitment to increase collaboration. Hence you may not need 'another SC' - just listen to the women scientists in LTIM and EWKR about how they are doing this and if/how it can be built upon.
- *Comments on adaptive management:* Science communication is a critical gap in the current program – CEWO are waiting to decide what to do in this space – prefer to see communications in the SA teams. The LEOs are a complimentary role but not in the right position to lead this work – should be from within the teams with messages pitched to local context. Two options – done internally or via the SA teams – but there are different audiences – for within CEWO and also for the general community in the SA. Ben Gawne used to come to Canberra and meet with all the WDT for an open and robust discussion – frank and fearless conversations – these were full on open discussions but invaluable to all WDTs (DN: capture point). There are not enough discussions across the WDTs.

Selected-Area project

- *What's working well:*
- Implementation – dealing with constraints in EWK:
- *Comments on reporting:* Quarterly and annually reporting – its an interesting alignment as working through the year monitoring is still happening when we are doing the planning, or monitoring has yet to commence annual reporting for 17-18 when we are beginning to plan 18-19. Workshops look at both current and past year's outcomes to guide which way we should be going for the next years.
- Quarterly reporting is an interesting beast – no template design in the first instance – then we developed a template for the Edward-Wakool – Fiona saw it as different/extra effort (beyond contracted requirements) so not as on board – but the WDT find it very useful to connect to the wider community (DN: check differences in progress reports)
- History of reporting from STIM in the Edward-Wakool - we gave license to Robyn to change if a better / easier way for her to report in annual LTIM reports.
- Reflected on how LTIM was established. Initially providers were asked to quote on the Rolls Royce version – providers went through a costly exercise of putting in a proposal. An understandably significant amount of frustration from providers when asked by CEWO to cut those proposals back considerably as the CEWO's budget could only afford a corolla. This frustration must be avoided in LTIM2 by setting a clear budget for each SA project. Through the original tendering process science communication dropped out (DN: capture point – different expectations across WDT re inclusion in contract for PR work).
- *Comments on adaptive management:* Since the monitoring and evaluation kicked off I have had regular interaction with Robyn and more recently with Fiona as well. This happens on a regular basis – fortnightly

to monthly to see what happening. As we are not physically close to the areas being watered, the LTIM teams are our eyes and ears on the ground as watering is occurring.

- Day-to-day management decisions are not captured well – mostly in people’s heads so it’s really an interesting issue. Fine scale decisions and documenting these are important - Fiona has noted this in her 2016-17 Annual LTIM report and included a recommendation to address it. *BH mechanisms?* Key tools are the watering actions and related acquittals – but these are not necessarily synthesised into a central/key document. A live log of decisions might be an option – if a discussion and decision is made then capture it on a live log – hosted by CEWO (DN: consider further – talk to Shane). Some sort of Word based document – a live report – CEWO staff won’t be keen to be required to use another database, has to be a modification of what we are already using (i.e. 'live' acquittal reports) to ensure uptake.
- A key area that needs attention is the linkages between EWKR, LTIM#1 and LTIM#2 and how science informs management decisions – saw a talk by Brenton Zampatti that had a great slide re monitoring showing patterns, research showing process and management doing the actions (see below – with permission from BZ). Critical to have the research element built into LTIM#2 (DN: capture point) and to provide clarity about 'what is monitoring', 'what is research', 'how do monitoring and research related to each other', and most importantly - how do they inform adaptive management and the use of environmental water. I think you will find a number of our LTIM scientists view each watering action as an 'experiment' and that the areas between 'monitoring' and 'research' is grey.



"The goal of monitoring is to identify pattern, research is to understand process, and management uses both kinds of information to balance supply and demand in the long term" (Walker et al., 1995, p. 100)

Reproduced with permission from B. Zampatti. From Zampatti et al. 2017 Environmental flows and ecological response: it's not just the size of the allocation; it's how you use it. ASL presentation.

Interaction with LTIM teams

- Not enough interaction between the WDTs – need a bit of a culture change in CEWO to engage more internally – goes to maximizing the learnings and adaptive management – also links to the idea of having a live log of management decisions (DN: capture point).
- Recent Native fish forum – all the LTIM fish guys were in town – most commonly LTIM was mentioned as a source of data but not as a program that has built a community of scientific knowledge and learning – so begs the question what will be the legacy of LTIM#1 and what legacy do we want from LTIM#2? (DN: capture point). There was no acknowledgement of the project and its contribution to science and collaboration.
- The LTIM culture should be they are proud to be involved – this should be a focus for LTIM#2.

Key lessons over the 3 years

- The biggest struggle we have had had been encouraging out lead to write strong and clear adaptive management advice/recommendations re how we should change watering actions. This is gradually improving in Robyn and Fiona’s draft annual reports. Where the recommendations were close to what we needed but not quite – both have been happy for me to write the recommendations in track changes to give them a manager’s perspective and they decide if they want to accept or reject my suggestions. Some CEWO staff are not as keen to actively engage in writing writing/editing recommendations in these annual

reports. There are two reasons for this (1) CEWO staff see it as the role of the 'service provider' to deliver what they are being paid to deliver, and (2) CEWO staff believe they need to be independent of the recommendations to enable those recommendations to be of greater value to the CEWO. I don't agree with either of those reasons as they don't develop a collaborative approach with our M&E teams. (DN: Damian please check I have this right)

- An early lesson – we were overoptimistic in thinking we could achieve the outcomes that were worded as 'improve X' and 'increase Y'. LTIM reports showing that we failed to meet those optimistic outcomes highlighted the need to be realistic about ewater objectives – need to *maintain and/or support* – don't want to overreach as there is not enough flows to achieve *improved or increased* etc.
- Future planning comments:
- Essential / critical to have in LTIM#2 and EWKR teams knowledge brokers to translate research into easily consumed information. Messages will often need to be pitched at multiple scale – local context will be important. Essential to define role of knowledge brokers v's science comms as they are not necessarily the same thing. E.g. knowledge brokers may focus on translating science into adaptive management by e-water managers & science comms may focus on translating science so that it can be understood by broader local communities within the MDB.
- It should be a requirement that all WDT staff do field work in their relevant SA to have a better grasp of what its like on ground. Could also consider having the WDT embedded in the LTIM SA teams – make it live and real – not just field work, but also involved in writing the reports – co-authorship, publications etc. – this would provide huge benefits to CEWO. Having a greater on ground understanding would have helped in the design phase.
- Linked to the point above, this type of initiative could also encourage CEWO staff to more closely engage with current science. Rarely are newly published science/journal articles circulated for information within the CEWO. CEWO staff note that they don't have time to keep up to date with current scientific literature, thinking and findings - even when it is relevant and sent to them. This is a worry in itself in terms of the CEWO being a learning organisation.
- Consider options for a citizen science component – outreach component. It's important in terms of building local relationships. Natural linkages to long standing programs such as Waterwatch should be explored by the CEWO
- Need to improve leverage within the research components – partner with other programs, ARC linkage grants – value add.
- Culture and legacy needs to be addressed – Unis that run SA teams should have a network of graduates honors and masters – give young grads a space, role and voice. Should also consider mandating gender equity in teams (proactively improving opportunities for women in science e.g. 50:50 If Not, Why Not?) and indigenous component – either as an academic position. Should be encouraging a new generation of scientists after LTIM#2 so important to pay attention to the culture and legacy (DN: capture point)
- Also discussed the need to encourage scientists to be strong advocates for environmental water. Noted how climate scientists are engaged in informing the debate & policy development in the USA, how biologists are looking at approach of climate scientists to improve relevancy of their science in public sphere, and how ecologists are looking to medical science to improve integration of ecological science in decision making (translational medicine & translational ecology)

Andy Lowes (Assistant Director, Southern Basin Delivery Section) – 24 January

Written response in italics – comments made during interview in non-italics.

LTIM Program

- *What's working well*: Given the scale and complexity of the program its going as well as can be expected – multiple contracts, multi \$, site to Basin-scale – the complexity is considerable. SA evaluations are working quite well, particularly where there is a history of environmental flow monitoring. Basin-scale evaluation is starting to show promise – time delay – can't say anything for the first few years. BH: modelling unsure what it will look like. There is still some uncertainty around the Cat I and if that is the best investment – still share some concerns, BM team is doing what the SA aren't doing – looking at broader aspects – e.g. fish assemblage as a whole versus just golden perch.
- **Adaptive Management**: Selected Area evaluation reports are being used to inform adaptive management of environmental water. A practical example in the lower Murray has been the recommendation to, where possible and under appropriate conditions, allow flows to bypass Lake Victoria to improve flow

connectivity and integrity. Examples also exist in the Goulburn River, where adaptive management of flows has improved the likely success of golden perch spawning in the system. The Goulburn River team also holds a specific workshop at the start of each year to review results and see how water use can be improved in future. Not so much in the Lower Murray (due to largely receiving return flows), but in most other catchments, there seem to be plenty of examples of CEWO staff working with M&E Providers to use the latest information for e-water use.

- **Data use for multiple benefits:** The LTIM Project has been clear from the start that transparency and accountability are key to the project. All data collected are available on request. This has not been reciprocated to the same extent and often, data has been used without proper acknowledgement. However, data collected are being used for multiple purposes and the notion of making taxpayer funded data, and the products from that data, 100% available is one that promotes confidence in the work, in that the results are there to be scrutinised and can stand up to scientific interrogation.
- **Evaluation:** This varies across sites and across indicators, but there are some examples where the evaluation of watering has identified some great outcomes. Bank morphology in the Goulburn and salt export in the Lower Murray are two examples of this. To date, and perhaps largely due to the longer term nature of the project, these have been the cat II and III indicators.
- *What's not working well:* SA teams are supposed to extrapolate to whole of the SA, for example the Lower Lachlan would like to see results interpreted at whole of Lachlan catchment scale – could also look at evaluation at catchment scale. Other scale of evaluation are southern connected, Northern basins.
- The Lower Lachlan project was largely established using cat I and II methods and so they have found it more difficult than others to evaluate at the site using methods designed for the Basin-scale, let alone extrapolate across the Selected Area. Perhaps the Murrumbidgee and Edward-Wakool systems may be better examples of challenges extrapolating to the Selected Area-scale. I think they should be in a better position to evaluate to other sites within their area as they have a greater proportion of cat III methods. An interesting question to then ask is, why has this been a challenge? Is it simply that it is too difficult to do it with some certainty at this stage, or it is possible for some indicators, but not being undertaken?
- For the Basin-scale synthesis – generic diversity – this relies a lot on complementary data – but not all agencies are allowing access to data – e.g. NSW DPI fisheries won't let access to their data – could argue all publically funded data should be accessible. Unis are often the same – see it as their data and don't want to share it. To clarify it not all NSW DPI - I know Jason Thiem and Gav Buttler (NSW DPI Fisheries) have been fantastic in providing otolith data to strengthen the work Rick is doing under both the LTIM Project and the MMCP project – a really good outcome from the project. It was when I asked about data for the Macquarie that I was told we could not access it – only for the year the CEWO paid for it.
- Should consider creative commons for all LTIM products All LTIM Products are creative commons, including the data, and we have provided it to other agencies and members of the public.
- I think the challenge is how Basin Plan world (I think it is beyond CEWO) can access data for the Coorong for example, which has been funded by public money. (DN: capture point) – but also not getting access to data collected under other programs – e.g. Coorong – water only gets into this system one way – but there are separate programs and separate IP.
- If complementary data are being used they have to clearly acknowledge this and cite any sources – some LTIM reports are not doing this – each should have a section upfront to acknowledge complementary work by other agencies – also LTIM is not being credited for data used in other programs.
- The question needs to be asked about the cost/benefit of monitoring bugs (micro's and macro's) and stream metabolism for an intervention monitoring project (DN: capture point). For bugs, it seems they do something different every time and it's hard to know whether it was good/bad/expected/not expected, and at this stage, don't seem to inform the evaluation of other indicators. Do we know enough about their response to flow to pay to include them in a comprehensive intervention monitoring project? Or should the data collected under LTIM one, with a smaller continuation of some sampling be consolidated as part of EWKR or a research activity. Monitoring these comes at the expense of frogs, waterbirds for example. Is the investment in stream metabolism across all sites worth the investment? Is there a cheaper, more strategic way to do this?
- Russell Shiel from the Lower Murray has detected invasive micro's establishing throughout the lower Murray, as well as increased rates of parasitism of native species. Could these impacts at the microorganism scale be undermining fish outcomes? I'm not sure, but it seems important enough for a EWKR type project to look at. I think there is a need to better understand bugs and metabolism in the systems we are trying to restore, but is the level of investment right? Are these indicators changing the

way we deliver e-water? Does some of this belong in research? Should it be determined on a catchment by catchment basis?

- Given the indicators above are not well understood by community, in years when we don't see fish results of note, we are left with nothing to communicate publicly except 'a model showed we exported lots of salt'. Noting my comment about the need to look at the entire fish assemblage (beyond golden perch), if this occurred, then each report should discuss the outcomes from e-water on the fish assemblage (the good and the bad), even if there was no GP spawning.
- CEWO data is widely used across projects; however this is not always reciprocated. Further, the apparent strengths of some organisations during tender assessment to access historic data, has not been delivered to the extent indicated. A general feel across some projects is that during the tender, the sense was there were some teams who claimed they had (example only) 10 years of experience and data for fish in this catchment, making them a stronger candidate for the project. We then received the first reports indicating that this is the first year of LTIM and there's nothing to say about the first round of sampling. Increasing the ability and willingness for agencies to use data from multiple funding sources to deliver a better product to inform the best use of water under a world-leading environmental restoration program, is something that I don't have an answer for (DN: capture point).
- *Re program strategy*: Worth noting, that in addition to the foundations documents, there were also the M&E requirements documents which set the scope and consultation process for selected areas and indicators. If a similar process occurs for LTIM 2, then this process can perhaps consider whether the indicators they are selecting are more easily communicated, but once they have determined whether they should be used to evaluate the outcomes from environmental water use. They may be determined obsolete for existing Selected Areas, but did inform M&E plan development, so may be relevant to additional areas being considered. It may be a good opportunity to review indicators across all areas.
- *RE the program logic and rational* Drivers for evaluation questions – the logic and rational – need to map to the Basin Plan, if the questions are too hard then how are the requirements going to be addressed in the 5-10 year timeframe.
- Needs to factor in the Basin-wide environmental watering strategy (DN: capture point).
- Very limited in terms of flexibility - enforcing the standard methods reduced flexibility. The results from LTIM 1 will reflect the costs/benefits of this. My initial thinking is that having comparable data across sites was essential, but not sure the level of investment in the methods was too much.
- Changes in scope usually require a variation to the M&E Plan, or contract (if involving funds). The administrative burden of this is high, but that is the nature of having contracts. Perhaps a contingency for unforeseen circumstances should be considered for LTIM 2, but it can be tricky as there is an endless supply of monitoring (DN: capture point).
- No concern about the scientific rigour of reports. A suggestion out of the last LTIM forum was that where scientists are not confident of making a recommendation and/or assigning a level of confidence to an outcome, they could propose hypotheses questions to be tested. An idea I heard was for the forum (or another level of governance) to capture knowledge gaps for PhD research. The thinking was that if students want to make sure their PhD is relevant to managers, then this would give them a direct topic to inform e-water delivery.
- *How much interaction have you had with other teams?* Collaboration between SA and the WDTs has been the real success of LTIM – particularly real time interactions between SA and WDT. Lower Murray is a bit different as it's basically just around return flows – not quite as adaptive – but Qifeng is great – the Lower Murray is not as complex as the Edward-Wakool in some ways – overall strategic adaptive management still really good in the Lower Murray – i.e. options to bypass Lake Victoria to improve connectivity.
- Thoughts on program leadership?
- *Comments on adaptive management*: Important to note that temporal scale of adaptive management differs across the basin (DN: capture point).
- The Portfolio Management Plan sets out the environmental demands and potential resource availability scenarios each year, identifying the range of e-watering options available for the year. During implementation, what is planned operationally and any deviations from this are, or should be, be captured in the acquittal reports. The acquittal reports (or at least the operational information) should then feed into the Selected Area evaluation report (DN: capture point). Key messages for adaptive management from LTIM reports should be captured in the Portfolio Management Plan, citing the LTIM report for a line of sight to the evaluation.

- On a broad scale, I think this should work reasonably well. But does this process capture every phone call or email throughout an action? I don't think so. Does each Portfolio Management Plan include the lessons learned to the extent they should?

Selected-Area project

- **What's working well:** The results presented from the latest on the Basin-scale evaluation are looking promising for some indicators, but it's a bit too early to determine how well the Basin-scale is working at this stage.
- **Implementation:** In the lower Murray, additional monitoring was added to the contract to evaluate the effectiveness of weir pool manipulation. Other than that, very little has changed from the start. The Lower Murray team has largely cat III indicators, so have implemented methods they are familiar with.
- **Comments on reporting:** In addition to reluctance to incorporate other data, prioritising publications over producing the evaluation report, I have the following comments with regards to reporting:
 - In my opinion, there is a tendency to assign a higher level of confidence to a negative outcome as a result of e-water, than a positive. If cod spawn and recruit, it is either unknown why or it is because of something else. If carp spawn, it was because the e-water was too early, inundated fringing habitat etc. (DN: capture point). We have always said we want the evaluation to give us the positive and negative, in full, so we can learn and improve, but there is a reluctance to assign a level of confidence, even propose a hypothesis to be tested, that environmental water has had a positive outcome, which is not always evident when attributing a negative outcome to a management intervention.
 - There seems to be a disproportionate amount of focus on golden and silver perch (DN: capture point). The LTIM project was set up on the advice that these two species were flow cued and therefore, that's all e-water could be expected to influence. In some catchments, we have sometimes seen successful spawning of 5+ native species, with some recruiting, but this barely gets a mention in the report because we're not expected to influence that. Setting up our evaluation questions to focus on Golden perch, may mean we are missing out on understanding any impacts (positive or negative) on other species. In the Lower Murray, we have now seen successful recruitment of Murray Cod (EPBC listed) – something barely seen in the preceding decade - for 3 consecutive years. Is it e-water? Weir pool manipulation? Something else? We're not sure, but it's not a focus because we're only supposed to be getting golden and silver perch to spawn. On page 200 of some reports, we'll find information such as 'catfish recruits were detected'. If other native fish are spawning and recruiting while we are trying to get perch, then we should be learning from this and perhaps be considering reproduction across the assemblage for LTIM 2. This focus on the assemblage is where I think the Basin-scale evaluation is well ahead of the Area-scale evaluations (DN: capture point).
 - Context is important for the accurate interpretation of results. Including context such as hypoxia, overbank flows (for carp reproduction), is something that we continue to work with providers on. In isolation, results without context are a risk to the reputation of the project, the CEWO and water reform (DN: capture point).
 - Literature: It is easy to keep recycling the same paragraphs in intro's and discussions, but as the project matures, I'd like to see scientific teams starting to use more recent literature and even across selected areas. We're now completing 10 years of environmental watering, yet using references from 1990 for aquatic life histories (DN: capture point).
 - Synthesis, integration of indicators: Perhaps an indication of a time poor environment we work in, but the integration of results does not always seem to be given the time it needs. When setting up the project, there was thinking that flows influence hydrology, then metabolism then bugs, potentially fringing vegetation and then higher order species. Some indicators would help the evaluation of others. This does not seem to be happening to the extent expected. Perhaps it's too early, or perhaps too complex (refer to previous comment about invertebrates and metabolism being more of a EWKR focus, with some monitoring as needed) (DN: capture point).
 - Management recommendations: Management recommendations can also sometimes oppose each other. As we enter the final two years of LTIM 1, management recommendations need to be prioritised for managers, weighing up the outcomes and recommendations across themes. After extensive introductions, methods and results, the synthesis and recommendations for managers seems to be the part that receives the least attention and limited-to-no discussion/consideration across theme leaders (DN: capture point).

- Reporting is addressing objectives, but as mentioned above, there are some limitations in some areas which require continued focus (use of historic/other data sources, integration across themes, context around results etc.).
- Comments on adaptive management

Interaction with LTIM teams

- Interactions between the SA and the BM team has improved but could still be better – Paul Frazier is a key person – maximise input without reinventing the wheel – however there are strategic issues as key people like Paul and Angus are limited by the time allocated/resourced under LTIM and their availability.
- Cross themes are not specified in the contracts that they should talk to each other – the leaders and themes are not required to talk to each other. BH: SC concept to steer the next couple of years? Great idea – forum doesn't work as addressing strategic process – the forum should be a sharing forum not about making decisions. A small group and champions for adaptive management for a SC role would be good.
- Read the Goulburn reports for last two years, seen presentations from Gwydir/Warrego-Darling team 3 years running, presentations from Basin-scale team, Murrumbidgee, Edward-Wakool. Reviewed aspects of all reports in 2014-15.
- Due to everyone being busy, I don't think they have capitalised to the extent possible to produce to internationally significant papers on monitoring and evaluating environmental water. (DN: capture point)
- It would be good to resource the development of a publications register. Cataloging and quantifying the secondary benefits (i.e. contribution to e-water literature) of a monitoring project would be an interesting process and perhaps also provide a repository for teams to use some of the latest peer reviewed papers across areas (as per previous comment about literature). (DN: capture point)

Key lessons over the 3 years

- Learnings around the design process and also the governance – these are key. For stream metabolism at the Basin-scale - is it appropriate to do it quantitatively at the Basin-scale, given the differences across catchments? Or is it more appropriate as a qualitative or aggregative evaluation, which allows for flexibility in the methods used. Mismatch between areas we water the most and those we are monitoring – eg Coorong and Barmah are not being monitored. In my opinion, this is a key issue. The LTIM Project was set up on the assumption that these sites would be covered by TLM and that the two projects should complement each other. In reality, I don't think this has worked and the CEWO has found it difficult to obtain and use TLM monitoring to inform adaptive management at the two sites which receive the most Commonwealth environmental water. (DN: capture point)
- There is a need for standard methods to an extent, but is the balance right? Are some indicators worth the investment (invertebrates, metabolism) or should they be research? Have we got the selected areas right (exclusion of Coorong, Barmah-Millewa)? Is there a role for a group to evaluate actions across the southern connected basin?
- For the next couple of years continue to emphasise the need for teams and leaders to synthesise information across themes to (1) strengthen the evaluation across themes and (2) make recommendations for water use which consider the trade-offs across themes (DN: capture point).
- Determine what is working at the Basin-scale, what is not, and where funds can be saved. Similar process for Selected Areas. Should M&E requirements documents be reviewed/updated? The M&E requirements documents captured the prioritization process for indicator selection, including consultation with other agencies to ensure as much as possible that everyone was clear on the scope of LTIM, had input to indicator selection and could consider how LTIM worked with other M&E activities within the states and vice versa. I think they are a valuable record of the process and should look to be reviewed or redone (in any new areas) for LTIM 2.
- This is a world-leading, large scale, complex project which requires a lot of effort. It will require time and effort which will impact other projects, teaching, marking etc. Fundamental questions people need to consider are, are they attracted to the challenge of it? Do they enjoy working on it? Are they prepared to give the time the project needs? If not, then perhaps consider whether this project is for them. (DN: capture point – relates to Damian McRae's comment re culture and legacy)
- Hard to change now, but probably more open consultation on the standard methods.
- Future planning comments:
- Review of LTIM#1 is it meeting its objectives and review of the science – this review – but there is no independent review of the science – to review the program internally will just increase the

competitiveness – there would be significant benefit to treat equally 3rd party review – goes to credibility – have to cast outside of the LTIM team. Having the LTIM teams review each other's (i.e. SA to Basin-scale) reports is good to get a different perspective but it's not independent.

- Key consideration for LTIM#2 is the need to build relationships between different programs (DN: capture point)
- Reconsider if the boundaries of the SA are right – e.g. Lower Murray should it be extended to the junction of the Darling? Would also capture Lindsay-Mulcra-Wallpolla. This is also a TLM site, but e-water (as well as weir pool manipulation) could be having substantial outcomes at this icon site. A rec fisher in South Australia said the L-M-W was a hot spot for fish and may be contributing to fish assemblage in South Australia. The SA could also cover the Coorong. The concept of extending boundaries of Selected Areas should not just be limited to SA Selected Area. Goulburn could extend into the Murray for example, but I think whether the boundaries are right should be considered for LTIM 2.
- Strategic ownership – SC idea is a good one – feedback from the forum is its not useful as not invested across all participants.
- Communication of outcomes – the good news story – greatest challenge for both MDBA and CEWO – who uses it – if not affected by watering – SC could tackle this.
- At some point the people involved in LTIM have to decide if they still want to be involved – need to get past the legacy issues and need goodwill and investment for the right reasons. (DN: capture point).
- Where possible, trial expansions into areas such as the Coorong. Look at opportunities for providers to build in complementary monitoring, particularly of outcomes that are of broader public interest. Request annual presentations to the CEWO and MDBA. Ask people/teams do they enjoy working on this project? (DN: capture point)
- There should be a requirement for a mandatory presentation to the CEWO/MDBA once per year. Suggest this is part or fully in-kind. Agencies are sending staff all over Australia and the world to present at forums, often using LTIM data, but are not able to come to Canberra to present to the funding agency (providing 5-year, multi-million dollar funding) and directly inform the use of environmental water, even piggy-backing it with other meetings in Canberra they attend (DN: capture point).
- Statement from head of school/research organisation that production of deliverables for the LTIM project is to be prioritised over the need to publish. Deliverables, and the capacity for them to inform planning have in the past been impacted in delays in delivering the final report (DN: capture point)

LTIM PROJECT TEAM MEMBERS

Ben Gawne (Stage 1 Basin Matter Team leader and Lead Monitoring Evaluation Advisor to CEWH; 2012-2017) – 19 December

LTIM Program

- *What's working well:* Foundation; logic and rational are working well – other than the misalignment with the Basin wide environmental watering strategy (out of sync due to timing of outputs).
- Intending to prepare a peer reviewed paper on the Foundation document.
- *BH: Would you go through the same process again?* Yes, but would do some things differently. In general at the time there was the SRA and the LTIM program each representing different ends of a spectrum, but fundamentally both were seen as 'service provision' which limited the options for push back from participants in the design stage. If repeating the process it would be better to have a greater level of collaboration as the perceived lack of collaboration led to a lot of grief during the roll out phase. For example greater connections with the environmental water delivery teams (WDT) would have been very beneficial. Inclusion of the WDT would have potentially lead to a more diverse M&E Framework – may have captured variation across the Basin better having greater access to the WDT. Not totally sure if it would result in a different framework, but it may have. This would have involved aligning monitoring with the types of environmental flows that are delivered, acknowledging that delivery teams were at the start of their learning curve and some key issues such as shepherding hadn't been sorted. Ultimately this should be part of the adaptive management process.
- This was mainly due to the timeframe by which CEWO had to get the program organised. MDFRC was directed to get it up and running as quickly as possible.

- *BH: what would you do differently/change?* The scoping phase needed a greater level of engagement and communication across all participants – from SA teams, through to the WDT. Not sure if this is needed now, or a change is needed in the future.
- Acknowledging the differences in culture and motivation between the different elements (CEWO, Basin Matter team/MDFRC, Selected Area teams, WDTs) and the complexity of the Basin and Area-scale teams, is important for future program management (DN: capture point).
- *Re program strategy* At inception the intent was to consider the SA consortia as service providers, contracted to deliver specified outputs. The CEWO sought providers that included collaborating research organisations who became the leads of the consortiums. The research organisations have a fundamentally different culture to that of say a consulting company or a CMA who are more frequently engaged in M&E – the expectations are different, as are the reward systems (importance of publishing, novel research are key considerations for the research organisations). Their motivation for collecting monitoring information aligns well with the adaptive management objectives where new information informs improved decision making, but is less well aligned with LTIM's reporting objectives.
- RE the program logic and rational –.
- How much interaction have you had with other teams? Basically three levels to LTIM.
 - Operational feedback which is done predominantly via phone calls, meetings, forums, etc. and there could have been more of this in the scoping and first stages of implementation.
 - SA annual reporting - provides feedback on results with the flow of information between the Selected Area teams and WDT working well; although there are some questions around improving the evaluation process. The SA reporting often does not provide the information required to evaluate outcomes, including the CEWO water action being evaluated. See King et al. for what we think is required, but is largely absent in most reports. This is improving slowly. The benchmark/reference against which the evaluation is undertaken is often not explicit and in at least some cases is a simple before and after comparison which is confounded by seasonal changes. The Goulburn is an exception to this, but they have 10 years of data to draw on. The evaluations often address the wrong questions, specifically; was there a response? This is not enough, there needs to be some consideration of why the response happened and what is needed to improve outcomes in the future. This was the subject of the last forum, but I am not sure that what we did will have any impact.
 - Basin-scale evaluation – this is still developing but heading in the right direction.
- Communications between SA teams appears to be working well, but not as well between the SA and BM teams.
- Most of my interactions with the other projects fall into the realm of governance and are, I suppose, out of scope. It is a pity that this restriction has been placed on the review's terms of reference.
- Thoughts on program leadership?
- There are some risks in the consortium approach – the difference in culture among the groups involved is significant and has consequences for project management
- The risks associated with leadership, oversight, collaboration and governance will change, but may be greater depending on the governance model and CEWO resource allocation.
- *Comments on adaptive management:* The program is quite flexible for example the limited overbanks flows led to the recognition that waterbirds and floodplain fish were not realistic to include and so were dropped from the program. There has already been significant adaptation in terms of sampling methods, data standards and analytical techniques. Adaptation is needed as patterns of delivery change but need to be considered in context of monitoring long term outcomes that require long term data, particularly at Basin-scale.
- The transition from service provision to collaboration has been a major change in the project.
- The relationships between the WDTs and the SA teams has improved and has good interactions. An example of this is that Angus Webb is looking at preparing a paper detailing the legacy and importance of the relationship between the SA teams and the WDTs.
- Complexity also exists within CEWO – M&E, policy and WDTs with an emphasis on process and avoiding risk. There has been significant adaptation in terms of sampling methods, data standards and analytical techniques.
- Project monitoring has been undertaken by the CEWO with three major activities that engaged the Basin Matter Team (BM team)

- Regular meetings between Basin Matter project leadership and CEWO that included updates on progress, response to agreed actions and evaluation of project risks. The latter was often a low priority.
- December workshop of Basin Matter leads that evaluated the previous year's approach and agreed on revisions and adaptations
- LTIM Annual forum in July which produced an Outcomes Report. This forum provided an opportunity for review and evaluation of the project and proposed adaptations

Basin matter evaluation

- What's working well:
- The Monitoring and Evaluation Advisors guided the development of the MEP for each Area, and provided technical review of the documents back via CEWO, however not all of this advice was taken on board and or passed on to the SA teams – the review process was not fully adhered to, advice not adopted and this subsequently led to some failures in the synthesis at the Basin-scale.
- BH: With regards to modelling what is intended – it's not transparent in terms of what it will actually involve. Also there is no timetable for delivery of details on the models? Vegetation Basin matter is progressing well. Stream metabolism models are going a bit slower but progressing. Ralph McNally is working with Mike Grace. For fish, Rick Stoffels won't commit to a specific model type but is working towards a modelling approach in collaboration with other fish experts – using the data to inform which model will be used. Can't just use the ARI models as they don't have links to flow.
- Implementation:
- It's challenging to get data from the SA scale to the Basin-scale for the BM Evaluation. The SA teams are predominantly just reporting outputs/results and not providing Area-scale evaluation.
- There have been lots of adjustments to the data management/data requirements however there is no QA/QC except some minor inbuilt processes in the database. Transfer of data between the teams could have been done better.
- There is no QA/QC in the field or application of methods, and this may have implications for data quality and outputs.
- There are issues around the identification, ownership and management of risk.
- Improved understanding of the wet-dry scenarios described in the CEWO Water-Use Framework (2013, Table 1) used for water planning and intended outcomes – need to capture what the basis of the expectation for the outcome is based on – needs to be explicitly stated..
- Quality assurance – no budget allocated to this (DN: capture point)
- Operational level – adaptive management is working well at both scales.
- *Comments on reporting:* Reporting could be improved, particularly in regards to linking response to type of flow. Also going from Area to Basin-scale could be done better.
- SA scale reports do not do Area-scale evaluation – there is no extrapolation to the Area-scale. This has implications for scaling up to the basin level (DN: capture point).
- Ensure minimum reporting standards are adhered to even if these have to be negotiated among participants. There has been an argument that applying reporting standards will lead to a homogenisation of reports and undermine the perception of independence. While this may be a risk, it can be managed and the consequences are relatively minor compared to the damage done by not applying quality assurance standards (DN: capture point).
- Lack of consistency, delays in undertaking Basin evaluation as authors seek to extract and then clarify the information contained in Area reports. Most importantly, the strength of inferences that are drawn from the reports cannot be easily assessed by even an expert reader, let alone the many lay readers (DN: capture point).
- My understanding is that Area reports are assembled in sections by the personnel responsible for collecting and analysing the data. The sections are then compiled into an Area report by the Area leader or their delegate. The timeline available to undertake this work has led to the inclusion of errors around water use information and there is little integration of the information provided on each of the indicators.
- The Basin evaluation initially sought to allocate senior technical staff to undertake the initial review of the Area reports and assemble the requisite information for the basin matter evaluation. Due to a number of factors, this model did not succeed and so the bulk of each basin matter evaluation is undertaken by the basin matter lead with support from technical staff for the hydrology and metabolism basin matters. The

basin matter evaluations are then reviewed and the results incorporated into the Basin evaluation by Jenni Hale and Ben Gawne (well someone else now I suppose).

- *Does reporting address the objectives:* LTIM currently reports against MDBA EWP objectives as this is what it was designed to do. There is the capacity to translate findings to report against BWS targets, but the extent to which this occurs is not clear and managed by the CEWO
- Adaptive Management and role of reporting: annual reports - relationships between SA providers and WDT mean that this occurs, but there is room for improvement in the reports At the Basin-scale - it is not clear to what extent the information contained in the Basin evaluation is influencing watering decisions. This may be due to the way it is presented or the fact that the Basin evaluation is still developing
- *Comments on adaptive management:* Reports are now being reviewed by each team; however this hasn't been overly successful in terms of promoting a collaborative atmosphere. The purpose of undertaking the review were not clearly stated – that it was to see if the reports were fit for purpose, it was not meant to be a process for airing grievances, but this happened to some extent.

CEWO interaction

- Very good, CEWO have been responsive and flexible.
- Once again, given my role in leading the Basin evaluation team, the vast majority of my interactions with the CEWO fall under the governance heading and are therefore outside the scope of this review. I think it would be most useful, when considering the governance arrangements for any extension of LTIM, that advice be sought from project managers with experience in managing large collaborative projects across multiple, contrasting institutions. Project management and collaboration may well be skills that should be considered when assembling an oversight group.
- The transition from contracted service providers was associated with a significant and dramatic change in the roles and responsibilities of the CEWO in managing LTIM. On reflection, I don't think this was appreciated and the reduction in the number of staff managing the project and their limited experience in managing a large collaborative project across multiple institutions with contrasting cultures has affected project implementation.
- CEWO initially allocated a large number (7 I think) to oversee LTIM development, then once the contracts had been signed, this number was cut to somewhere around 2. This reduction assumed that the workload would decrease when in fact it probably increased because;
 - The change in purchasing model needed to be managed very skillfully by people who understood the challenges and new how to manage the change.
 - LTIM is an adaptive program and there is an ongoing need to evaluate and adapt. These processes require robust decision-making processes and leadership, which was not allocated.
- These issues have been exacerbated by the significant staff turnover that rob the project of both corporate memory and experience in managing collaborative M&E

Key lessons over the 3 years

- The foundation process could have benefited from greater effort in collaboration over a longer time period, but recognise the limitations on CEWO.
- Collaboration is essential to the success of the program.
- Culture differences across the teams have not been adequately addressed to date; has had a strong influence across all aspects of the project.
- Future planning comments:
- Consider adopting a Program Oversight Body – this is very important, the style would be very important to get right (DN: capture point). Appoint additional CEWO staff to managing the project making it clear that the position runs for the life of the project and needs experience in M&E.
- Undertake a strategic review of the whole portfolio.
- Basic foundation is sound. Linking responses to flows via use of conceptual models – currently there are too many hypothesis statements. To improve the models these need to be refined. Current work with Deakin University (Ben Gawne and Rebecca Lester) is investigating how manipulation of flows can be used to confirm hypothesis and lead to greater conceptual understanding.
- Need to recognise the importance of culture and cultural differences as these strongly influence how project management and collaboration are undertaken, which in turn affects outputs (differences between academic and non-academic groups). There are multiple objectives, multiple scales, different levels of

existing relationships all contributing to complexity. Collaboration needs to continue to be built across the teams. This aspect is seen as critical.

- Communications between the area and basin teams is not funded and should be. CEWO expect this to happen, but it takes time and commitment and therefore funding. This is important particularly in terms of managing risks.

Nick Bond (Stage 1 Basin Matter Team leader and Lead Monitoring Evaluation Advisor to CEWH) – 19 December

LTIM Program

- What's working well:
- What's not working well:
- *Re program strategy*: – The original vision of collecting data over a number of years and feeding that into a larger scale evaluation was strongly influenced by projects such as VEFMAP. Developed program logic, then more effort went into developing standard methods and data required. A lot of thinking went into the methods which were in turn influenced by budgetary constraints.
- A turning point in the process of developing the program was when the Selected Area process went to Research organisations who indicated/wanted input to research and direction of LTIM at which point there was a need to have greater collaboration between the Selected Area and Basin Matter teams. The original data provision role for the Selected Areas was in conflict with the research agenda of each consortium.
- Overall project management/governance connection between Selected Areas, Basin Matter team and CEWO needs work. Relationships could have been better – there are some short term opportunities to address some of this, with some already occurring (see fish example below).
- *Re the program logic and rational*: There is a mismatch between area-scale research and the Area-scale output. This could have been better if the output had been done by the Basin team. Considered a lost opportunity. There could have been a better output with higher scale analysis; the outputs from the areas-scale projects could be improved.
- Perhaps there's scope to consider the suitability of asking/answering particular questions at different scales to try and highlight opportunities for everyone – e.g. SA that only have one site – how realistic is it to expect SA evaluation?
- *How much interaction have you had with other teams?* Within the fish theme Rick Stoffels has put an enormous amount of effort into increasing the level of collaboration between the fish team members at both scales of the program. The outcomes are there is now general agreement on the approach in the fish theme and that publications will include all members as authors.
- Working groups across the themes have resulted in a willingness to 'stick with the methods'. This is an improvement from the early stages of the implementation when there were issues over the methods.
- There is a strong need for an oversight body/role. Basin Matter leads role is to encourage and distil collaboration across the Basin matter themes. Reporting to the Area-scale forums on what is happening in the Basin team is instilling collegiality which is a positive outcome.
- Despite progress on greater collaboration, there are still issues (DN: capture point).
- *BH: Area-scale teams, how do they contribute?* Need to improve the level of involvement with the Basin Matters theme leaders to have an input into the synthesis – however this doesn't have significant funding. Also the synchronisation across the scales of reporting is poor. There is a lack of mapping of reporting cycles from area-scale to the Basin delivery team.
- *Thoughts on program leadership?* There is a lack of a clear decision maker role – leadership in coordination and collaboration is required as this is not a deliverable per se in the Selected Area contracts.
- Comments on adaptive management:

Basin matter evaluation

- *What's working well*: See comment re fish collaboration between Rick and SA fish team members. This could also be an approach adopted for the vegetation and stream metabolism themes.
- The fish modelling is progressing well with some good work being done. Vegetation and stream metabolism are only just starting. Ecosystem diversity is taking simple approach focusing on just inundation extent – Enzo in the CEWO office is providing good information. This work has contributed to a revised ANAE layer.

- The Basin Matter team are now beginning to do what they intended – for example the vegetation theme is starting to make progress but that it is important to include the Selected Area teams as well.
- *What's not working well*: a potential problem in the planning stage is that we didn't state how much variability was likely to be in the results – that the signal to noise ratio will be very high and therefore it will be hard to detect changes. This wasn't emphasised enough – wasn't a clear message which will have influenced CEWO expectations with regards to when good outcomes will be achieved. "Flow variability is influencing the response" not necessarily CEWO water per se. This is not necessarily the message CEWO would want to hear. CEWO watering effecting the objectives of the program is to some extent secondary to the influence of flow variability. Variability will likely necessitate truly long-term data collection: this has not been sufficiently emphasised.
- Not sure the intended purpose of reporting is being achieved and so the impact of reporting is also not clear.
- *Implementation*: A positive change has been the Selected Areas introduced a quarterly phone meeting (largely driven by Paul Frazier and Skye Wassens).
- Nick joined the latest meeting to provide an update on the Basin Matter team progress. This has been a positive move to strengthen relationships between the area and Basin-scale teams.
- *Comments on reporting*: Some over reporting – some Selected Area reports in particular are overlong which reflects a shift in the program over time.
- Some of the reporting is overdone, overly long, and there needs to be a scaling back of annual reporting. Need to match content with the length of the report. Describing the patterns in the data in many cases does little in terms of answering the questions of greatest relevance to the CEWO (DN: capture point).
- Reports are currently prepared by each team separately but recently each team reviewed the others reports. This will hopefully lead to avoiding conflict in interpretation of outputs – seen as a positive outcome of the process. There were Terms of Reference and language guidance provided to avoid conflicts and promote collaboration.
- It may be possible to pursue options for joint authorship of some of the reports/publications arising from the program. Funding from CEWO has been allocated to both teams, and could be allocated to this end.
- Comments on adaptive management:

CEWO interaction

- Would like a closer relationship between the Basin Matter team and the water delivery team – may help in terms of explaining things. There may be a problem with what the water delivery team 'wants' to hear as opposed to what's actually occurring – they won't find some things palatable.
- Basin-scale message is not that strong, but this may improve over time - actually starting to see improvements now which is great. Basin Matter team feel they have under delivered compared to area-scale teams possibly due to the lack of connection with the water delivery teams in CEWO. Water delivery teams don't feel that the Basin team is delivering.
- Publishing of talks, papers etc. – need to be clear about who gives approval for publications. The CEWOs response has been that its fine to publish but this is not funded as the program is not about 'research'. There needs to be a level of trust between the CEWO and the LTIM teams; to trust researchers: to 'not comment' on government policy is perhaps unreasonable – for example over bank flows. In an ecological, scientific sense it's valid to note/comment that over bank flows are important. There is no clear process of achieving 'credibility' which is desired by CEWO, if not through independent peer review of publications..

Key lessons over the 3 years

- In terms of a broader narrative, it should be recognised that this is a very large program and that it is relatively new in terms of managing the water at the Basin-scale – shouldn't be understating the challenge involved.
- Future planning comments:
- Broader peer review – no harm in it, but this could be achieved by the different teams doing some of the review elements of the reports.
- Data management processes and QAQC needs a significant overhaul. The MDMS/data issues are considerable. Currently it is costing huge amounts of time and causing major delays, and poses a major risk in terms of data quality. For example I would say data issues have delayed veg data analysis this year now by ~ 5 weeks, and they are still not resolved (DN: capture point).

- QA/QC needs to be addressed and included in future. Some of the technical reporting could be scaled back, particularly the annual reporting. The function of the reporting needs to be clearer – what is the reporting providing/what function does it serve – need to specify what the reporting is for.

Mike Grace (Basin evaluation team, Stream Metabolism Lead; Goulburn Selected Area team) – 21 December

LTIM Program

- *What's working well:* Generally very supportive of the LTIM Project.
- Very pleased that CEWO have agreed to include metabolism in LTIM –probably the first monitoring program in the world to include metabolism.
- Considers LTIM to be an excellent example of science underpinning the evaluation of outcomes of management actions (i.e. e-watering).
- Happy with the way all aspects of the metabolism component is going. Noting there is considerable international interest in the metabolism results from LTIM. Mike Grace is a key member of an international consortium ('StreamPULSE', led by Profs Emily Bernhardt and Jim Heffernan out of Duke University, North Carolina, USA) encompassing North America, Europe and Australia with the task of examining biogeographical constraints on metabolism. This will help answer the key questions of 'What are "normal" rates of GPP and ER?' and 'What is constraining these parameters?'
- Most Area-scale teams are following the agreed metabolism protocols.
- *What's not working well:* There is a lack of river channel metabolism data in the Gwydir system. In fact, there will be no metabolism data for 2016-17. The problem is that the DO loggers are all in wetlands where metabolism data are difficult to obtain.
- MG has agreement with Darren Ryder that this issue will be addressed.
- This lack of metabolism data for the Gwydir is an issue because this is one of only two sites in the Northern Basin.
- Re program strategy:
- Re the program logic and rational:
- *How much interaction have you had with other teams?* Teams are generally collaborating well with MG, and are prepared to modify the program where needed (e.g. change of one sample location in Goulburn).
- Southern basin area teams are working very well, and are collecting an excellent database on stream metabolism.
- Held a workshop in early 2017 to discuss issues associated with metabolism monitoring – was very pleased that most of the area-teams were engaged.
- There has been close collaboration with the Hydrology and Fish Basin-scale groups. And also with Jenny Hale regarding the preparation of the Synthesis Report.
- Thoughts on program leadership?
- Comments on adaptive management:

Basin matter evaluation

- What's working well:
- *What's not working well:* See comments re problems in the Gwydir and actions to address.
- *Implementation:* Some sampling locations have been modified over the past 2 years.
- The model used to calculate Gross Primary Production (GPP) and Ecosystem Respiration (ER) was modified for 2016-17 as a result of new information published by Song et al. (Limnology & Oceanography - Methods 14, 557–569, 2016). All previous data was recalculated using the modified model.
- The model does not fit some data very well, resulting in these data being rejected. MG is reviewing whether the criteria for acceptance of a model fit are too conservative.
- Currently, metabolism is only reported at the monitoring site in mg O₂/L/day. MG is working to obtain additional data to permit metabolism to be calculated over a reach (will select 1 km initially).
- Additionally, MG is working with Rick Stoffels (Fish Basin Matter) in preparing a new model that will attempt to link metabolism (as a food resource) to fish populations. The broad question they are seeking to answer is: 'what is the amount of organic carbon required to sustain a particular fish population?'
- See also the comment above relating to the Gwydir.
- Regarding QC/QA - the area-scale teams do their own QC/QA checking.

- *BH: is there an accepted protocol for this?* There are NO standard criteria in the international (or national) literature for acceptance of metabolism fits. The LTIM program did agree on a set of criteria for data acceptance at the start of the program. This initially was an r^2 of at least 0.90 and a coefficient of variation in GPP of < 50%. Subsequent annual meeting discussions have added the coefficient of variation in ER and K must also be < 50%.
- Most recently (July 2017) there was discussion about using a plot of reaeration rate against discharge as an additional criterion to remove outliers. Allowing for temperature variation, the reaeration rate at a site should be constant at a given discharge. With sufficient K vs Q points, can build up a 'calibration curve' for that site. If a K value on a particular day is much higher (or lower) than that from the curve, the data point is excluded. The shape of the curve is entirely empirical as it depends on local site geomorphology. This has not yet been implemented..
- MG is concerned at the lack of nutrient data being collected before, during and after environmental watering events (has a max of 7-10 samples per year. The state WQ monitoring data are of limited use since it is not targeted at environmental watering events.
- It would be beneficial if more logger sites could be added to the program, particularly in the Northern Basin.
- Also the telemetering of the DO data to a central location would assist in reducing the time taken to get to remote sites (e.g. Darling R).
- However, the DO probes would still need regular maintenance (e.g. replace batteries, remove growth of biofilms). Perhaps local staff could undertake this maintenance (e.g. by NSW Parks staff for the Warrego-Darling sites).
- *Comments on reporting:* Has experienced some problems with delays in the preparation of area annual reports. This has caused delays with the preparation of the basin-scale metabolism report.
- MG expects to have problems in early part of 2018 with the preparation of the basin-scale metabolism report, because this comes at the same time as his major Semester 1 teaching load.
- He is currently negotiating to obtain some assistance with this situation.
- Metabolism Basin-scale reports could be made more meaningful to managers if the discussion was focused more on organic carbon as food resource (DN: capture point).
- Comments on adaptive management:

CEWO interaction

- Generally good.
- There have been some issues due to the changes of staff within the CEWO.
- Additionally, in the early stages of the LTIM Project experienced some issues as the level of understanding of metabolism was not sufficiently developed to provide constructive criticism/feedback.
- Very positive with one minor exception. Mike has twice requested permission from the CEWO (e-mails to David Papps, as David himself recommended) to share the LTIM metabolism data with the StreamPULSE consortium, but 8 months later he still has not had a response.

Key lessons over the 3 years

- Essential that all metabolism team members understand and are committed to this part of the LTIM Project.
- Also that team members are flexible and prepared to make changes when needed.
- It is difficult to achieve more than just the contractual requirements if area-scale teams are not interested in metabolism.
- The annual LTIM meeting/workshops are essential in getting 'buy-in' from the area-scale teams.
- Some broad patterns across the MDB are becoming clearer, e.g. the Southern Basin streams appear to be nutrient (P) limited, while the Northern Basin stream are light limited (high turbidity); the introduction of return flows (from floodplains and wetlands) can have a major influence of metabolism.
- Future planning comments:
- Maintain metabolism in the program and address implementation issues, particularly in the northern basin/Gwydir.

Michael Stewardson (Basin evaluation team, Hydrology Lead) – 22 December

LTIM Program

- *What's working well:* Had input mainly on hydrology but also involved in the broader thinking from the start of the project.
- For the Basin Matter team the focus on model based method was chosen because monitoring of environmental flows over multiple years – wouldn't work as a typical experimental design. A counterfactual approach was considered the best approach to take. Models also allow reporting to extend beyond sites that are being monitored to entire basin.
- This is going well; over the last year there has been some better progress – the Basin Matter leads are getting into the modelling stages: Rick Stoffles work is very promising; Mike Grace is well positioned as well.
- Being involved from inception, for the hydrology component there was a strong belief this was the right strategy and that we could get results – going through the scoping phase had confidence in that the CEWO could make a contribution. Modelling methods are already well established for hydrology.
- For the other Basin Matter leads they have had to go through a process of upskilling to come to grips with the modelling requirements – was less intuitive than for the hydrology team. However there is real evidence showing progress – the last meeting Rick and Mike were coming to grips with the challenges and this is allowing links to evolve between the themes. Not on top of what is happening with the vegetation matter. *BH: Any barrier to vegetation re eflows?* – No real barriers – extent of inundation is pretty straight forward, duration data are limited. Using Landsat imagery, but doesn't work if emergent vegetation is present. We have managed to compile inundation extent data but there is no basin-wide data on soil moisture or water depth on floodplains for the other Basin Matter leads to use in their models.
- *BH: What is driving the modelling approach?* – The modelling approach was there from the start in the program logic – but models were not fully specified at the start of the project. Recent change in leads of the Basin Matter team – Nick Bond has had more experience with modelling than Ben, so this may be a positive element of change.
- *What's not working well:*
- *Re program strategy:*
- *Re the program logic and rationale:*
- *How much interaction have you had with other teams?* Interaction with the other Basin Matter themes is starting to increase – early on we weren't able to supply needs but that is changing. Mike and Enzo are now supplying data to some of the other Basin Matter leads – e.g. Shane Brooks, Mike Grace. Mike G has requested flow velocities to convert to total loads/biomass – we are working to provide this using SRA site data.
- Mike Grace and Rick Stoffles will be interested in upstream data – this is work pending as its not easily done, but something more than what they have now. Needs are becoming clearer over time.
- The hydrology group will be presenting to the water delivery team/CEWO in February – would like to see how hydrology outputs will help the water delivery team in adaptive management.
- Thoughts on program leadership?
- *Comments on adaptive management – what aspects of the project would you change and why?* In modelling space – need skills in domain knowledge but also need to understand the modelling techniques/options – need to be able to conceptualise and parameterise the data to the methods – some of the teams may not have that full capability/expertise and this should be considered in future rounds of the program.
- Across the Area-scale and Basin scale teams there is some expertise, but there would be some merit in thinking more broadly with regards to model development.
- Advise – domain knowledge is useful, but would be best to drive the modelling from a single point – e.g. from Melbourne Uni.
- What is written in the contract for the Basin Matters is that inferences at the basin scale and evaluation of CEWO contribution will be done using modelling but it's not specific as to the type of model. This is being developed within the project but no additional budget to develop models. – This is a barrier as there needs to be greater effort in the modelling. (DN: BH: we will come back to Mike for comment re recommendations around modelling).

Basin matter evaluation

- *What's working well:* Hydrology Basin Matter is progressing pretty well as its not reliant on Selected Area Provider data. Basin scale assessment is restricted to CEWO watered valleys. The report cards produced so far are a bit turgid but provide an account of what CEWO has done on a site by site basis.
- *BH: Data provision – any problems?* No this is working well. Having Enzo within CEWO but part of the hydrology Basin Matter team is GOLD. He is great at organising and sourcing data. It's a complicated process but having someone with good access is great. He has also been able to negotiate some minor analysis of data by partner agencies.
- Limitation is existing data – The counterfactual models of streamflow do not represent buy-back and inundation data are limited to observation of maximum extents. Need to get additional data – MEWG also recognised this. For example what was the pre buy-back flows, what are other players doing, can't be evaluated as we don't have the data. MDBA has developed a method of modelling pre-buyback flows for the Murray river but this is not being applied elsewhere at this stage.
- The other problem is with regards to wetland inundation – there are some limitations. There has been some work in NSW mapping inundation extent which is automated but reliant on a third party and is just extent – most of the other data is just observation and therefore there is no counterfactual.
- *Whats not working well:* Need some dedicated work to improve the hydrological platform, both data gathering and modelling – this will improve informing operations of rivers.
- MDBA is listening but are too busy to address these needs. MEWG also agrees, but still waiting for action. Overall the hydrological working group is still dealing with complex issues but at this point are not looking to improve the modelling.
- Need to improve collaboration and alignment between the Area-scale and basin matter teams.
- *Implementation:* The methods have been adapted to some degree. At the beginning of the project the hydrology evaluation focused on basin annual watering priorities; now focus is expanded to include BEWS targets and some generic measures. Although they are important in CEWO planning. The basin annual priorities are not necessarily comprehensive of all the objectives and factors considered by the CEWO in a given year (**DN: capture point**).
- In the past the hydrology has been reported valley by valley – changed in 2017, with the report card approach in the hydrology report. Seen as a good move to more basin scale rather than valley. Annual priorities are not as front and centre as previously.
- One of the major problems is that Selected Area Service Providers are accountable to CEW but provide data to meet the requirements of the BMT. The BEMT is entirely dependent on the Selected Area Team but have very limited direct authority in negotiating data delivery (**DN: capture point**).
- *Comments on reporting:* Timing issues – there is a critical path for the basin matters team. The BMT is reliant on data from the Selected Area teams, if there are errors its checked and then updated – some delays here. Next the watering table – what CEWO has done for the year; this is not straight forward to collate as an event can be for multiple purposes, meaning it can be challenging to finalise. For example Jenny Hale has had to go back through minutes from meetings to make sure the water table is finished and accurate. Finally the hydrology data needs to be done by October/November, but is dependent on the other activities being done first. This means the number crunching is done in Sept to Jan.
- The Basin Matter Team met in December 2017, we now know what are the critical steps and the required timing; however a large part of the work is dealing with delays in getting the data.
- Timelines for reporting are planned by MDFCR leader of the Basin Matter team. Third party delays but also delays in getting the basics of the reporting right. Working out how analysis will be done in the first couple of years – this is still going on due to the nature of the project.
- Need to have clear communication with CEWO and LTIM teams – need timely communication about potential delays in providing data – key recipients of data need to be alerted to the delays so that a plan of moving forward can be made.
- Comments on adaptive management:

CEWO interaction

- Great interaction via Enzo. Significant effort being put into getting the watering action table right.
- Important lessons so far is the impact of time lags as this makes the data less current which will require more conversations and clearer messaging. So more routine contact would be good.
- May need a process to streamline data transfer between Selected Area Providers to BMT to CEWO and more specifically the water delivery team. Should be part of the adaptive management of the project –

regular conversations but informal are occurring, but need to recognise the importance of these and nurture them.

- CEWO have been incredibly flexible and supportive, They haven't been discouraged when presented with an honest point that may not be what was expected.

Key lessons over the 3 years

- Need to be better at telling a narrative with the results – needs to be engaging for the audience and this will in turn help with adaptive management.
- Synthesis report at basin scale – start with Basin Matter reports – there could be better use of the information from each matter report – they could better inform the synthesis report.
- Area-scale reporting could be improved.
- With regards to the technical aspects – a better way to do evaluation centered around a modelling approach across the Basin Matter themes. If a new program is to commence would suggest starting with a model based framework and adapt the program. If this change in approach was to be adopted it would need to begin now to be a win-win. It would also require more funding and personnel. The challenge in moving forward is ow to increase/improve alignment between the area and basin scale teams and not increase discord.
- *Future planning comments:*
- To deal with potential delays and lack of communication between the Area and Basin scale teams a single team could be used – would require different coordination. However can't afford to have misalignment across the project teams. More a CRC type model – with the monitoring team autonomous and governance – serving more than one agency. This would change investment – potentially broadening the cope of the program beyond the CEWO as the sole client.
- The standard protocols – these led to prolonged discussion with disagreement between teams in some areas. CEWO were the arbitrators, but advice given wasn't always adhered to. In contrast – the SRA approach was more successful as committees were used; careful thought all lead to the best outcome with agreement across partners. Methods, analysis data etc. all went more smoothly in the SRA. LTIM there is lots of opportunity to improve – for example the Basin Matter modelling –there is more opportunity to undertake collaboration drawing on modelling expertise across the selected area teams Angus Webb and Rod Oliver –.
- Would recommend longer and deeper discussions within themes; e.g. metabolism, flow, carbon sources, water quality site variables – the whole Basin Matter team discussed these at the last annual meeting with a good outcome – but no real mechanism to fund these meetings. May need these group discussions to last 2-3 days to tease out all the issues and resolve them.
- Whilst there has been some funding distributed to the teams, there hasn't been any way to coordinate how the money is to be spent. The Selected Area teams are considering investing in adaptive management and see the BMT as a separate role.
- The focus of the evaluation in the first stage of the program has centered on detecting and attributing the effect of CEWO on ecosystems. To date we haven't been able to ask/answer the effectiveness question – Need to switch the question to “what could the CEWO be doing better?” This would drive the models and also take into consideration the constraints, and inform adaptive management.
- There is merit in someone asking what a comprehensive monitoring program would look like and what it would cost. What is the right \$ number.

Robyn Watts (Edwards-Wakool, Selected Area Lead) – 15 January

LTIM Program

- *What's working well:* Impressed with scale and scope of this program and pleased to be involved in it – Program is impressive on a world scale.
- Concerned that Selected-Area (SA) teams were not involved in the initial development of the LTIM Project – believe that involvement would have lead to an improved Program (BTH note – the original intent was a 'top down' establishment of the Program with SA teams contracted to provide data – the Program has adapted since the start).

- *Re program strategy* – had very little to do with the process. It was difficult for some, particularly those involved in the short term monitoring that occurred before LTIM commenced as we could have contributed to the program development – shared lessons learnt. There wasn't a lot of cross over between the short and long term programs and the SA teams were basically excluded from the design phase.
- *RE the program logic and rational* – we were informed of what would happen and only at a high level. Didn't agree with everything so when we developed the MEP our project fits with the program logic but doesn't actually refer to it.
- *How much interaction have you had with other teams?* Interaction between SA teams is not structured but now occurring based on good will – Selected Area leads have regular (4-6 times per year) teleconferences – seen as essential to share experiences.
- Interaction between SA teams and Basin-Matter (BM) teams – has not been good in the past – recent improvements welcome – more involvement with fish and metabolism Matters but not vegetation – RW believes this relationship would be helped with more communication between BM and SA teams (e.g. teleconferences more regularly – but see also below).
- Progressively getting a bit better of time, but didn't have any interaction during the inception phase – we were kept separate. Still some significant improvement in some matters – e.g. fish and stream metabolism. These are more interactive between the BM leads and the SA team – much more interactive now. This hasn't happened with the vegetation matter (but my selected area is a bit peripheral to the vegetation work as not a focus in the Edward-Wakool).
- When interaction between the teams hasn't happened it has had consequences, in particular no understanding of where data is required. There has been a shift in engagement between the SA and BMT so this is a good, but not still not enough engagement. There is still a need for more engagement/meetings with the BMT.
- *Thoughts on program leadership?* Leadership of the LTIM Program is not well defined – part CEWO and part MDFRC (Nick Bond) – should be clarified.
- There is a lot of goodwill from the SA teams and this is being driven from 'underneath' (bottom up) - with efforts being put into the project that are beyond the requirements of the contract, and not funded. Even if we have done our work well, done a good job, our work is linked to the basin scale so there is a need/interest to improve input into the BMT. As academics there is a drive to do a good job, to go the extra distance to ensure a quality outcome. A genuine effort and desire to see the LTIM project work.
- The recent transition in leaders at MDFRC – Nick is new to the job but this shift in leader is increasing the interaction between the SA and BMT. Nick is prodding the BMT leads to have greater interaction with the SA, despite some contractual issues – this may require some juggling of budgets – but teleconferences don't cost that much. For example the SA leads meet on a regular basis – 6 or so times a year. This has led to other interactions between the SA teams – aim is to learn from what the other SA teams are doing.
- *Comments on adaptive management:* There have been some minor changes in the methods resulting in adaptive management of the water regime – for example with fish. The original fish design was changed resulting from discussions on how to maximise the use of resources with the whole fish team/working group being engaged – has allowed more flexibility at area level. A much more collaborative approach involving lots of teleconferences, reworking of budgets, identifying savings, and refining requirements to inform BM evaluation – got signoff at the Basin evaluation level but also resulted in more appropriate SA outcomes – all agreed, across consortium/CEWO/BMT – really good process with a good outcome.
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Edwards-Wakool Selected-Area project

- *What's working well:* Working very well from day 1 due to past learnings from the Short Term monitoring program.
- Even in developing the MEP the learnings from the Short Term project were invaluable – a lot of adaption done before LTIM started. We had a lot of insight into which sites would work, we had replication already in place. Human resources were also largely sorted as we had short term contracts in place and some really good people. Important point – the team is crucial to the project. Having a good team helps to

answer questions for the Edward River and elsewhere in the SA if want to make comments on whole SA scale evaluation.

- Considerable benefits from University involvement – involvement of high quality and highly skill staff – information is being published in peer reviewed literature (credibility) – Honours and PhD candidates linked to projects thus producing additional relevant knowledge – able to leverage additional funds for side (but relevant) projects. For example Skye Wassens and RW have several other connected projects – Forestry NSW, MLLS. Very applied on ground focus – on a personal level this is my interest, working on applied issues.
- Complex system – have been working on this system since around 2008 (before LTIM) – gaining considerable knowledge on the system and the most effective environmental watering regimes – the project team (CS Univ, NSW fisheries, Monash, etc) is working well. Stakeholder committee even engaged in MEP development, led to being able to retain certain components.
- Have a very effective stakeholder committee that meets regularly and is involved in the environmental watering decision-making – RW sees considerable advantage in that Hilton Taylor (CEWO) chairs the committee (high profile and good buy in by CEWO at local scale).
- *Implementation – dealing with constraints in EWK*: RW see this as a long-term game which requires the slow changing of stakeholder thinking. This is occurring with some perspectives from the local stakeholder committee changing and more interest in managing regimes – e.g. trials with higher flows. It's a longer game to bring stakeholders along and is reliant on good science/data. Have been fortunate in being able to collect good data on floods and a range of flows. Fundamentally about trust and legitimacy. Achieve this through making presentations on a more regular basis, including pre LTIM, but building trust by not withholding information. In recognition of this there were some changes to the original contract with the progress report format changing to be able to present to the public via CSU website – didn't just go to CEWO. The quarterly reports that go to CEWO are public documents in the Edward-Wakool. RW takes the lead on developing these. Four distinct audiences - CEWO, BMT, stakeholders and academics.
- *Comments on reporting*: – required to provide quarterly and annual reports to CEWO (see above) – places considerable demand on the SA teams (and particularly the leads) - concerned that format of the above reports not suitable for stakeholder group (too complex) – also concerned that reporting template does not permit enough detail on the outcomes of the actual annual environmental watering actions – perhaps need to review SA team reporting so that they more clearly differentiate local (area) and Basin-scale aspects.
- Internal peer review of all draft chapters occurs – CEWO also reviews reports – occasionally use outside peer reviewers (but rare).
- Unsure how the BM team obtain required information from the SA annual reports – little interaction between SA and BM teams – SA teams do not see the Synthesis report until completed – RW concerned that significant errors in 2015-16 Synthesis report that could have been picked up if SA leads were better involved in preparation – more collaboration is desirable, but not sure if this will change in current program but should be considered for Stage 2.
- Only a proportion of the data collected is used for Basin scale evaluation. We use the MDMS – no problems with this, the process is working, but not a lot to do with MDMS, had some discussions but limited.
- The timing of reporting can be difficult. Having an independent review role/committee – one with no vested interest might be a good thing to do in current project. Getting feedback on year 1-3 reports from an independent reviewer(s) could improve how we deliver the final set of reports. Given the nature of the project it might be challenging to get independent advice, but doable.
- Modelling – work going on between 3 SA teams (E-W, Goulburn, Lower Murray) to develop in-channel hydraulic models to assist with interpretation – group are meeting in Melbourne 18,19 Jan)
- *Comments on adaptive management*: Murray CMA became Murray Local Land Services, with a significant change in their core business. Their initial commitment to LTIM was a significant in-kind pledge to commit

to communicating outcomes to stakeholders, but with the change in business they could no longer maintain that commitment. Discussions with CEWO were undertaken to solve the problem with the outcome being CEWO and CSU to provide this communications role. CEWO have a greater role at the SA scale which has had a lot of benefits. Hilton Taylor has chaired a newly structured committee – some angst at first but ultimately the right decision as CEWO recognised the value of investing time.

CEWO interaction

- Program management team (Paul Marsh, Sam Roseby) – interaction working well – CEWO sufficiently flexible.
- Delivery teams - Also working very well – have monthly teleconference with delivery team – good interaction that facilitates adaptive management - RW and others are drafting a paper on this aspect.
- Interaction with the delivery team excellent – have long term staff, so they know the system well – Tom Heart and Damian McRae – see this as a big advantage. Hold preliminary discussion for water planning based on delivery team aims, includes stakeholders, OEH (Paul Child, Sascha Healy) etc. using previous years outcomes/experiences and drawing on learnings as a whole – very positive,.

Key lessons over the 3 years

- Science – major improvements in understand the system – need to increase work in the Edwards River – hopeful of more environmental flows in time. We would like to see larger flow pulses in the future, but these would still be within the channel, but would connect backwater and instream geomorphic features
- Governance – need for collaboration from the start – ‘top down’ approach does not work – interactions between SA and BM teams now improving.
- Stakeholders – having good engagement and understanding is essential. Understanding that what CEWO is communicating to operators is different between different groups – ie MIL – project is allowing us to bridge communications.
- Advantages of the Edward-Wakool system is that is starting to show trends overtime; has multiple reserves which receive different flows at different times – not a single channel system. Some of the rivers in the Edward-Wakool will have data for both with and without ewater – which informs trends over time.
- Also had the hydraulic modelling which meant able to predict what area would get affected under different flows – informs decision making as we can separate out different flow components.
- *Future planning comments:* Outside LTIM there are three SA teams looking at Cat 3 methods and the associated lessons – developing a synthesis paper to share the adaptive management. A positive spin off of being involved with LTIM are these spin-off groups.
- Broad basin models need heaps more data as there is currently large amounts of noise in the data therefore need Stage 2 as we need to have much more data. See its essential to continue the Cat 1 data collection.

Skye Wassens (Murrumbidgee, Selected Area lead) – 15 January

LTIM Program

- *What's working well:* Initial challenges – no involvement of SA teams in overall logic and rationale (‘Top down’ approach) – now improved interaction between SA and BM teams, but still a way to go. Even with some of the challenges LTIM has gone pretty well given the scope and perspective of the program.
- Framework of the Basin Plan – could argue if focusing on the right aspects. However very successful/function compared to say some CSIRO projects.
- Long history of short term projects, so having a 5 year project is good.
- *Re program strategy:* There could have been more collaboration on the foundation documents – sequenced to when people were brought onto the project.

- *RE the program logic and rational:* Not a great deal to do with the development. If the logic and rational are revisited in the future might want to do this a different way – there was a legacy of issues from the approach, but starting to be resolved for example the fish group is working better.
- *How much interaction have you had with other teams?* SA teams now interacting very well – mostly via teleconferences – still somewhat ad hoc – but largely driven by Paul Frazier who is leading this, he has been very active in bringing selected areas together.
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- Interaction SA and BM teams – improving, e.g. fish BM and increasingly metabolism, but still little interaction with vegetation BM. Tension between SA and BMT due to a bit of competitiveness between the two scales. The tension is a legacy issue – SA to Basin Matter team interactions re Cat 2 vegetation methods could be better as well – starting to talk a lot more about the methods being used, how we can link data sets together. There is more scope for groups among the SA teams to work together on more of the themes/matters.
- The interaction between the SA teams is being driven by the SA groups – we chose to do this. Still greater capacity for PhD and researchers to more between the SA, to be more inclusive, which would mean we are better placed to answer the key questions.
- *Thoughts on program leadership?* Ben Gawne was the leader at the start, but the activities of the SA groups has shifted this.
- Leadership – uncertainty about leadership in the early period of development with insufficient oversight so tension around SA-BA methods and collaboration were unresolved. Nick taking a pretty proactive approach now, and working to resolve some lingering issues– what is evolving is a form of ‘network leadership’ with various groups working collaboratively. Each have a series of leaders – CEWO, basin, and SA matter leaders. See CEWO as the client so Sam R and Paul M are leaders.
- *Comments on adaptive management:* In terms of program adaptation – the BM team have realised they need more information/input; which will require more time from the SA teams, so if not of value to the SA and they are not asked nicely – it won’t get delivered. Needs to be a lot more collaborative.
- Being adaptive when running a long term program can provide challenges – tension between long term and adaption – want to stick with things so to get a greater number of years of data. However there has been adaption around the fish methods. Would like more around stream metabolism – happening to some extent but there are financial constraints in getting this happening.
- Re adaptive management to support water planning - tend to be able to vary stuff more easily if it helps the WDT to make decisions. This is not necessarily the case with LTIM reporting as it’s a bit rigid. Learnings from the Short Term project were much easier to capture and do a synthesis report – focus on reporting how things responded to a watering event.
- At the SA scale some of the KEQs are questionable in value – we provide a lot of input to the WDT via memos about other aspects of water management – and it would be good to incorporate this into LTIM, but it tends to be done off the LTIM books. For example the optional Cat 3 methods – new methods are being developed.
- Concerns around LTIM KEQs – In some cases there is not great alignment between watering objectives at the Selected Area scale and the KEQs, we are required to provide quantitative assessment of the KEQs, even when we have not expectation that a watering even should have contributed significant changes in the KEQ. While we have the option of adding additional KEQs each year, this added a lot of additional time to the reporting process and has contributed to increasing report length. It makes sense to keep some KEQs and to look at them at the basin scale analysis because most SA won’t have matching watering objectives, but it would be useful if SA reporting could focus on the specifics of individual watering events and evaluate whether the watering objectives had been met, rather than trying to retro fit the KEQs.
- Perhaps a solution would be to keep a smaller number of KEQ that align with basin and long-term SA objectives, but allow for specific hypothesis driven KEQS to be developed during water planning and then evaluated each year, this would also make it easier to link the reports to adaptive management (DN: capture point)
- Tension between keeping the WDT informed so as to make good decisions – these don’t necessarily line up with the LTIM reporting – could be reworked at the basin level – into common KEQs, But SA should focus on WDT questions for that year. This could be included in LTIM but would require the WDT specific objectives to be lined up with the monitoring.

Murrumbidgee project

- *What's working well:* Frogs are providing good information – Southern bell frog, endangered, having good data is useful for adaptive management for this species. Vegetation is proving to be surprisingly informative, waterbirds – good, but there is a bit more needed to be done – rapid surveillance of breeding events in the Red Bank system – look at botulism issues. Would be good to have nest counts at more sites.
- Interactions within the SA team is working really well – strong benefit from past history of having worked together. We are engaging more with indigenous groups – in the next round having greater indigenous involvement would be good (DN: pick up this message). MLLS no longer involved, but strong on community engagement – would come along on field trips, supporting field work efforts – the main person involved became the LEO position for CEWO so input was maintained. MLLS not engaging hasn't been a huge change/loss.
- Some of the indicators are proving to be not very useful – wish we had the capacity not to do macroinvertebrates as they aren't very informative, also there isn't any water delivered specifically for macroinvertebrates. Whilst there may be a process to address this by CEWO – internally it would be a problem as it would impact on team structure. Metabolism is also proving to be uninformative.
- Modelling is working well – looking at fish/cod spawning we can now say its temperature driven. Zooplankton can be uncoupled from the spawning – but this may be system specific. We have spent lots of time explaining that the Murrumbidgee River is a cold, fast high running system, so it doesn't benefit from having more summer pulses.
- Need more wetland indicators as most of the watering actions are aimed at wetlands – therefore stream metabolism and larval fish not as efficient in this system. Should line up better with the common watering objectives. Cat 1 fish and metabolism are collected at specific times and there is a mismatch of indicators – showing that can get spawning on an irrigation release.
- There are a number of science issues in the Murrumbidgee – challenging dealing with wetlands – lots of levers that could be pulled, watering is often targeted at high value sites – having fixed sites – could only have data from 1 wetland despite say 20000ha being watered. Have good temporal replication but spatial is poor. Wetlands don't tend to be good spatial replicates due to legacy issues (differing antecedent conditions) . Prior to LTIM there was more flexibility to increase spatial replication. Provides a challenge as not enough data to provide a good report.
- Solution – more flexibility in design to allow for trials – separate contingency funding to pick up a proper design for wetlands. We have priorities call Cats and Kittens – Cats equate to the Cat 1 methods, kitten sites are those we would like to sample if there was funding. Rivers can be easier than wetlands with wetlands being much more complex – a lot of actions are not monitored. Overall the design is robust – have published pre LTIM outcomes – the science is fine – it's the evaluation design that's probably in need of some more work. Issues around detectability, bathymetry etc. (BH note: need to consider effectiveness of evaluation between rivers and wetlands).
- *Comments on reporting:* Too much reporting. Includes post field memo, quarterly report and annual report – the first two being the most useful and read. Challenge is that every year the reports are getting longer – don't like snappy 1 pagers, but the reporting is time consuming – not sure if anyone is actually reading the annual reports other than the reviewers. It's a challenge for the SA team to reduce them.
- *Comments on adaptive management:* Some tension between SA and BMT – BMT expecting SA to collect the data and then report on it. Now morphing into BMT wanting to look at reports and pull out information. Many of the Basin matters are not necessarily relevant in the Murrumbidgee – can deal with this two ways, can have a separate section on BM in the SA report, or have a collaborative report for basin matters and a separate SA report addressing the SA specific objectives.
- Basin leads have appeared to have struggled to determine what is happening at the basin scale – SA are more informed than the BMT. May have some SA teams involved in the BM reports. BH: SA reports – hard to focus on watering actions, seems to be a lot of hypothetical information The short term reports were much easier to write – LTIM is much more challenging.
- Adaptive management at local scale working really well – relationship with WDT has been maintained and is good.
- Considerable value adding occurring – PhD and honours students on complementary projects – share data – LTIM enables leveraging e.g. call recorders at LTIM sites. (SW to supply list of associated programs)

CEWO interaction

- Program team (Paul Marsh, Sam Roseby) – interaction working well – CEWO sufficiently flexible. Some tensions between CEWO and MDFRC directives.

- Delivery team - working very well – regular meetings (teleconference) with delivery team – weekly during a watering event - good interaction that facilitates adaptive management – but clear that the discussions and learnings are not being formally captured.
- Discussions with the WDT draw on past data as well. Overall a large time commitment but very effective and good to be involved in the process. The WDT appreciate the real time data, but not documented in LTIM reporting as LTIM not designed to capture planning. It would be good to explain this to the community so people don't think it's just putting water into the river without knowing why.
- Murrumbidgee EWAG – historical group – present LTIM work to them but not as involved in the fine tuning – not involved in the real time decision making. Good composition – community and indigenous representation, plus agencies.

Key lessons first 3 years

- Need more collaboration between SA and BMT – had it been a collaborative, team approach it would have generated better outcomes. This is starting to change, but not in the reporting as yet.
- Need to address the tensions – poor interpretation at the BM scale – considered a big issue. Improvements starting to happen with the fish group – but there has been absolutely no discussions for the vegetation group. The fish group had more workshops, was tough going, forced interaction but better outcome.
- Would be greater benefits in collaborative reporting – avoid misinterpretation, lack of citation and acknowledgement of work taken from SA reports.
- There is a huge willingness of all players but lacks a driver.
- *Future planning comments:* Leader at Basin scale needs to be able to coordinate things better and have the time/funding to do it.
- Will try to do more in multiyear evaluation over the next few years and feed this into the reporting – trying to develop more modeling linking flows to outcomes (see FW Biology paper). Need to have shorter reports and more publishing – increases the credibility of the work
- Don't change methods onground – keep for next phase to get longer data set.

Darren Ryder (Gwydir and Warrego-Darling, Selected Area Co-Lead) – 15 January

LTIM Program

- *What's working well:* The science is working well – a less positive aspect of this was the standard methods process.
- Implementing the program is going well - CEWO and SA are driving this. Sam Roseby and Paul Marsh are doing a very good job engendering trust and holding open discussions.
- The SA teams started as competitors but have now moved to being collaborators. Paul Frazier and DR initiated SA meetings, hold 4-6 per year with all the SA leads only. The intention was to help build relationships and to enable adaptive management. For example the SA leads stay for an extra day post the July annual forum. Proving to be a really positive thing that is working well. *BH: did you mean to leave MDFRC out?* Yes; the interaction has been limited – need to have better outcomes/process by which the SA and BMT leads can interact.
- *What's not working well:* In a 5 year program leadership changes are not a good thing – not a fan of changing roles midterm. Would have been better to focus on results and changing in next phase of LTIM.
- Communications across all scales/aspects – hasn't been working well and this limits the outcomes – engagement could enhance the outcomes, improve the narrative provided to the general public – this would be good. Basin matter leads – need to do the narrative effectively then need to do this with the SA teams/matter groups – to date the SA teams have been kept at arm's length and never involved in conversations re Basin-scale. Both SA and BMT are challenged as they don't have a good appreciation of the goals of each of the groups. Basin matter reporting would improve if there was engagement with the SA teams. This is definitely some that could be worked towards in this phase of LTIM (DN: capture point). For example – Nick Bond invited to attend the SA team meeting to provide an update on the leadership changes.
- Within SA – Paul F and DR initiating the SA leader meetings. Intent was informal and SA leads only. Could include BMT leads in the future – not sure how the interactions with Nick will progress given he is new to the role. No change in SA communications yet. Also shared our reporting format with the other SA teams, but it doesn't seem to have been taken up. This was done to try help the other SA groups in their reporting. We negotiated a new template in the first year of reporting – which is different to others. With

the involvement of ELA – a more business style approach has been adopted that has led to positive reporting outcomes.

- Stream metabolism standard method is not working well in the northern basin as end up rejecting >90% of the data – the data/criteria can be used differently and get a better output using the data – after three years of making this point – still not resolved.
- Do not consider stream metabolism in its current format as being suitable for LTIM2 as its being poorly managed. There are lots of opportunities to make this indicator work, with offers to have input from Rod Oliver, Ben Wolfenden, Darren – but not taken up. Critical to have this conversation now re tweaking the method as its not efficient or wise use of resources to not best use the data available (DN: capture this point).
- Re program strategy
- Re the program logic and rational
- *How much interaction have you had with other teams?* Very little with BM team. Main interaction is with other SA leads and CEWO. Need improve communication/collaboration with BM team.
- *Thoughts on program leadership? What is Nick's role?* Challenging. Not clear at present. Project management of BMT is okay, but is unclear how that relates to the SA. RE the basin matter leads – recognise it's a difficult job with possibly limited time/resources to the reporting. *Option of an independent oversight group* – Yes potentially a good idea – there is an opportunity to improve processes and governance to make things work – it could be advances as there is a very high level of goodwill – everyone wants to make it work.
- Comments on adaptive management:

Selected-Area project

- *What's working well:* Team is awesome – the partnership is working really well. The university/consultancy mix leads to the project being run more as a business process than a traditional research project process. Paul Frazier, Mark Southwell and DR meet on a regular basis. Also have well established local relationships – as the team is local and well known have been easier to get things done. Locally based teams very important for the science (eg, access to sites) and engagement.
- ELA and UNE share resources. University value adds by having PhD and graduates working on associated projects. The link to the consulting business has educated the scientists how to do better project management.
- *Implementation:* Similarity between systems – there can be a lot of water on the floodplain but only a small amount is CEW. Relatively easy to structure sampling in the Gwydir as CEW is identifiable – allows a robust design – can do pre-, filling, post filling etc. Warrego-Darling is a little less clear with regards to floodplain inundation as the connectivity dictates sampling – but still straight forward to implement.
- *Comments on reporting:* No reporting issues, but no feedback from CEWO to change format after original year one changes. Team members know what is due when – who does what, then its internally reviewed with a 2 day meeting to finalise.
- *Comments on adaptive management:* Integrating the SA groups with each basin matter lead across the whole basin would be an improvement.
- Joint Management Committee and EAC OAC (Environmental Contingency Allowance Operations Advisory Committee) both work well in terms of engagement with SA team members. DR been a long time representative on EAC OAC. Both are very good groups – respect the science - will ask the hard questions but respect the answer.
- Refined timelines a little to improve data handling. Only trying small tweaks to indicators – although we are trying to improve the stream metabolism method.
- Additions have been made due to some available resources – so did some extra works on biodiversity assessments in Warrego following prolonged floodplain inundation to assess CEW contribution (outside of standard methods), tracking of sediment and nutrient loads along the Warrego during connection – found that Warrego water can improve Darling water quality during connection. Didn't involve changing methods but CEWO was flexible in allocating the budget to other things. Major improvements to adaptively managing CEW gates for floodplain inundation of Warrego connection.
- Drafting a publication on adaptive management process within the LTIM project with the other SA leads – focusing on lessons learnt around golden perch, algal blooms, and black water events. Workshopping the paper on 7/8th Feb at UNE. The idea is to help get ideas to analyse multiyear watering patterns. The SA leads are staying an extra day after the workshop to work on the paper.

CEWO interaction

- Can rely on Paul and Sam – can have candid conversations – and have had many. The WDT staff changes make it a little more difficult – an added challenge.
- Interaction with WDT is very positive – advice from the WDT is always good, no problems with getting advice, just a challenge with changing staff – have to re-establish understanding. Both SA delivery teams have members which sit on the JCA or ECA committees – these two committees engage with the SA group four times a year. Outside of the committees then its ad hoc, usually about hydrology/delivery reports. Especially the case in the Gwydir – information on when licences are activated/called on – automatic sharing of information.
- DR has been a member of the Gwydir ECA for a long time – there is a great certainty in each year for the Gwydir – pretty much know 12 months in advance the type of watering regime – gives you power to plan. Exception to this was the recent water trading email – didn't know in advance. Not as straight forward with the Warrego-Darling – have more involvement with Parks, but they are good at letting us know when they are opening gates to get water onto the floodplain. However we have a new person on the WDT for the WD system – also the JMC is not involved as much. We can only make a guess at how much water will arrive - and only about a month in advance, but never quite sure of the volumes as Parks may open the gates u/s based on CEWO advice.

Key lessons over the 3 years

- Across all scales:
 - The way in which the program was established was not good – particularly the standard methods. Needed to be much more collaborative.
 - LTIM is about people, relationships and leadership – these vary across the scales.
 - We are not making as much as we can of internal and external communications.
 - Funding for more targeted workshops are imperative. There is really good science being done but not being communicated externally – not been done well so far. There is a lack of an overarching communications strategy between SA, BMT and CEWO – tends to be a bit ad hoc.
- Future planning comments:
- Improved engagement and communication
- Consider Basin-scale indicators done by basin teams (not selected areas) (DN: capture point). Fewer Basin-scale indicators done at more sites would benefit analysis and spatial coverage (suggest fish, birds, veg, WQ).
- SA some freedom to develop indicators to engage with local stakeholders.

Shane Brooks (Basin evaluation team, Ecosystem Diversity Lead) – 15 January

LTIM Program

- *What's working well:* The overall logic and design and initial work on the outcomes framework seems to provide a solid foundation.
- The large size of the combined project team creates some fundamental challenges, but the mix seems quite good. A few people seemed a bit prickly at the start but a culture of working towards a common outcome has developed and improved every year and is quite strong now.
- *What's not working well:* I've been surprised by the inefficiencies created by the large number of people, diverse roles, and dispersed nature of the project teams– perhaps reflects unprecedented scale of program. BH: *what inefficiencies?* The logistics of getting people together, the amount of planning and project management to coordinate and schedule tasks seems huge. Partly a function of scale and partly of it being 8 separate project teams. I wonder if LTIM could be delivered more efficiently with fewer people.
- *Re program strategy/structure:* The initial program design work was developed *a priori*, and then tendered out for implementation. During the tendering process design decisions were challenged and compromises were made as CEWO tried to balance the prescribed approach with new input coming in from multiple teams. Unintended consequences of this approach was the erosion of standard methods limiting or weakening Basin evaluation, and competing priorities of Selected Area and Basin evaluation that has at times created friction that has been detrimental to the project. There is certainly a need for improved QA/QC of data particularly since the Basin matter team is reliant on evaluating data they did not collect. Data issues raise questions about the integrity of the data collected. BH: *what alternative structure would*

you propose? You could run Basin evaluation from subgroups in the Selected Areas but this approach might be somewhat stymied by geography with such dispersed teams. I think if the Selected Area teams had been more involved in the initial design, the program might not look vastly different but there would be greater ownership and potentially improved collaboration. For example the fish groups were slow starters with many disagreements in the first few years but they have come to greater consensus more recently – initial delays, additional costs, and frustrations may have been avoided if everyone had a seat at the table at the start.

- Consultants vs. Universities have different approaches. Gwydir and Warrego-Darling appear to deliver succinctly and perhaps more efficiently as they have a culture of getting the job done for their client and share resources across two areas. Universities bring additional ideas and innovation but for these benefits there are increased transaction costs to filter new ideas and manage change.
- *RE the program logic and rational:* Difficult to digest due to the way it was written but I think the logic and approach are still valid and appropriate though it doesn't come through in reporting like it should.
- Erosion of standard methods has serious implications – has made some analysis incredibly difficult at the basin scale.
- *How much interaction have you had with other teams?* Virtually none in my role as Ecosystem Diversity Basin matter lead other than at the forums where I contribute to other working group discussions (fish, veg). I have more contact wrangling data issues across different matters in my data management role.
- *Thoughts on program leadership?* CEWO must lead strongly as they own the program, however they are also managing their own limitations and rely on the Basin matter team for advice and Selected Area leads too so perhaps leadership is quite diffuse. More clearly defined roles of a program manager and program science leader would be beneficial.
- *What about an oversight group?* An oversight group is possibly worthwhile – could come from the existing teams – formalizing this as a roll for the Selected Area leads + Basin reps + CEWO – could happen now as seeds are there. On the flip side an oversight group may mean more inefficiency if there are too many voices and another layer of management to deal with.
- I'm not exposed to all the intricacies of project management but initially the project management needs seemed disproportionate to just getting on with the job. There seems to be less 'busy work' now so it appears efficiencies have been eliminated as people in the project are more comfortable with the direction of the project and more unknowns are known.
- *Comments on adaptive management:* There is adaptive management of the project, and also adaptive management in of delivery of Cew. Both are important but when people talk about adaptive management in LTIM it's not always clear which they mean (DN: capture this point). Regarding LTIM's contribution to adaptive management of Cew delivery, there are clear local examples of watering events within Selected Areas but from a Basin perspective at larger spatial scales across valleys and longer term regime changes we're not there yet (DN: capture this point). I do think we're on track so that at end of 5 years we can start to shift the perspective from individual events to flow regimes and start looking at the spatial heterogeneity of Cew delivery. This will ultimately need a longer-term data set >5 years. I think there are lots of examples of adaptive management of the project e.g. solving problems, improving methods and evolution of evaluation approaches.
- *MDMS:* All Selected Area teams upload their data onto MDMS, but they each use their own data management systems internally then export a copy in the required formats to the MDMS. The MDMS is therefore a reporting obligation for Selected Areas rather than a tool they use for their own data management. This creates an issue whereby data are uploaded then largely forgotten about until basin matter leads then try to use it and often data issues are found months/years later that should have been rectified much earlier. For Basin Matters the MDMS is critical. It is the authoritative source of all data for evaluation and currently QA/QC is insufficient eroding confidence in the data set. The MDMS aggregates the data across Selected Areas into standard formats. For CEWO, the MDMS it's the long-term data archive.
- In the future it is expected other researches will also have access to the data. The current system is not without problems but the configuration of data types is flexible enough to keep ingesting data for future iterations of LTIM also.
- Issues with the MDMS are that the interface is outdated, overly complex to manage, and not user friendly and only works on a PC (not MAC). In practice only one person per selected area has learned how to drive it. Some better than others. Most people find using it a chore. For basin matters I extract all the data and pass to our Basin matter team.

- QA/QC is challenging - finding and fixing errors found in exported data sets is a chore. The technical ability is within the data base - we're getting better at it using it and slowly tightening up the controls so that the system works for us, not against us.
- Extracting large data sets has proved challenging this year - but the supplier is currently working with us to improve the "data extract tool". Overall it does the job, but it's hard to love it.

Basin matter evaluation

- *What's working well:* The Ecosystem Diversity matter is following the foundation plan and basically on track – no problems foreseen. Recent improvements to the ANAE and ongoing improvements in the mapping of Cew inundation improve confidence in the evaluation. CEWO and MDFRC have been proactive in resourcing a retrospective evaluation of Y1 and Y2 data to update them to the new ecosystem mapping.
- *Implementation:* No Area-scale evaluation of Ecosystem Diversity is being done and the basin evaluation of Ecosystem Diversity is not dependent on data from Selected Areas.
- Initial work on the design of LTIM placed a greater emphasis on evaluation of outcomes at larger scales (Basin and Selected Areas) (DN: capture point). To date the Selected Areas have emphasized individual site responses to watering events and have not yet embraced area-scale evaluations of the role of Cew. It isn't clear to me if this represents changing priorities of CEWO for LTIM (e.g. greater appreciation of the role of event based sampling to support adaptive management of flow delivery), the program running off-track, or just that the areas are still working towards broader area-scale evaluation of Cew.
- Providers respect how their results fit into basin scale evaluation – this is getting better and we're working better together.
- General opinions of how the other matters are tracking –seems slow, but generally on track.
- *Comments on reporting:* Impact of reporting? – no perspective on how basin matter reports are perceived – at this stage I think CEWO is the main audience not sure if all groups have time/energy to fully digest all the reporting. There is a big time delay between when water is delivered and the reporting particularly at the basin scale – this a necessary evil but does influence the types of adaptive management outcomes that reporting can contribute to (e.g. strategic program decisions rather than event management)
- Currently most reports seem too long and arguably too frequent if the objective is to understand flow regime changes rather than responses to individual events. It might be more efficient to coordinate annual summaries of outcomes in a non-report form and defer the detailed interpretation to maybe only 2 reports over the 5 year period (e.g. a short progress report in year 3 and go all out in the year 5).
- *Comments on adaptive management:* CEWO have been quite responsive to recognizing and supporting project improvements. E.g. freeing up additional resources to support multi-year evaluation of Ecosystem Diversity; providing additional funding to support greater collaboration between project teams; increasing exposure to water delivery teams.
- Basin matter team has recognized the need to have more interaction with delivery teams and this is a work in progress.

CEWO interaction

- Interaction with CEWO is good and quite frequent through my role assisting with data management
- I've not had much direct interaction with the delivery teams yet –It may be that basin scale planning is more suited to strategic Cew portfolio management rather than delivery of specific watering actions.

Key lessons over the 3 years

- The non-collaborative tender approach to starting the project created ill will that was detrimental at the start of the project but has certainly improved with time. With such a large group it's not surprising there was a diversity of expectations and the lesson is that in projects of this size and scope it's critically important to get everyone on the same page.
- Increasing the role of Selected Areas in basin synthesis has potential to smooth out some wrinkles – especially with regard to data quality and consistency.
- Adopting a common standard or format for reporting could greatly improve the ability to synthesise data across teams.
- A stronger hand to constrain scope at the start may have been beneficial - I think some teams over-promised and working under such high resource constraints can stifle innovation as there is no spare capacity to respond or improve. . BH: *coordination between groups?* I think the "us and them" mentality

created by the distinction between area and basin evaluation has created unnecessary challenges. There is certainly collaboration among groups but I don't know how much coordination of activities there is other than alignment to project deadlines and watering events.

- Future planning comments:
- Transaction costs seem to multiply as the total project team grows in size beyond a critical mass. A smaller project team with greater time committed to LTIM might be more efficient than an army of people with many competing part time interests.
- A draconian "rule with an iron fist" approach (SRA style) might also work if the logic and rationale of the first LTIM is found to be solid. LTIM#2 could concentrate on implementing the plan with less negotiation and compromise.

Rick Stoffels (Basin evaluation team, Fish Lead) – 16 January

LTIM Program

- *What's working well:* The emphasis on quantitative assessment of watering actions with the objectives stated upfront with the intent of isolating impacts of watering regimes at the scale being addressed is a world first. Emphasis is on the quality of the data and collecting lots of data – hasn't been easy but the data is speaking for itself - the quality of unbiased data is really high.
- *What's not working well:* Good progress on development of models noting it's still early days, and a bit behind where they should be – mainly due to surprises in terms of shifting scope (including challenges associated with people management), changes to standard methods and issues with data access and tidiness. In terms of reporting there has been poor allocation of time. (DN: Get Rick to expand on issues around modelling – ambitious from the inception, an enormous amount of work and poorly resourced). BH: *what's the solution to the modelling – is it a lack of leadership?* Broadly LTIM has suffered from a lack of strong intellectual leadership at the top – recent change with Nick Bond on board; will fill an enormous gap. In addition it would be good to engage a world leader to independently review some of the foundation documents – I have discussed this with Nick. Need someone to think more deeply and longer about the specific challenges we are facing (DN: capture point).
- BH: *timing of engaging a world leader?* If it doesn't change the activities, it could add further credibility; even if on track it could settle a lot of debate among the different groups and allow us to get on with the job (DN: capture point)
- Predictive tools are important for the Basin-scale evaluation – challenge is we are dealing with impacts that are un-replicated, and the use of response models is novel. We don't have an understanding of what a certain magnitude of CEW will do in terms of ecological response – without this there is a lot of hand waving in the reports – not able to say anything as yet.
- Collaboration with respect to the fish theme has improved enormously – taken four years of effort to achieve. Believe the fish data will provide very good things by year five, with more robust reports from the SA and at the Basin-scale. Probably won't deliver everything that was originally stated – SA may not be able to deliver against all objectives either.
- The project is ambitious which is admirable and the only reason why we won't deliver on some aspects is because it's an innovative project. There have been too many surprises but still some good things will come of the work in the end.
- *Re program strategy – different structure options?* Could be lots of change - for example what's Basin Matter and SA reporting responsibilities – not productive at present; there is a barrier which is artificial causing both scientific and cultural division. Rethink the objectives – CEW basin – the approach on objectives - scale the teams differently – have all basin matter team members contributing at the Basin-scale – may lead to people being happier and more productive. A more effective, efficient and collaborative model would be to, for example, have the entire fish monitoring team working together to report across all scales, but where labour is divided among processes (e.g. movement, spawning, survival, etc.) rather than scales. Currently the division by scales doesn't work as activities are repeated by different people (e.g. selected area staff analysis spawning response to flows within an area and then I do the same thing using data from all areas – also translates into duplication of reporting).
- *How much interaction have you had with other teams?* Without the SA on board from the start – there has been a huge time commitment to address this. Bringing together a lot of people working together – very rocky road, but starting to see good collaboration at the Basin-scale now.

- Comments on adaptive management:

Basin matter evaluation

- *What's working well:* Rick has spent considerably more time engaged with SA team members than the other BM leads – has invested time into breaking down the relationship issues inherited from the project inception – if the other BM leads had the time, they could possibly do this as well.
- *What's not working well:* Not likely to get answers outside of the management areas – too much uncertainty in data (cutting standard methods for spawning didn't help). Multiyear scenarios are not likely to be done for population dynamics / survival – we will likely not have the data.
- *Implementation:* Time allocation has been a problem with regards to all Basin matters – need more time allocated to writing reports and publications – the time taken to manage the data to achieve the outcomes has not been resourced properly – the budget allocated to data and evaluation is not enough. One option to address this is to do less better – the breadth of the entire program is too great – for example microinvertebrates, geomorphology – having 10 indicators is too many. The project could be cut by half and done really well – but wouldn't do this yet, but should be considered for LTIM#2. Overall resources have been spread far too thinly. (DN: capture point).
- *Comments on reporting:* Agree that reporting is poor LTIM wide. There is no clarity on who the audience is, what the reports should look like. Basin Matter reports are a dogs breakfast – the BMT is now thinking about it and who is the audience and what do we need to convey.
- Scientific validity of reports, content and presentation all needs to be done better.
- CEWO reports are posted on their webpage – what's the point? There has been little consideration given to audience, and hence the structure, content and pitch of reports. Quality can only be judged in light of objectives, and the objectives aren't there. Again – leadership is required - It hasn't been there from the beginning. LTIM needs strong intellectual leadership. That needs to be resourced.
- Penny prepared a communications strategy but it wasn't received well. CEWO wants the reports to include the technical elements.
- Recently the reports prepared by the BM team have been reviewed by the SA teams. Rick prepared a detailed response to comments, but this was never passed onto the SA reviewers.
- This year collaborated on preparing the fish matter Basin-scale report. This approach could be trialed across the other BM reports, but need to get the collaborators on board first and needs to be approached carefully.
- *Comments on adaptive management of the science:* Have been looking at the adaptive monitoring – Gene Likens papers – conform to the best practices – documented. For example – problem solving, have spent a huge amount of time focusing on the issue of sample size and adapting activities to help manage relationships. Undertook analysis to show an approach does work, which resulted in changing the sampling across all SA. Savings made by first asking what the team thinks, getting agreement then implementing the changes – about optimizing efficiencies. This process is documented in email chains, but not captured formally. CEWO hasn't done this.

CEWO interaction

- Some of CEWO staff seem to be a bit green; don't appear to be trained in NRM so this makes it challenging for them as they have little knowledge, therefore don't get critical evaluation of the project – ultimately this is not productive as it leads to them reacting to whoever. Also means they have very little appreciation of what work is required to undertake tasks. This is improving over time. In terms of clients have worked with in the past, CEWO is the most challenging to work with, but again this is improving overtime.
- SA fish ecologists questioned a lot of the methods and approach and got the WDT of CEWO on board in terms of questioning the science. It appeared that WDT responded to the complaints from the SA team members, which were then passed onto CEWO project managers (Sam and Paul), which in turn came back to Rick. Initially had very little interaction with the WDT as they have a focus on the SA level – have presented to the WDT and they are now on board.

Key lessons over the 3 years

- Top down doesn't work – hasn't worked. Taken years to resolve issues – has to be collaborative. Also need to have world leaders on board to advise based on their lessons learnt.
- Needs strong leadership – this could have been better. It's imperative to have the right people involved in the leadership.

- Being ambitious pays off – this is a real positive. Reliance on quantitative data is challenging in the current environment but we need to be able to justify water for the environment – need to be able to point to the data with confidence and say here is the evidence. There are risks involved with this approach but also great outcomes.
- Future planning comments:
- It's monitoring AND evaluation. Authorities need to stop spending 90% of funds on monitoring (data collection) and only 10% of funds on evaluation (data management, analysis, modelling interpretation, reporting). Balance needs to be established here if we want good outcomes for flows adaptive management in the Basin.

Mark Southwell (Gwydir and Warrego-Darling, Selected Area Co-Lead) – 16 January

LTIM Program

- *What's working well:* Relationship between SA and CEWO is working very well. Collecting useful information at the SA scale. Some messages to the community. CEWO were a bit sensitive about this at first in terms of checking the information before releasing it. We use twitter, LinkedIn, Facebook etc. to provide exposure on the project – this is working well.
- We are strongly involved in adaptive management and in managing with both the CEWO and others.
- Interaction with other SA has improved over time, needed to get past the competitiveness of the tendering process which led to initial hesitation to interact. Much better interaction now.
- Having one provider doing multiple things is good. There may be value in changing the model by having one team doing fish for the whole basin, one team doing veg etc. However also need concentrated input and knowledge at the SA – this relies on individuals.
- *What's not working well:* The biggest issue is the relationship between the SA and the BM team – it has improved but still needs to improve more. The approach of 'trust us this is what you need to do' – this didn't work. BH: where is it getting better? There is a willingness of the BM team to collaborate – asking the SA what we think and giving recognition that they haven't done as good a job as they could have. Some are doing better than others – for example Rick and the fish teams are better than others. Some indicators are also not as problematic. Metabolism hasn't got its act together – not a heap of confidence that it will achieve the desired outcomes – vegetation is going okay.
- *Thoughts on program leadership?* The client is the leader – but its not clear who is leading the scientific component. For example the contingency funding for collaboration – its not clear how it is intended to be used, no one is coordinating suggestions or driving it. Hard to get people on board as MDFRC is not driving it. No one knows who is driving the show. Strong leadership would surely lead to bigger gains across the project.

Selected-Area project

- *What's working well:* Both projects are generally working well – we are looking at it as 'this was the plan and yes we are getting it done'. We had some efficiencies in the Warrego-Darling which we were able to spend the money doing other things – CEWO was very happy with this as value added.
- The consortium is working really well – based on a solid history of working together; for example we are able to collaborate with OEH and as we undertake combined sampling on different projects by sharing staff resources. Also gives us leverage with OEH in terms of sharing data. We also have a strong focus on communications – newsletters, twitter, presentations etc. Not specifically funded – most is done by ELA staff – don't use a communications specialist.
- *What's not working well:* The nature of the Basin-scale indicators – e.g. fish monitoring is the same across the whole area, but this doesn't work as in the Gwydir there is a mismatch between flows and sampling times – overall they are not flexible enough. We did propose other options but these were not accepted. Cat III fish work but the Cat I fish doesn't. If local representatives had been included this would have been a better outcome.
- Fish currently takes 1/3 of the budget for only 1 indicator out of 10, and the data will not have a high degree of confidence – need to rethink this. BH: *would a different model with less indicators work?* Agree - need to consider the methods, cost, public perception and do the indicators respond to water. Models need to be more robust for fewer indicators then will free up funding for more targeted work at the SA scale.

- *Implementation – any challenges?* The Gwydir is working well – not so much of a challenge – Warrego is different kettle of fish – cant plan in advance. Once water is in the channel we have some flexibility but down the Darling – the impacts of entitlements and take in an unregulated catchment makes it more challenging. In the modelling it's hard to calculate the past level of extractions – acquittal numbers are not delivered until after the report is due.
- Technical problems – water quality probes, always an issue in low flowing turbid systems – they foul up quickly and stop working, NSW Park have been very helpful – we can call on them to check probes some times. Currently dealing with replacing a \$20K probe that got washed away – this didn't help.
- The vegetation basin report – Sam had to reanalyze the data to make it consistent – double handling of the data. Means the vegetation data is being told in three ways and possibly with three different stories – risk that the answers are not the same across the different reports.
- *Comments on reporting:* Lots of late nights – and lots of effort put into this despite only a very short amount of time being allocated to the task. There are some bottlenecks in the timeline for delivery of reports, but overall no problems with either the progress or annual reports. Some of the SA areas have a different approach to delivering the reports – some will over deliver and others will just say the client gets what the client wants. More broadly the delay in getting the Basin-scale reports out to the public is significant as they are obsolete in terms of adaptive management. Need a mechanism to speed up the flow of information to the public. BH: comment on audience? In the Gwydir there is a strong interaction with the Environmental Contingency Allowance Operations Advisory Committee (ECAOAC) – our best interaction is on a face to face basis during the planning process. Very few of the ECAOAC would actually read the reports – we have a CEWO representative on the ECAOAC so interaction and exchange of information is in real time – therefore more valuable. To completely streamline reports then the audience has to be 100% CEWO, not include the general public, however the style of report is an issue. Quarterly progress report to CEWO – the others do theirs differently for different reasons. *BH: if more collaboration with BMT would the annual reports be different?* Probably not – don't consider Basin-scale matters at all when writing the reports.
- *Comments on adaptive management:* Adaptive management is not formally captured – haven't tried to do this. The annual reports are mainly arm wavy statements – CEWO push for more specific statements by the scientists tend to shy away as they want more confidence in the data before saying anything concrete.

CEWO interaction

- Interaction with project management team (WDT) really good relationship – know them well and have personal relationships – consider them flexible and we have a lot of good conversations – open well engaged, knowledgeable in the area.
- Warrego – the WDT had very detailed understanding of the system – Adam in the Gwydir is a bit more easy going. High turnover of staff for example Nerida changed to the Gwydir. Don't have as much interaction with Bruce Campbell.
- Interaction with Paul, Sam, Karen really good – Karen has been very helpful particularly in regards to the MDMS.

Key lessons over the 3 years

- Collaboration early in the process if you don't have it then end up in the situation where it's taken three years to develop. Openness brings trust (DN: capture point).
- "It's a bloody great project" – ambitious so no wonder it had a bumpy ride – really unique opportunity to get some really good quality data.
- Future planning comments:
- Don't change the sites, need to value add to the data already in hand, but could consider new sites. Definitely don't dump all the current sites for new ones.
- Wouldn't hurt to rethink the program logic – need to increase the number of sites in the northern basin so as to improve the confidence in data for the northern basin.
- Need to have greater interaction with the Basin matter leads – this will help avoid failures.

Angus Webb (Goulburn, Selected Area) – 16 January

LTIM Program

- *What's working well:* Across the SA things are working well, reasonable communication has emerged through an informal process – the collaboration funding has been useful in this space; but we were already talking beyond what was required in the contract requirements.
- Like having a voice – being able to speak on, and be associated with a substantial program. Really at the cutting edge – this isn't currently acknowledged and should be. There is no program like this anywhere in the world – having the focus on the large scale is a real positive.
- CEWO has had a major success in getting 5 year contracts – working really well.
- *What's not working well:* Lines of communication between the SA and the Monitoring Advisors – we hear rumors of poor funding, which might be an echo of the early top down approach. Need standard methods to do the large scale data – but not sure that they hit the sweet spot. Will need to work towards getting the best outcomes and this will require managing expectations between the two teams. For example in year 4 there are still problems/grumbling in the fish theme. Not sure how to solve the problems between the providers and monitoring advisors. The challenge is at what time do you stop the conversation and someone makes a decision – too many opinions/voices can also be a problem. Stopping the conversation doesn't mean acceptance – e.g. Wayne Koster managed to get light traps changed, and still keen to argue that fyke nets shouldn't be used – he has little faith in the data from the fyke nets. Would like to get otoliths involved, but has stopped arguing. For LTIM#2 need to have early conversations around methods so that it's in place re having a final decision (DN: capture point). Important though not to give up on the idea of standard methods. If each SA were allowed to do its own version of adult fish monitoring, then those data might work well for local scale assessments, but could not be easily brought together for basin-scale assessments. Given one of the requirements for LTIM is an ability to make predictions of outcomes for areas not monitored, then the large scale analysis is essential. We (collectively) need to continue to be ambitious in this area.
- The lead time on the Basin evaluation reports – not seeing these until nearly 2 years after the water was delivered. If the Area-scale reports are delayed then this has consequences for the Basin-scale reports. BH: not really a collaborative process. Fair enough statement – specific complaint is that results are misinterpreted/misused by the Basin team, which is to some extent understandable as they may be under resourced. Collaboration funding may be able to address this. The additional funding has too targeted purposes for the SA – to fund reviews of the Basin-scale reports. Only nominal funding for reviews in year 3 but more allocated in year 4 and 5. Second – collaboration activities in general – vague description but was used to run a workshop on adaptive management in Canberra during 2017, and a forthcoming workshop at UNE on multi-year data analysis with the SA, Basin matter team and the MDBA.
- Re program strategy
- *RE the program logic and rational* The goal to have Cat I methods to be evaluated and analysed is a good one and should NOT be lost – would hate to see LTIM devolve into a SA based series of programs. We don't want to lose this – don't want to be less ambitious (compared to what happened with VEFMAP when ARI took over). The same thing happened with IMEF in NSW despite the initial plans for large-scale analyses. So it's a challenge to stop this from happening and we can't be complacent about it.
- *How much interaction have you had with other teams?* No idea of how the data is used – we put it into MDMS and it gets chunked up, but I haven't looked in detail at how the Goulburn data is used in the BM reports. BH: *is there a need for a process on how data is used?* Had thoughts about it but walked back from this idea. Basin-scale hasn't evolved to big scale models as yet – could improve so waiting to see. BH: *thoughts on using skills from SA in Basin-scale?* There is a timing issue, and it would need resourcing. For example stream metabolism is world leading – but its capacity is limited as Mike Grace simply doesn't have the time to do all the things he'd like to with the data. We have a paper coming out of the adaptive management workshop held in Canberra last year – we will work on this a little at the Feb workshop this year – but it is time consuming and it's difficult to fit in these valuable, but ultimately 'non-core' activities. It's partly about leadership – it adds value from an academic point of view but it's not core business in LTIM.
- *Thoughts on program leadership?* Good question – don't have a good answer. Being an academic I have never had to work in a rigidly structured process. Gentle leadership from Paul Marsh – he has been very supportive and open. Ben Gawne was in a hard spot being having to be the advisory team lead as well as keeping MDFRC afloat – imagine he was very hard pressed. So in terms of who is ultimately leading/responsible – Paul Marsh.
- *Comments on adaptive management:* Adaptive management is working well for most selected areas within watering years. There are good partnerships between the water managers and monitoring teams

that allow the monitoring results to inform decisions within years in near real time. At the yearly scale, several of the selected areas are providing formal inputs to the Seasonal Watering Proposal process. In the Goulburn, we do this through a yearly workshop around February, and it's working well. I'd like to see the LTIM results affect new rounds of environmental flow assessments in the selected areas and other similar systems, but these processes happen on a decadal scale and there is a lot of inertia towards existing consultant-delivered approaches like FLOWS.

Selected-Area project

- *What's working well:* The Goulburn River SA is working very well – gratifying to see the professional network have influence on practice. Unique in naming and including the CMA – embedding them in the project team. The GBXMA host a workshop every February which reviews the previous year's results and provide a stakeholders perspective on the seasonal water proposal - pretty effective and enjoyable relationship. Shorter scale monitoring involved – e.g. advise on the timing of flow to hit golden perch requirements. Always saw the GBCMA as a partner.
- Understanding is improving rapidly, i.e. golden perch well understood, could consider moving \$ into something else.
- The science manager collaboration is a real winner. Hubs and spokes model – 4 discipline leads then data fed to Melbourne Uni – data analysis is undertaken – we use the same approach across the indicators – this has been a real success story.
- My main role was in data management and analytical skills – this is working well within the project but also personally learning a fair bit about ecology.
- *Implementation:* Going really well in the Goulburn – field work is going well. *BH: would you do anything differently?* Probably not – at year 1 yes, but not now. Completion of annual report is challenging – hard to get content in a timely fashion – means falling behind; if we were audited it would show we were not on time in delivering the report – data finalized okay – then everything needs to go right to hit the end of August.
- *Comments on reporting:* Haven't looked at other SA reports (all areas confessed to this at the Armidale workshop) – may be worth a look (DN: capture point). The style of the reports is a bit of a problem/annoyance – the contract specified the style/content but every years its come back with requests for more information – this year talked to Kerry and Sam and the year 3 report is shorter, down to 30 pages plus appendices.
- SA group therapy sessions organized by Paul Frazier have been useful for gauging whether different SAs are having the same experience particularly around reporting – i.e. ballooning report size. (
- Early in the project we had twice yearly hook ups with CEWO – these are not done now – its in the contract, but CEWO are not sticking to it. However the reports were in danger of getting too hard to read. The contract actually has some quite definite words on what each section of the report is meant to cover, and they make good sense. It was the reviews from CEWO that were asking us to go beyond these and to repeat content among sections. However, to their credit, when I did push back this year, the arguments were accepted to the benefit of the report I believe.
- *Comments on adaptive management – is it being captured?* The annual report has a short section on adaptive management. The April workshop is disseminating the knowledge learnt at an Area-scale – could be improved, but not sure how. Needs to be addressed – Fiona Dyer had to search across a range of reports for information that she could use – if we could solve this issue it would be groundbreaking – if we can find a means of capturing learnings across projects and getting those learnings out to other SAs (DN: capture point).
- *Knowledge broker* – Could be a good thing – we identified the need for a 'reflector' to be within a team as a check on success/progress – may also need a 'disseminator' – there is a real need, and potential to get the knowledge out there better (DN: capture point)

CEWO interaction

- Mainly with Paul Marsh and his team – very little with the WDT other than with Kerry Webber the contract manager), interaction with CEWO project management is very good on whole – good relationship.
- CEWO has been better than expected in terms of being flexible, might not always be good outcome, but very responsive. Strong appreciation for what teams are doing on ground.

Key lessons over the 3 years

- Would be reluctant/guarded to move away from a top-down approach – would consider this a disaster. Agree that it's hard to arrange large scale coordination but the project needs to remain ambitious at the large scale to have a robust outcome – has to be large scale.
- Future planning comments:
- Need to be brave re LTIM#2 – lots of effort/endpoints to decide if all remain good values – metabolism for example is not showing good results as yet, so shouldn't be limited. Adult fish – 2025 outcomes are we going to learn anything more – fish is a big part of the budget. Need to take a hard look at what is and isn't working. Taking some risks would be good.
- I think LTIM2 needs to be a bit more definite on the expected time scale of response of different variables. Our current projects recognize 1 and 5 year expected outcomes, but we're expected to report annually on 5 year expected outcomes! If we were a bit more solid about reporting on those aspects that we expect to respond quickly (mostly ecological processes and what Rick Stoffels calls 'means' variables), then we could just stick to collecting (or even not collecting) data for which we don't expect to see a change for years (e.g. adult fish assemblages). These are the 'fundamental' objectives. By defining those a bit better, we might have some better chance of making the argument that we are seeing the types of changes that we're expecting and on the time scales we're expecting.

Brenton Zampatti (Lower Murray, Selected Area team) – 16 January

LTIM Program

- *What's working well:* Initiative is fantastic and unique, but a few issues with the construct of the project from inception. SA providers were presented with protocols and whilst there were some discussions, the Cat 1 monitoring techniques were mandated. In the Lower Murray we were always concerned that the Cat I indicators were not going to be able to meet the objectives of the LTIM project - a sentinel/condition monitoring approach was being applied to an intervention monitoring question, thus causality could not be determined. This was never resolved (DN: capture point).
- In terms of collecting the Cat I data and handing it over – that has worked well.
- Re program strategy
- *RE the program logic and rational* Feel that MDFRC is not clear what modelling will entail. *BH: Rick and Nick Bond are still confident but not demonstrated as yet* The approach used for LTIM Cat 1 appears to be similar to that initially used by VEFMAP – a generic large-scale approach that did not work – it's now evident that Victoria has moved to intervention monitoring (testing hypotheses) – specific questions in specific rivers, the results of which can be integrated.
- *How much interaction have you had with other teams?* Rick Stoffels is integrating the data and the interactions have been more two way conversation than before – but still unsure about the approach to evaluating the Cat I data.
- Interactions are getting better, but not there yet. Its very hard to change the structure at this point – therefore LTIM#1 has suffered from not being a truly collaborative approach. Not sure how much this can be addressed in LTIM#1.
- *Thoughts on program leadership?* This has been lacking particularly scientifically. – Have a large group of fish experts, and whilst communication has improved, this expertise has not been effectively utilized from the outset. Many of the fish leads from the selected areas had similar thoughts about the mandated approaches and provided constructive critique of approach. After spending a large amount of time providing initial input we received very little feedback.
- Comments on adaptive management:

Selected-Area project

- *What's working well:* Cat III questions will be able to address CEWO/LTIM objectives – these are working well, but, as yet, few positive fish ecological outcomes from environmental water delivery (given delivery regimes we have predicted this from contemporary ecological conceptual models). From a SA perspective we have interacted with Paul Marsh, Sam R, Andrew Lowes and a host of other CEWO staff, and they have indicated they are happy with approach to Cat III and outcomes. CEWO is interested in the narrative, not just the science, and the adaptive management story. For example we have been able to show that although ~1000 GL/annum of environmental water has been delivered to the lower Murray over the past few years the fish community transitioned to a drought community – not a great ecological outcome, but we understand the mechanisms and this contributes to learnings.

- *Implementation:* Lower Murray SA is different to the Goulburn or Murrumbidgee as its not as easy to manipulate the flows in the Lower Murray – 1000 gigs is a lot of water, but when smeared across a highly regulated flow regime it doesn't substantially change the flow regime, nor hydraulics of the weir pools (i.e. the river is still not a river). So not much of a response is expected. *BH: what is achievable with 1000GL?* It's not clear yet – but learning this in itself is important.
- *Comments on reporting:* The original construct was for MDFRC to do the Basin-scale – BM report. Still unsure about outputs from this, but it appears that MDFRC are also integrating info from selected area reports as part of BM reporting. In the interim we are using some of the Cat III data which is not captured in the Basin reporting. *What about SA scale evaluation?* Now looking more broadly at the SA data and Cat I data – have been requested by CEWO to provide some temporal analyses of patterns and provide commentary on mechanisms behind patterns. Cat III data has much broader application and has provided a positive platform for interstate collaboration – big positive. Similar to EWKR and also the intent of Hume to Sea programs (**DN: capture point**)
- *Comments on adaptive management:* There is a lot of talk about adaptive management – but don't see it being formally implemented – it is occurring in some instances, but still not captured. The concept of using LTIM for adaptive management is plausible, but in reality e-flow management tends to be more ad hoc, spatially constrained and informal. In the lower Murray, the delivery of e-water and its interaction with consumptive water is complex – also many players e.g. state, commonwealth (MDBA and CEWO) and the upstream states. Relationships across players are complex. Difficult to see how LTIM is guiding the adaptive management of e-water in the lower Murray. Having said that, we are learning from LTIM, particularly Cat 3 and this knowledge is being applied (just that it's mostly informal). In future, consolidating with other programs such as EWKR and LTIM#2 will be critical.

CEWO interaction

- Interaction with CEWO is quite good overall – comes down to the individuals involved. They are hungry for information and thinking big picture – Paul Marsh, Nadia Kingham, Ryan Breen – all have been great. Driven by David Papps, so unique in recent times. It's a big project and at times the reporting requirements can be onerous, particularly for selected area leads.
- WDT – good interaction and communications directly with them from a science and information perspective. We have a SA working group which contributes to environmental water planning also ad hoc meetings which aren't formal. Turnover of staff can be an issue – i.e. loss of Ryan Breen.

Key lessons over the 3 years

- Model used at outset was unique, we were more used to a much more collaborative approach – but this is starting to improve.
- Impressed with the scale of the initiative – 5 year process, very ambitious
- Regardless of meeting assessment of CEW, the learnings will be significant – not so sure about this for fish at the Basin-scale, but overall learnings will be great.
- LTIM is facilitating interactions between researchers, science, and managers despite the original project construct. These interactions are being driven more by individuals in selected areas rather than formally through MDFRC.
- Future planning comments:
- Would adopt a EWKR approach in terms of leadership team – being based on merit. Still needs leadership by an organisation but overall it may be a better process.
- Would be a good idea to have an independent review process – project needs a critical scientific review.
- A model going forward would be specific working groups and a central figure. LTIM#1 has been lacking this all along.

Paul Frazier (Gwydir and Warrego-Darling, Selected Area Co-Lead) – 17 January

LTIM Program

- *What's working well:* Selected areas (SA) seem to be getting on with their stuff and interaction between the SA is good.
- In the Gwydir and Warrego the community/stakeholder engagement.
- Interaction between the SA and the CEWO.

- *Re program strategy – what would you change* Fewer Basin-scale indicators with data drawn and collected from more sites.
- More autonomy for selected areas to develop a sound scientific program for the SA with less Category I constraints.
- Much more focus on teamwork and collaboration from the outset. If we have a system diagram then each arrow should be two headed.
- Much more focus on communication, particularly from people in the field.
- *RE the program logic and rational* Oh god this was a very hard document to penetrate, can we make it more accessible?
- How much interaction have you had with other teams?
- Thoughts on program leadership?
- Comments on adaptive management:

Selected-Area project

- *What's working well:* The SAs seem be nailing their tasks
- Internal communication and good will seems to be improving. At this stage I wouldn't change anything – we have to make this project work and work well.
- *Implementation:* Right now we should be getting on with our stuff and doing our best to make all aspects of the program work – so not much to change
- The contracts are fairly set so wiggling requires good will and trust between the SAs and CEWO - this has worked ok for my two SAs
- The overall program structure was set up to be quite rigid – this has/had pros and cons but ways to be a bit more trusting need continual effort. For us we have continued to tweak methods and sites at a micro-scale, our reporting approaches have evolved and we expect that to continue, we added more sites in
- We added considerable efforts for comms and engagement and internal LTIM team collaboration has started to evolve as a focus.
- Probably find out how the MDMS is being used and its effectiveness – it is a lot of effort for what feels like isn't effective, but I have a SA perspective only.
- We have focused strongly on engaging with the other SAs to improve our work.
- We get a little view of the Basin-scale at the annual meeting and via reports
- MDMS seems to have been troublesome and I am not sure of its value
- *Comments on reporting:* No comment – going as planned. Internally creating the report gives us a focus – but not sure who else reads them.
- Our reports are written primarily by the field team and leader then reviewed by the project directors in an iterative process. The CEWO then reviews and provides comments (these have been fairly small so far). Lately the Basin Matter leaders have provided feedback too.
- We don't need to have to have all people present at all things or review all things, we need sensible approaches to team development and collaboration and multiple teams that may form and reform for different tasks
- *Comments on adaptive management:* Some extra funds/focus on specific tasks as issue have arisen, there has been modification to some of the standard methods and we have increased monitoring site numbers as we found in-project efficiencies
- Selected-area and Basin-matter interactions: Relationship improving but still some way to go – needs more effort and probably a person to lead closer collaboration.
- I'd increase focus on collaboration strongly to try and help solve some of the more complex problems especially with multi-year approaches – we have some allocation now we need a suite of great ideas at multiple levels to get together and work together.
- Increase effort in communication and engagement – this is beyond the current scope but we need to find ways to get out there. Important that the entire LTIM team work toward closer collaboration – without this no meaningful changes will occur – PF believes this is yet to become a priority
- Believes that the BM team members still have some way to go before they are a real team – they weren't set up as a team to start and this is a difficult process – believes this is partially due to time constraints (some B-M members have too little time commitment to the project).
- Concern that there is still no consensus on how the Basin-scale evaluations will be done, i.e. what models will be used to bring the data together.

CEWO interaction

- Good, once we established 2 way trust and we did that early this has been good.
- Love it - they are enthusiastic and intelligent people – clearly they enjoy their work.
- The CEWO staff rotate around a lot and that adds complexity to interactions when we have to form new links and understandings quite regularly.

Key lessons over the 3 years

- This is a hard task.
- More comms and collaboration from the start.
- More focus on people interactions from the start.
- Future planning comments:
- Up up up the focus on communications both internal and external. Find ways to help the teams engage as broadly and effectively as possible - try and keep trying to build team cohesion and collaboration - if we can do that we all win.
- If the intent is to continue LTIM, PF believes there is a need to start to planning next year – perhaps starting with a facilitated workshop involving key players from CEWO, MDBA, MDFRC, BM teams, SA teams and some external.
- Need for recognition that the Basin-scale integration and evaluation is difficult and has not been done elsewhere in the world.
- There is a need for a robust review of the current LTIM program to establish what has worked and what has not worked in relation to the overall objective of LTIM, which is to evaluate the role of Commonwealth environmental water in achieving the ecological outcomes of the Basin Plan (DN: capture point).
- With regard to Basin-scale monitoring suggest the criteria for selecting indicators should be:
 - Scientifically meaningful at the Basin-scale (i.e. can be related to CEW) – suggests this would be limited to: fish, vegetation and hydrology/water quality (perhaps also some water bird monitoring);
 - Can be monitored at sufficient spatial and temporal intensity within the available budget.
- Has some concerns about the usefulness of the Cat 1 indicators and locations – the fish monitoring utilises approx. 1/3 of the monitoring budget.
- Also concerned about the Basin-scale models that are to be built (fish, metabolism, vegetation) – little discussion of what these will look like, the feasibility of their development, and the usefulness of them in answering the key question regarding the role of CEW.

Ross Thompson (Lower Lachlan, Selected Area team) – 18 January

LTIM Program

- *What's working well:* Huge pot of information – robust, useful, unique world data set. Massive value achieved through having good data sets.
- Networking at the SA level is really working well – a big positive. This has emerged and matured compared to the start of the project. Now have pretty good relationships and much more interaction between agency staff and other researchers. LeRoy Poff noted there is nothing like this project elsewhere.
- *What's not working well:* Hard to judge Basin-scale evaluation as not evident yet – time and space factors – delayed outcomes means not able to do the evaluation at the larger scale. The emphasis on the basing perspectives is not realistic – harming the good efforts at SA scale. Some matters are not suited/realistic for ecological systems – the narrative at the Basin-scale is not working – practically this is really difficult to achieve, but stick to the current program for the remainder of LTIM#1.
- The type of modelling required for the Basin-scale evaluation is of such a scale that it would be world leading and basically MDFRC doesn't have the skills to do this (DN: capture point). It's easy to conceptualise as your only dealing with generalities but these become meaningless. Contingencies at small scale but need huge scale data – its an astounding thing to do so just end up with generalities. Integration of SA data may be useful at the catchment scale but not likely at the Basin-scale (DN: capture point). Catchment, northern, central and southern basin – you are layering contingencies so it boils down to being meaningful at catchment scale.
- Resources have been spent doing the wrong things – Basin-scale evaluation focus has compromised the SA work as it had to fit into the Basin-scale methods.

- *Would a review of modelling done now be useful?* Yes – would need to manage expectations with CEWO, but getting the likes of LeRoy Poff, Ralph MacNally and Eve McDonald-Madden (UNQ) would be very helpful.
- *Re program strategy* Conceptualisation was good – the front end built off other projects – the downside was there were lots of parties involved, but that's how it was done. The procurement model affected by CEWO was a reflection of them being an immature procurer – this has had its consequences as it affects a lot of other elements. For example the reporting – Fiona has approached in a consulting sense, others will do lots of extra work, others will do the minimal or what best suits their own interests. Therefore the first round of reports were a mixture – we received grief from CEWO and the difference between Universities cause some ill will. LTIM#2 – it would be a mistake to adopt a similar process (DN: capture point). Analogy with the MDBA – they have struggled in terms of knowing if they want to be a procurer or a partner – hasn't been consistent which makes it difficult to engage with them. CEWO wanted a partnership but purchased as a consulting job.
- RE the program logic and rational
- *How much interaction have you had with other teams?* Very limited interaction with the BM team – not clear what they are trying to achieve. Forums make it worse as they have tended to be a bit dark/gloomy. Part of the problem is there are constraints placed on what the SA team are allowed to do, but they also don't have confidence in what the BMT can do with the data (DN: capture point).
- Thoughts on program leadership – Nick's role? Nick is well equipped to bring about a cultural shift/different narrative in the BMT and MDFRC. Past leadership was unlikely to be able to successfully lead the model development – but this may still need additional expertise (see other comments). Agree LTIM needs more clarity around project management and scientific leadership.
- Comments on adaptive management:

Selected-Area project

- *What's working well:* Fiona Dyer has been doing an exceptional job building networks, managing the team – full credit to her for leadership. Transactions of leadership is very high - the project is being treated as a monitoring prospect not a research project. No ARC-linkage grants, but we have lots of PhD students working in the Lachlan – so they value add.
- *What's not working well:* Reporting and CEWO attitude to reporting – we are not doing the extra stuff that some others are doing, also negative feedback on style and context, scope reach – both have improved in the last year. The reports are awkward documents – contracted to include the technical elements, then there is scope creep to do the narrative – overall the reports are not great
- *Implementation:* There is a bit of a perception that the project is failing – an engrained negative which is a bit of a problem. This was turned around in the past year (DN: capture point).
- *Comments on reporting:* Internally within CEWO there is a tendency to criticize other reports from other SA and try to play them off against other SA. Not profession and can lead to ill will. We need professional consistent advice presented to the SA teams (DN: capture consistency point).
- Tension was what was the 20 pages to say in year 1 – 1 data point – cant say much. Audience is not the public – that was the tension.
- Need a separate person tasked to write the 1 pager – this shouldn't be the SA team responsibility (DN: capture point).
- Independent reviews are a good option to improve the reporting.
- *Comments on adaptive management:* Really good conversation between WDT at the local level. Ongoing and real degree of trust which means they are prepared to undertake experimental manipulation of flows. OHS delivery team has the interaction with the CEWO WDT, we don't have direct interaction. The interactions taking place feed into the seasonal water planning process. BH: is adaptive management being captured? Significant question – we are building a business case around a consistent set of questions around the Murray – What is needed is a real time matrix of knowledge that can be shared with others – if you have a particular flow, in this type of ecosystem it can be rated as red, green, yellow – the matrix is updated as we learn – basically proposed a knowledge framework – as a key tool for use in water planning and management. Shown it to MDBA/CEWO and DAWR.
- From a selfish academic position the opportunities to publish are considerable – joint papers across the SA teams; there are some very interesting possibilities. We could learn from the Americans – they do this very well, but its funded well. CEWO has the option to do this which would enhance the credibility of the

project – but currently this is not budgeted and people are time poor. It would need to be funded to succeed.

CEWO interaction

- Going well – took a while but got there.

Key lessons over the 3 years

- Can coordinate at large scale with partners to get a usable data set but needs to be realistic.
- Narratives should be developed early then refined over time – hooks people in.
- Face to face time invaluable. SA leads meet too infrequently – needs to be more funding to promote meetings across SA and researchers. The collaborative funding budget is not enough – need to have onground teams get together to kick round stories and ideas – gives the start for general insights.
- Knowledge exchange team needs to be funded. If initiated in the current LTIM#1, and run a conference where talks are longer than possible at the forum – will get to value add to the outcomes. The current format of the annual forum is missing this opportunity.
- Future planning comments:
- Don't cast aside LTIM#1 – it's a good project. Whilst it had a difficult beginning it is more important to focus on what will be achieved – which will be substantial.
- If starting over then could look at adding 1 or 2 additional SA but don't sacrifice the existing SA.
- Consider Basin-scale reporting outputs – dashboard to show response to Basin-scale – 4 or 5 gauges is the way to go, but with more SA/catchment scale indicators rather than focusing on Basin-scale indicators (DN: capture point – relates to rethink of basin matters/evaluation).

Jennifer Hale (Basin evaluation team, Generic Diversity Lead) – 18 January

LTIM Program

- *What's working well:* Difficult to answer. Feel more positive in this past year as the models are starting to kick in – starting to get a better feeling from the whole BMT – the first two years there was no data – couldn't really provide anything – starting to change in year 3.
- *What's not working well:* Standard methods were not adopted – there was a clear vision at the beginning of the project but this has shifted. Data now sites better with SA watering and assessment of specific events. Cat I methods were not fully applied consistently – fish Cat I not well placed in river reaches as don't necessarily receive Commonwealth environmental water and maybe not “representative” of the zone – there was a lot of competitiveness which was disappointing. *BH: Standard methods and top down left SA feeling disenfranchised.* There was a lot of consultation, there could have been a lot more arguing than we have had – fish has had a lot more collaboration at the beginning. In the beginning of the project Tim Wyndam was clearly in charge of the project – he made a lot of very definite and very decisions – he had a very clear vision for the project. Then Tim left and there was a fair bit of turnover of staff in CEWO – our expert review of the MEPs didn't get picked up – it didn't get through to the SA. The project lost direction, current team within CEWO may not have the same vision. Paul and Sam try to keep the project on track but may not have Tim's original drive or vision.
- There was a scientific advisory group but it got dissolved – it had a role in reviewing products and was intended to help guide CEWO. Advice is hard to share, for example communication for BMT to CEWO is through the MDFRC so some things may be lost in translation. In the scoping phase while EWSAC was still around all material developed had to be presented to the committee.
- It's surprising how little money goes into the synthesis reporting – 6 days general and 10 days synthesis – there is no budget for BMT get together in this allocation. This may or may not be an MDFRC choice / allocation of budget. That's above my pay grade.
- Re program strategy
- RE the program logic and rational
- *How much interaction have you had with other teams?* I'm a bit outside of this as I'm more involved with the generic diversity – it's not an indicator the SA have to collect data for specifically. Waterbirds onground team there is good interaction – they are pretty cooperative and happy to send data / reports. From the rest of the SA I don't see evidence of a lot of interest in making a contribution to BMT – the last two forums it has been thinly veiled aggression. *BH: is it a legacy issue and that the SA were not shown the BM*

reports – could be better if SA were involved. Then why wasn't any BMT invited to the workshop in Melbourne recently?

- *Thoughts on program leadership?* Paul Marsh is the leader, but I am not sure if it is not active leadership – I am distanced from day to day governance. I assume Paul attended the SA meetings, but the outcomes don't trickle down to me.
- Comments on adaptive management:

Basin matter evaluation

- *What's working well:* Nick is taking advice so we will be having a meeting in April to do interdisciplinary stuff – discuss what the big picture is – however there is always the timing issue. Its planned for a 2 day meeting to foster conversations – more conducive to evaluation and doing the synthesis report.
- *What's not working well:* Probably still not working as a team – individual silos and a get together once a year in December so that meant we couldn't talk about data. Each person dealt with their own matter and then passed it over to me to do the synthesis. I can't write a decent integrated evaluation in isolation.
- *Implementation:* I get the data from MDMS, collate information from other reports – TLM etc. I don't really do any analysis – that's not my job. Would interact more if they were making inroads in relation to integration of data from SA to catchment to Basin (DN: capture point). BH: *is there real potential to get outcomes at Basin-scale – should it be catchment, integration instead of modelling?* Mike Grace is very excited re southern connecting basin and getting an output at large scale.
- MDMS is very clunky – Shane has to extract all the data as anyone who uses a MAC or old software can't access it. Very little QA/QC – there is absolutely no auditing. For example Sam Capon had a lot of problems with the data – multiple species spellings – there are no audit procedures about anything. Also can't access large data sets – nothing above 20K records. We strongly recommended an audit procedure be put in place in the scoping phase but it was not adopted.
- For the generic diversity matter I'm using lots of other sources of data, water operations, ad hoc data, acquittal data, Ramsar site information e.g. Hattah outside TLM monitoring.
- Big gap in the northern basin – no avenue to source data for QLD – so the reports are a bit biased (DN: capture point).
- Knowledge exchange is mainly in the forum setting but this may miss people as not everyone attends. Govdex is used quite well – but you can't access all teams areas – SA and BMT can't see each others sites (DN: capture point)
- *Comments on reporting:* Gwydir and Warrego Darling are easy to read, but maybe light on for detail – Lower Murray and Goulburn putting a lot more effort and thought into the reports. However, I get the impression that CEWO likes Gwydir and Warrego-Darling format and the easier to read style (getting that information third hand).
- Synthesis report goes to the Senate Estimates – has to be written for high level managers in the CEWO or a Minister and the general public. The Appendices are too technical or dense for public consumption, so the high level synthesis probably gets read more.
- Basin matter reporting – this year it's being done differently – April workshop.
- *Comments on adaptive management:* As far as I am aware nothing from the Basin Evaluation or BMT has been adopted to change the way in what water is delivered (DN: capture point). RB: *what about strategic large scale long term sequencing – if no LTIM would it be different?* No evidence of change with BEWS/BP. Interactions at the SA scale might be okay, but not the larger scale. We were told in the past absolutely not to link the Basin-scale evaluation to BEWS (DN: capture point). BH: *Edward-Wakool, Goulburn, Gwydir – doing okay.* At the local scale there may be some learnings from how water should be managed. For example at lunch time a conversation was had around water actions to outcomes – learnings not being captured at the local scale – just report on the next set of outcomes. There is no scaling up of watering outcomes to the Basin-scale – are we doing strategic thinking re watering actions at the Basin-scale?

CEWO interaction

- More now – the initial direction from MDFRC was that CEWO were not to be bugged by everyone – this lead to some missed messages. For example CEWO are supposed to deliver a summary of all the watering actions, but wasn't being delivered in a timely fashion – this year I took over and did the table in a few days then got CEWO to approve the final product, with some direct contact with Sam Roseby. It seemed to work better.

Key lessons over the 3 years

- Hard question – the data base is not the best.
- Model of separate SA teams and BM team may not be the best option – I’m biased a bit but I’m not sure academics were the best choice to be involved as leads. To date it appears that the Uni’s haven’t implemented all the standard methods or reported on the outcomes of CEW in a standard way. Separation of research needs from monitoring is important and maybe not occurring consistently across all SA.
- Need to capture more of the adaptive learnings from the project.
- Future planning comments:
- Needs a different model – but there would be a lot of resistance to changing – needs strong leadership from in CEWO.
- Need a scientific advisory group as can’t expect CEWO to be tech domain experts – needs independent oversight. Strong drive/leadership from CEWO is important.
- CEWO decided not to fund certain indicators (e.g. birds, tree condition) – these decisions may need a rethink.

Ben Wolfenden (Murrumbidgee, Selected Area team) – 22 January

LTIM Program

- *What’s working well:* The project has brought together a lot of very skilled and experienced people with a common goal and I find that reassuring. It’s hard to see how well the broader project is succeeding. I’m not an area lead so not in a lot of the conversations – not sure how much information flows to operation staff (DN: capture point).
- *What’s not working well:* Focus on experience with the Basin Matter metabolism – I think the way the project was initially conceived was limiting, particularly for a relatively new field like metabolism – I feel like the selected area members could have contributed a lot of essential local knowledge when defining what was possible regarding the initial experimental design and research questions. The entire process doesn’t seem to have been carried out transparently and the SA teams weren’t given enough of an opportunity to help. A better approach would be to collaboratively distill the overarching objective (which is vague) into a testable set of questions, and then design experiments/analyses to answer the questions. The current design doesn’t achieve this – the objective is too descriptive therefore not achievable (DN: capture point). The key step of distilling the objectives into predictions didn’t happen. People are trying to fix this. BH: who is fixing it? Nick is making a lot of really positive changes. There have been technical issues preventing the project from moving forward and I don’t think there was a lot of time allocated for Mike Grace to address these. The project is now moving towards a conceptual model and answering questions and that’s a good outcome. There have been ongoing technical issues relating to daily flows and metabolism. BASE varies in its ability to return usable data among the selected areas. It has worked okay in the Murrumbidgee but in other places it only dealing with 10% of the data. BASE2 has not fixed this problem. The acceptance criteria could be fixed, but that’s basically about your tolerance for more variable data – but that’s not a good solution. BASE itself doesn’t consistently fit models across data – sometimes failing to fit models to data that are otherwise fine. Not having a continuous timeseries of data will likely change the kinds of questions that can be answered and the way we approach our analysis.
- Re program strategy:
- *RE the program logic and rational:* See comments re metabolism indicator
- *How much interaction have you had with other teams?* There is no active collaborative process, other than at the forum. The people involved in the selected areas have inherited a problem – for example Mike is not adequately resourced – they should have used all SA experts but they didn’t have ability to be collaborative due to the way it was set up. I have friends and colleagues in other SA teams and that promotes interaction.
- *Thoughts on program leadership?* I guess its Nick (from the technical LTIM perspective I see and interact with). I expect some of the SA leads are also leading behind the scenes – tends to result in ad hoc collaboration in the past. More collaborative processes are now planned and that’s good. The forum is too much feel good stuff with only ½ day allocated to talking about the issues – but there is no time to actually find the solutions, just identify problems.
- Comments on adaptive management:

Selected-Area project

- *What’s working well:* Skye is great – good whole of team operation.

- **Implementation:** In the Murrumbidgee it's still not clear if the way we're measuring metabolism has the power to answer the questions I expect we want to answer – we may not see a response because the thresholds that flows need to exceed, at the right frequency and timing, aren't being captured by the dataset. This is largely due to water delivery constraints that are more of an issue than we thought initially. Need to change expectations now in terms of what can and can't be achieved (DN: capture point). I think there needs to be more funding to work on this issue. Developing the BASE technical modeling capacity further won't solve all the problems – the testable research questions aren't defined – what effect size are we targeting with eflows, can the current approach detect that level of change? Without this we may not be able to show a result. Can't do more sampling and this won't change the outcome – need to explain the narrative clearly.
- **Comments on reporting:** From the beginning there appears to have been little coordination across selected areas – how they should be written, structure, what they test, what they look like – done in conjunction with the WDT. Too much variation in appearance/content among SA reports and, apparently, not good uptake. Mixture of trying to support the science and justify the program – but without peer review and exposure to target audiences it doesn't quite seem to be achieving either. This is a considerable use of resources that needs to be addressed (DN: capture point – very strong opinion re reporting) – from the discussions I've had/heard we all agree that the reports need to be shorter, on message, directed to the target audience.
- **Comments on adaptive management:** A key point to capture in terms of program learnings is that expectations need to be managed in terms of why a non-answer is still an answer (DN: capture point). Non-answers are sometimes more difficult to explain and justify.
- Very strong focus on adaptive management in Murrumbidgee SA – after each field trip we write a short memo with the key outcomes – a 1 pager which is sent to all players. Also the progress report is housed on the website – shared with everyone – this seems to achieve advertising to a broader audience than the annual reporting.

CEWO interaction

- Most interaction has been with the WDT. In the past the WDT staff can change so different advice is received which can be an issue. Has been good consistency in recent years.
- Overall very good – e.g. interaction with Sam and WDT. They're professional and responsive.
- I worry that the CEWO doesn't understand how Unis and consultants work – for example there is the misconception that the SA team members would expand the work being done through either good will or self-interest (DN: capture point). This is true to a degree, but need to realise that this occurs when there's incentives (publication). Publications are happening behind the scenes, it just takes a while.

Key lessons over the 3 years

- SA team working very well – providing lots of advice in real time and is a solid success. This happened organically as a result of previous (STIM) projects run by Skye. I think we've learnt lots that could inform LTIM#2 and WDT to have a better program – including being more flexible particularly with regards to fixed vs variable wetland sites. Could look at LTIM#1 as a pilot study and use the information to improve LTIM#2 (DN: capture point).
- Currently LTIM#1 is not being adaptively managed – it's too static (DN: capture point – cross ref to lack of process evaluation).
- Having an independent oversight group is essential – can't adapt without this (DN: capture point). There could have been an external steering committee or the CEWO could've expanded the role of its independent scientific committee.
- Future planning comments:
- Future planning for LTIM#2 should start now; focus on project design and analysis.
- Essential to keep the program going. Given the limited resources and delivery constraints, I don't see how the broader program can succeed without monitoring to inform adaptive management.
- Need to flag and address transparency – the legacy of inception – easy to criticize but should be addressed and not repeated.

Qifeng Ye (Lower Murray, Selected Area Lead) – 22 January

LTIM Program

- *What's working well:* Overall the hierarchical basin wide then SA approach – the program logic and rational – the SA design and considering how things progressed – these are going reasonably well. Southern Connected is working well as is the short term work. We've interacted with CEWO water delivery team, and other water managers (MDBA/DEWNR) well regarding providing our knowledge input for the adaptive management of eWater in the southern connected basin
- Goodwill between the SA leads and use of the collaborative funds is leading to cross fertilization of ideas – moving beyond LTIM to some extent.
- *What's not working well:* concerned with the basin-evaluation. It seemed a fair bit delay for some of the indicators/BM leads to find appropriate methods to evaluate basin-wide outcomes. Although we all acknowledge the challenging nature of this work, perhaps improved collaboration between BM leads and SA team may help to better solve some of these problems. However, this kind of communication/interaction is limited probably due to initial resources allocation. For some indicators (e.g. fish and metabolism) – there have been problems but there has also been improved engagement. Additional collaborative fund has probably helped.
- Some issues may be beyond fixing if the project design is flawed – for example with the fish basin matter – Rick is trying to do his best, but had there been a joint approach between the SA teams and the BM team at the project design phase, then we probably would have been starting with the right questions (DN: capture point).
- Share BH view re modelling – we are in the 3rd year and we are very concerned re the Basin matter reports is not delivering what CEWO want. Granted it might be too soon to do annual report for some basin matters. Flip side is they can't afford to let things get to the end of the program and then try to work it out. *BH: external review of modelling – beneficial?* Probably a good idea to do this now otherwise some may only be qualitative answers. Also consider getting external experts to input to the model development. At an earlier LTIM fish workshop in Sydney, scientists all requested a 2 pager, clearing articulating questions/hypotheses, what parameters to be used and explaining what modelling was to be undertaken, but these have never been delivered (DN: capture point).
- *Re program strategy – the provider advisor model – does it need modification?* It's not totally flawed, but had there been better collaboration from design to implementation then it would have been a better outcome. Also, I share with a few other SA leads' view, the names of 'advisor' and 'provider' are inappropriate (DN: capture point).
- *RE the program logic and rational* Basin Plan program logic does provide a framework to guide monitoring, but evaluation questions and design of monitoring need more careful thoughts with better defined ecological questions that are flow responsive at appropriate spatial and temporal scales (DN: capture point). For example, it's unlikely to be able to do basin scale evaluation for all indicators/parameters in a quantitative manner as it's too hard and some may not be appropriate. May need a mix for different basin scale questions. Acknowledge the time and resource required at set-up phase, through a collaborative approach across basin jurisdictions – for example SRA condition monitoring, it went through an intensive planning and design phase, and a pilot study for data collection and method trialing; and then most cost-effective methods were identified to implement the monitoring program. SRA was acknowledged as a long-term condition monitoring program for key indicators (hydrology, fish, veg and macroinvertebrates) in the Basin. There was a multi-year reporting cycle, noting it may take decades to show condition improvements. My general view is that, for CEWO LTIM, we need more intervention monitoring not trend/condition monitoring (DN: capture point).
- Further examples regarding the need of improving the design including the term use in evaluation questions (i.e. needing better defined ecologically sensible evaluation questions). For instance the use of the terms 'fish reproduction' and 'fish assemblage' – these are not specific enough when evaluating flow responses, which means you lose rigor (DN: capture point). Also need to consider a diverse need for different systems (i.e. need flexibility) – for example in the Edward-Wakool and Goulburn watering actions are targeted at habitat diversity via provision of slackwaters but in the Lower Murray it's the total opposite – restoring flow habitat (i.e. velocity) is of importance not slackwater because of the impact of river regulation which transforms the lower River Murray to a series of weir pools (DN: capture point).
- Need to think about the need to rework the KEQ so as not to focus on CEW contribution specifically, but to focus on doing work in areas in which CEW occurs. Learning ecological response to flow regime is important for adaptive management. For example, the LMR experienced high unregulated flows and flood in spring/early summer of 2016-17 – with minor CEW delivery when most of our biological monitoring occurred. This was a common issue across SAs, we raised this with CEWO and gained managers' support,

thus in 2016-17 we continued with the monitoring work when there was a flood – contributes knowledge to flow response which is critical - example of adaptively managing the project (DN: capture point)

- *How much interaction have you had with other teams?* Reasonably good interaction with other SA leads, e.g. regular phone meetings, adaptive management workshop, hydraulic workshop, collaborative workshops, also interact on an as needed basis, e.g. co-author papers).
- *Thoughts on program leadership?* Not clear who is leading – not enough advice has been received and in the long term this is a problem. BH: CEWO project managers, Nick intellectual leadership – Not sure - the SA leads have been running the meetings – trying to get everyone together – we could have engaged Ben Gawne, shouldn't just be a single meeting, leadership needs to be resourced properly. Could formalize the meetings – CEWO originally had 2 per year at the beginning of the program, but this stopped, so the SA leads organized the meetings – note that lots of these were based on good will, they were not funded. BH: *thoughts on an independent oversight group?* This would be helpful – governance needs to maximise success of stage 1 at the basin scale and key SA that model – think about sowing greater collaboration.
- *Comments on adaptive management:* See the section re this topic for adaptive management.

Selected-Area project

- *What's working well:* SA team is working well – strong relationship with all key players in water planning (CEWO, MDBA, DEWNR, regional NRM Boards) – beyond LTIM engagement in the Long Term Watering Plan development – engagement process in South Australia is really positive / a strength. Can value add to LTIM as connected to a range of MDBA monitoring and research – allows maximum use of data. DEWNR staff were involved in Stage 1 and implementation as in kind contribution.
- *Implementation:* Have five indicators - 2 used modelling approach: Cat III hydrological regime – looking at how changing discharge affect velocities and water level changes, which can potentially lead to improved ecological outcomes. Cat III matter transport indicator modeled salt, nutrients and phytoplankton transport and export in the lower River Murray from Lock 1, to Lake Alexandrina, and to the Coorong, then out of the MM. This indicator started from STIM – these modeling can do counterfactual evaluation with or without CEW – pretty straight forward. Other ecological indicators through empirical studies include stream metabolism Cat I and III, Cat III microinvertebrates, Cat III fish spawning and recruitment which studies how flow and environmental water delivery affect the spawning and recruitment of flow-cued spawning species (i.e. golden and silver perch). These indicators involved bi-weekly or monthly field sampling during the spring and summer period – gorge and floodplain. For the LMR, it would a good opportunity to test flow response if CEW creates a distinct 'in-channel' flow pulse during spring/early summer (such 'in-channel' discharge (~15,000–20,000 ML day⁻¹) are conspicuously absent from the contemporary flow regime. These pulses of flow increase longitudinal connectivity and contribute to a broad range of ecological outcomes in riverine and estuarine ecosystems (e.g. increased matter transport, lotic habitats and spawning and migratory cues for fishes). – so far challenging in the first three years as first two years were dry years when we didn't actually had a significant flow pulse (CEW was a smear across different season), and 2016-17 was a very wet year when flow occurred. Because we are the end of system, most of CEW we get is from return flows through watering events upstream. A coordinated approach will be required from eWater planning to implementation to generate a decent flow pulse for the LMR (noting delivery constraints)– but if we get an in-channel flow pulse of above 15,000ML/day then we can get some good data to advance our learning of flow-ecological responses in the lower River Murray .
- Within the life of CEW there has been increased collaboration with upstream users / players and we are able to coordinate return flows to increase flows to South Australia – the SCEWAG is helping to get this done and conveying more understanding of the needs in South Australia. BH: *what about flows from Lake Vic?* We can, but sometimes water is not just water, we are also trying to promote connectivity and main flow integrity.
- *Comments on reporting:* So far this is working okay – progress report is more about project management type of reporting. Annual report we have had to ticktack with CEWO – wanted a more technical report – relaxed about the length – feedback has been reasonable. We use environmental flow data from MDBA modelling via CEWO in Sept so the timelines are a bit different for the Lower Murray compared to the other SA (noting even so, it was a very tight timeframe for the LMR reporting). Has implications of getting data to the BM team in a timely manner – but doing the best we can.
- *Comments on adaptive management:* The Selected Area working group includes key stakeholders either eWater managers, on ground river operations, NRM agencies – meet 3-4 times per year. Also have 1 major workshop to present to this group just before we finalise the annual report – benefits the project having

their insights. Every meeting has minutes recorded and I run the actions. Allows for very good connections across programs, SRA, Living Murray, Ramsar. I'm also on the SAG for DEWNR so engaged in planning and river operation decisions. There are biweekly teleconference over the short term – another mechanism to providing feedback for adaptive management. Adaptive management for eWater delivery to South Australia needs a holistic plan and coordination across southern connected basin

CEWO interaction

Key lessons over the 3 years

- Overall better engagement is needed between SA and BM teams especially in regards to the design. We are in the mid-term of the program and we still need more facilitated collaboration between the SA and BM teams – someone needs to drive / facilitate this.
- Future planning comments:
- Wouldn't necessarily change Cat I methods now, it is probably a bit 'too late' for change now and would be dangerous – better to leave things as they are for next two years and treat as a pilot.
- Redesign operating structure – learn from LTIM#1 and rethink balance of SA to Basin scale.

Enzo Guarina (Basin evaluation team, Hydrology co-lead) – 23 January

Placement within CEWO 2 days a week minimum. Situated within the Central basin delivery team – but also provide support to the policy team – help in determining what will be achieved within a portfolio – if it will achieve its intended outcomes – main role is in evaluation, delivery and data products.

LTIM Program

- *What's working well:* The LTIM program is an essential need for CEWO and lots of tangible use by other agencies to help make decisions. Huge benefit overall – has had some governance issues particularly with personality issues but that's normal in large projects.
- Meeting objectives or at least trying to meet the objectives
- *What's not working well:* When I read an evaluation report I'm looking for evaluation so there are some issues with the way in which reporting is being done as it doesn't give any sense of the evaluation – what made it different – at times the reports don't get there. Granted they are dealing with wicked problems so very tough to separate outcomes for the different indicators. (DN: capture point)
- Re program strategy.
- RE the program logic and rational
- How much interaction have you had with other teams?
- Thoughts on program leadership?
- Comments on adaptive management:

Basin matter team

- *What's working well:* The hydrology basin matter work is going really well – a good experience. Can be trying at times – finding out some really cool things – kicking goals (see paper in FWB).
- *What's not working well:* Inundation – we are making progress – making in roads and will get some response but its slow – ran our own workshop and invited all the players and then wrote report on what was required and submitted it to MDBA, however MDBA didn't see the need so focused on fish and vegetation. However MDBA people are starting to define an inundation mapping project. Without inundation mapping OEH and other State agencies won't be able to do anything. Possibly on track for a five year outcome. Re the TBD model – haven't heard good things, nothing in writing as yet. BH: *what about constraints/lateral connections?* Working in the Edward-Wakool we have been able to get around constraints a bit by adding to floods. Some frustrations – having a mix of fixed and random locations might be more useful; monitoring of themes in reaches or when ewater gets delivered – capacity to model lateral connections – number of ways of getting observations/data – direct observation, satellite data – however when you put this on a basin map it looks like a poorly lit Christmas tree – very small area in which lateral connections are occurring. Need a tapestry of different methods to achieve the outcomes (DN: capture point).
- *Implementation:* There are constraints in terms of time – the team gets on well and some are putting a large amount of extra time – e.g. Shane and Jenny. The recent change in leadership may see some benefits but too early to say. The legacy issue from the way the project was set up is improving. There is evidence

of cross cutting – interactions across the disciplines. For example at the last forum Mike G indicated he was seeing a low level relationship between e-water and metabolism. This was in contrast to earlier findings that there wasn't a relationship. A problem with metabolism is that the non-technical audience find it hard to understand and sell. *BH: thoughts on the modelling?* Mainly I provide the data s don't have a huger interaction with those doing the modelling – no real conversations at BM team meeting at last forum – no discussion on this yet other than very high level conceptualized. *BH: will it be achieved?* It's a pretty big expectation / ask compared to the portfolio and its use (i.e. local SA scale) CEW contribution is small in the scheme of things – the question should be asked if we should have gone to areas in which there was a lot of CEW, rather than focusing on areas with no prior monitoring or little CEW? For example the Macquarie system had a big flood and lots of e-water when from 40,000 ha to 80,000 ha inundated – but the volume of water that was CEW was about 1% - how do you model this?

- *BH are we in a position to Basin-scale at 5 years?* Its an aggregation of data – with respect to fish it's hard to say as we have no understanding of genetics, if the fish are stocked or not, etc. so there is lots to consider in the model. MDBA/CEWO/States are combining efforts where it aligns (DN: MDBA/basin state asset monitoring and aggregating to Basin-scale)
- Comments on reporting:
- *Comments on adaptive management:* Workshop outcomes from MEWG workshop – but the outcomes haven't been shared. 20 people came to the workshop but outcomes didn't go beyond. So some improvements could be made.
- There is lots going on – Ben Gawne put together a report late last year promoting the idea of an adaptive management database to capture what's been happening. Current the Environmental Action Database has objectives, watering actions etc. but you have to dig to get the information. Water action table hasn't got the context. Currently nothing that pulls everything together.

CEWO interaction

- Very positive – most are passionate about the program and CEWO as a whole – not as much churn/turnover of staff. Some feel partners have not been giving all the data – LTIM has broken down some barriers – e.g. between SA/CEWO/jurisdictions – big positive.

Key lessons over the 3 years

- Requires lots of trust – for example LTIM has been established with the assumption that lots of data will be available – if there is a loss of trust this will fall apart.
- Need to consider value of some elements – If scientists were armed with the cost of each action would the evaluation be viewed differently?
- Future planning comments:
- There have been a lot of programs of late – some projects are being funded as stim, but the data resulting from these short term intervention projects does not seem to be incorporated into the MDMS system, I think they could contribute a lot
- Need to think more simplistically – need to defensibly demonstrate outcomes – need to show this is essential to secure a healthy working river – have to focus on the core values of what was originally set ut to achieve – not all will work but still huge outcomes in the long term .
- Covering all themes – could expand and could be more adaptive for example focus on top 3 valleys in terms of expenditure for each portfolio.
- Basin-scale has a plan– need to have it to meet BEWS (DN: capture point) – the Basin-scale evaluation is needed to meeting this obligation
- The Coorong lower lakes is not included as a selected area. It receives on average 500-600 GL a significant portion of the water portfolio but it is not studied. Whereas, other areas may be watered 10GL in a good year get an evaluation project. The Coorong should be included given the significant amount of water delivered to this asset.
- Could consider a more adaptive monitoring project where monitoring is not fixed to valleys or themes. Eg monitor areas where the water is being delivered. Similarly, monitor themes where CEW is being delivered to support (eg. Blue green algae/black water).

Sam Capon (Basin evaluation team, Vegetation lead) – 24 January

LTIM Program

- *What's working well:* Fantastic project, a privilege to be involved – inception problems are being dealt with – it's a great, proud to be part of the project. Both Ben and Nick have big picture ideas and this requires recognition that it will take time to achieve – the conceptually and operationally believe will get there in the longer term.
- *What's not working well:*
- *Re program strategy*
- *RE the program logic and rational – BM objectives – doubt they are achievable?* I agree – almost certainly the case for vegetation – we will have some level of predictability, but may not fully meet the original expectations. For example hydrology is the limiting factor – inundation patterns not the vegetation data is the limiting factor. Held a workshop last year and a modeling plan was developed – came out of that workshop very confident that can get great outcomes – certainly better than what we have now which is nothing, however I agree that we need to have the specifics of the modeling documented.
- For vegetation – the modeling is not spatially explicitly – its more tied to the vegetation communities – responses to predictor and response compositional variables (DN: capture point). Loathe to do spatially constrained / mapped vegetation communities – paradigm shift – no vegetation scientists, so limited and biased science understanding. Inundation limits – can get wet or dry from SA reports but no mapping available. Data interpretation is limited with regards to time allocated in the project. Also the meaning of wet varies – for example in the Warrego-Darling if reported as 'wet' then that means it was wet in the past 12 months.
- *How much interaction have you had with other teams?*
- *Thoughts on program leadership?* The challenge in leadership is working for CEWO – managers are not ecologists so its challenging for both Ben and Nick – CEWO has a particular view. Time are change and thinking has progressed into a new paradigm – clearly defined objectives and being more adaptive is essential. Interactions with CEWO have been great, but the paradigm not well articulated in terms of adaptive management evaluation. E.g. ability to review project objectives as the program evolved (DN: capture point – relates to lack of process evaluation plan).
- *Comments on adaptive management:*

Basin matter evaluation

- *What's working well:*
- *What's not working well:* Data was a huge mess – so a lot of time spent getting the data into shape in consultation with the SA teams – in many cases had to just revert to either wet or dry. Also the SA teams are not using the data sets in the same way – the analysis is different. SA and BM team separation has led to potential for conflict – led to laziness as no vested interest in the Basin scale data – left to the BM team to fix. If it had been collaboratively it would be a huge improvement. There was supposed to be joint analysis/standard metrics - but each SA uses different metrics and analysis is divergent – much more important to sort this out as it has compromised the basin scale evaluation (DN: capture point). The people that were engaged don't have a priority to do basin scale so their priority is SA scale – not collaborative. Also, limited data analysis at SA scale. BH: what would you change? Can't do much about it now – not worth the effort – ideally would have a collaborative workshop with people excited about the power of the data set – do analysis together and produce papers. Hard to do this due to funding restrictions – need to have a more positive and collegiate atmosphere/culture.
- Vegetation workshop proposal – BM team workshop – it hasn't happened, it was meant to be collaborative but it never happened. Vegetation hydrology metrics, revising functions groups – all was to be done via a collaborative workshop. BH: what was the process? In 2015 I sent it to Ben and Penny after that years forum – essentially it was a proposal to get the vegetation people together – to have a better use of time and a more targeted discussion/outcome. Didn't go anywhere. There is collaborative funding but it's not clear how it's being spent or who makes the decisions – it seems to be being used to support

research projects, not being strategic with regards to the LTIM project – seems to be all going to the SA (DN: capture point).

- *How much interaction have you had with other teams?* Very little – very disappointed and quite frankly hurtful that the SA teams are not inviting or even telling the BM team about workshop – it's a very strange dynamic. CEWO appear to be on a much shorter leash – can't argue with the SA leads. (DN: capture point) (DN: not aware that contracts are run via the WDT). Have to make LTIM more collaborative – currently too competitive. *BH: Steering committee idea:* Would need to include the Basin Matter leads as otherwise there would be no vegetation expertise on the SC. But a SC is a good idea (DN: capture point)
- *Comments on reporting:* Final project will require an independent review – should be using more internal resources – having a workshop in April 2018 when we will be looking at reporting.
- Some of the SA teams would benefit by looking at other SA reports.
- The role of the basin scale reporting in providing good messages needs to be raised importance – it should be a place for managers to get information so there should be more emphasis on the BM reports not the SA scale.
- The recent experience in receiving reviews on BM reports from the SA teams was very disappointing - it was used as an opportunity to let loose, the comments were not constructive, and just plain nasty in some cases – very unprofessional. In comparison the BM team were given guidelines to the BM reviewers and we were asked to use softer language – may have been too nice (DN: get TOR from Nick).
- *Comments on adaptive management:* Issues raised in the forums – documented by Penny but not been addressed – not sure who owns responsibility for addressing actions arising from forums.

Interaction with CEWO

Key lessons over the 3 years

- Clearly collaboration is the single biggest thing - has to be initiated from the start rather than being designed as such an atomized project.
- Collecting data – not enough emphasis on the analysis and evaluation – need a statistician to be involved to review.
- Evaluation could have a more clearer framework – the early foundation documents were too high level – the step missed was the bit between analysis and outcomes – there was no project process evaluation plan (DN: capture point)
- *Future planning comments:*
- LTIM#2 a standard approach to analysis – need much more buy in by all teams. LTIM#1 may not be able to achieve a total fix of these issues.
- Would be good to have annual forums for the themes rather than the current annual forum – too big! A lot could be achieved with 2-3 days of concentrated veg time.
- Jointly produced communication products that we could all feel proud of would be good – e.g. integrated selected area and basin scale reports by theme.

OTHER PROGRAMS – EWKR, MDBA

Nadia Kingham (CEWO, EWKR Program manager) – 25 January

EWKR Program

- EWKR originated from a need for better research and knowledge to support delivery of the Basin plan and associated research and knowledge needs.

- EWKR commenced in July 2014, took longer than scheduled to get all the consultation done in Phase 1 to inform identification of priority research questions. In 2015-16 foundation/conceptualisation research was undertaken to further refine the research questions, in 2016-17 all themes commenced on-ground research and data collection (Waterbirds commenced in 2015-16).
- Unlike LTIM, EWKR aimed to respond to basin wide stakeholders – not just CEWO – the project has not been able to cover everything identified during the consultation, we had to prioritise to come within allocated funding.
- EWKR was designed and commenced implementation when it was not part of the CEWO, so it was not designed to directly respond to the needs of only CEWO water managers, it was Basin wide across all Jurisdictions. EWKR is therefore less embedded compared to LTIM as part of the CEWO adaptive management framework. Improvements should be made to link EWKR and LTIM in future so research is better utilised as part of monitoring and evaluating CEWO e-water.
- Improving the science available to better inform e-water delivery and management is the main objective of EWKR. At the conclusion of Phase 1 consultation a long list of knowledge gaps was derived and consolidated into priority research questions with four themes emerging – waterbirds, vegetation, fish and food webs.
- Allocated \$10 million over 5 years – research collaboration program. There was an expansion of interest after the research questions were set – this led to an increase in consultation. This was a positive but also an issue in regards to managing the vast and diverse experiences, needs and expectations.
- EWKR has a Scientific Advisory Group (SAG) – wanted a really strong logic and rationale. Having the SAG has been very positive as it has assisted the research teams to be more focused. Overall the SAG has been a very positive tool for CEWO as it has provided the independent scientific input to the project and ensured that the science is robust and credible.
- Within the priority questions lots of other questions emerged so had to go through a process of refining the questions – drill down to what was really achievable. SAG recommended the ‘conceptualisation phase’ to further refine the questions and provide a stronger logic and rationale for the priority research.
- The SAG met once a year and provided advice – are supplied with ½ yearly research plans which they review. Also involved in the mid-term review.
- Four themes across four sites (Lower Murray, Upper Murray, Mac Marshes and Narran Lakes/lower Balonne) – but research is not being undertaken at all sites as originally intended – needed to be flexible to respond to where it was best to do the research – e.g. fish in the Ovens River due to needing a mix of habitats. For example the birds, had to go to where they are breeding.
- Primary stakeholders are water managers, project is less engaged with some broader stakeholders ie community– some water managers have been less engaged due to timing it has taken, but stakeholders continue to remain involved in the project as they can appreciate the benefits which is positive and as results start to emerge from the project it will be more useful to water managers.
- As with many projects of this size and similar to LTIM, the issues around up-scaling are similar and being able to apply/infer research findings to whole of basin – expectations are needed to be managed.
- Communications component – used for communication and engagement but the program doesn’t have a specific knowledge broker. Could see that a knowledge broker role would enhance the outcomes of the project and facilitating people across many fields working together and sharing knowledge, and even could have led to forming other collaborations.
- Over the next 6 months will be focusing on knowledge adoption – communications and engagement with managers to shape how best to ‘package’ research knowledge so it is easily accessible, available and relevant to e-water and water managers. A review of DST’s in Phase 1 strongly recommended that EWKR not develop a DST and that most water managers are getting their science from peers, from talking to scientist and being able to use information that is available for them to apply to their area or situation. It will be a balance between site specific needs with the wider needs and this will be a challenge to address i.e. finding a balance to making the research relevant to a wide range of water management needs.
- As EWKR was less embedded in CEWO initially the research wasn’t designed around the WDT needs – however EWKR needs to respond to the monitoring being done by LTIM and be part of the adaptive management of CEWO environmental water. The LTIM annual workshop or other combined workshops between WDT, LTIM and EWKR providers would be great to document learnings and knowledge gaps and shape future research as well as responding to ad hoc and emerging issues. Monitoring and research needs to be delivered in an integrated manner – whilst currently there are some difficulties/obstacles in terms of contracts there are also significant positives in the fact that there is overlap between LTIM and EWKR with

regards to providers, sites and ecological focus. More could be done in this space to improve integration. Work on EWKR fish and veg and food webs are interacting with LTIM i.e. utilising and sharing data, doing field work together, sharing models.

- *BH: re the evaluation plan – who is driving it?* Helen Watts undertook the Phase 1 review – but most of the report needs to be interpreted in terms of the timing and context setting. For example project management was identified for improvement – this reflects the leadership at MDFRC at the time and therefore CEWO had a lot more involvement than intended – this has eased a bit in the past 6 months – project management, efficiencies and effectiveness will be better now – and with clearer roles and responsibilities as the project has developed.
- Project sub-committee includes reps from CEWO, MDBA, and jurisdictions – helped in phase 1 consultations. Good representation from the states – part of their role is to disseminate information.
- With regards to capturing adaptive management – there is no formal line of sight, so documenting outcomes requires the coordinators to document those decisions – captured only broadly.
- BH: is the evaluation plan useful? Need to pay more attention to the plan on a regular basis – tend to do it on the go – no single person is assigned to oversee its application. Need to track this better and keep it on hand all the time.

Interaction with LTIM

- Limited to date, seeing more interaction with the on-ground research – an inventory of knowledge gaps/emergent issues from LTIM would be useful that could inform research – having interaction with LTIM is highly desirable and could be improved in future to improve adaptive management of CEWO e-water.
- Lots of opportunity – RipRap, EWKR stories, research publications, face to face interactions, networking and relationships – all build trust. Need to be able to call on researchers to have input to these.
- Future planning comments:
 - Key lessons – maintaining contacts and relationships which in turn build trust – this is essential.
 - Integrate monitoring and research better in the future – monitoring outcomes (trends) are informing research (processes)
 - Create the space and time to have the communications between LTIM, EWKR and WDT and funding to support this adequately.

Chris Pulkkinen, Jo Kneebone, Di Mead, Andy Lowes (MDBA) – 25 January

DN: only CP and AL approved notes

BH: what do you know about LTIM, was it used in the recent evaluation report, and what types of interactions are there between CEWO and MDBA?

- CP: There is good officer to officer level interaction with those that run the program – not the planning aspect – but they do provide good information.
- CP: Paul and Sam are a great source of information – good interaction.
- CP: Relied heavily on 20 LTIM reports, fish (Selected Area evaluation reports 2013-2016), one vegetation (Basin-scale evaluation Capon and Campbell 2017) and one asset report (Gawne et al. 2013 Logic and Rational report) for input to the evaluation report. The individual reports are very dense and very hard to access the information we need – but these have improved recently with a front end table that summarises key findings – much easier to interpret. Well defined in terms of linkages to BEWS.
- CP: Relied on the data assessment done by the authors – so a really valuable source of information (**DN: capture point**).

BH: no communications strategy, style of writing is very technical.

- CP: Agree – reporting needs some work. The area scale evaluation of the CEW contribution analysis is tricky (**DN: capture point**)
- JK: Need to give some thought re context it sits – funny space in terms of line of sight to basin scale outcomes – but this doesn't come out at the basin scale assessment – informs local scale and overlaps with states assess scale assessment – answers question of did a watering event work or not – were the risks

managed. Also have conditions change – BEWS is basin outcomes from LTWP (not all finalized yet) – but see LTIM sitting in this space (DN: capture point – not as aware of basin scale evaluation reports).

- JK: How does TLM fit with all the programs – needs to align better with Basin Plan. Unpacking this through to 2020 and focus on basin scale for LTIM.

BH: what's doable in 5 years?

- DM: we grapple with what is basin scale and how to do integration to basin scale (DN: capture point), how do we make sense from local scale findings:
 - Anecdotes of single watering events
 - More case studies
 - Temporal and spatial tracking of trends in change at significant sites.
- JK: Capture of learnings - adaptive management – really needs to capture this and have it accessible across institutions (DN: capture point).
- JK: re basin scale need closer alignment between CEWO/MDBA and basin scale evaluation – need to agree between the projects what should be used and each contributing.
- CP: Met with Paul and Sam recently to start discussion on this. Also needs to happen at the asset scale – joint venture – these are clearer – have longer term data and trends against site specific objectives, Need to ask jurisdictions what other sites/objectives/fish, bird, vegetation stories they have – how contribute to basin scale condition.
- Joint program – joint venture M&E – overall evaluation of Basin Plan – not easy but some elements working well.

APPENDIX D: OUTCOMES FRAMEWORK

Expected Outcomes from environmental watering at the Basin-scale are presented in Table 7 (shaded). Expected Outcomes to be monitored as part of LTIM for Basin and/or Selected Area evaluation and indicated with an * and Expected Outcomes which may be monitored (i.e. are optional) are indicated with ^ (Gawne et al. 2014, Commonwealth of Australia 2017).

Table 7. Summary of expected outcomes at the Basin-scale.

Basin Plan objectives (MDBA 2012 – see Appendix E this document)	Basin Outcomes (Commonwealth of Australia 2013)		Basin-wide Environmental Watering Strategy – Expected Outcomes (Commonwealth of Australia 2017)	Five-year Expected Outcomes (Gawne et al. 2014)	One-year Expected Outcomes (Gawne et al. 2014)
Biodiversity (Basin Plan S. 8.05)	Ecosystem diversity			• Species diversity	
	Species diversity	Vegetation	<ul style="list-style-type: none"> Maintenance of the current extent of river red gum, black box, coolibah forest and woodlands; existing large communities of lignum; and non-woody communities near or in wetlands, streams and on low-lying floodplains Maintain the current condition of lowland floodplain forests and woodlands of river red gum, black box and coolibah Improved condition of southern river red gum 	• Vegetation diversity*	• Reproduction
				• Growth and survival*	• Condition*
					• Germination
					• Dispersal*
		Macro-invertebrates		• Macro-invertebrate diversity	
		Fish	<ul style="list-style-type: none"> Improved distribution of key short and long-lived fish species across the Basin Improved breeding success for short-lived species, long-lived species and mulloway Improved populations of short-lived species, long-lived species, Murray cod and golden perch. 	• Fish diversity*	• Condition*
				• Larval and juvenile recruitment*	• Larval abundance*
					• Reproduction*
		Waterbirds	<ul style="list-style-type: none"> Maintained current species diversity of all current Basin waterbirds and current migratory shorebirds at the Coorong Increased abundance with a 20–25 per cent 	• Waterbird diversity	
				• Waterbird diversity and population condition (abundance and	• Survival and condition^
					• Chicks^

Basin Plan objectives (MDBA 2012 – see Appendix E this document)	Basin Outcomes (Commonwealth of Australia 2013)		Basin-wide Environmental Watering Strategy – Expected Outcomes (Commonwealth of Australia 2017)	Five-year Expected Outcomes (Gawne et al. 2014)	One-year Expected Outcomes (Gawne et al. 2014)
			increase in waterbirds by 2024 • Improved breeding events for colonial nesting waterbird species and an increase in nests and broods for other waterbirds	population structure)	• Fledglings^
		Other vertebrate diversity		• Adult abundance*	• Young*
Ecosystem Function (Basin Plan S. 8.06)	Connectivity		• Maintained base flows - at least 60 per cent of natural levels • Improved overall flow • Maintained connectivity in areas where it is relatively unaffected • Improved connectivity with bank-full and/or low floodplain flows • Maintain the Lower Lakes above sea level		• Hydrological connectivity including end of system flows*
			• Improved movement with more native fish using fish passages		• Biotic dispersal and movement*
					• Sediment transport*
	Process				• Primary productivity (of aquatic ecosystems)*
					• Decomposition*
					• Nutrient and carbon cycling*
Resilience (Basin Plan S. 8.07)	Ecosystem resilience			• Population condition (individual refuges)^	• Individual survival and condition (individual refuges)^
				• Population condition (landscape refuges)^	
					• Individual condition

Basin Plan objectives (MDBA 2012 – see Appendix E this document)	Basin Outcomes (Commonwealth of Australia 2013)	Basin-wide Environmental Watering Strategy – Expected Outcomes (Commonwealth of Australia 2017)	Five-year Expected Outcomes (Gawne et al. 2014)	One-year Expected Outcomes (Gawne et al. 2014)
				(ecosystem resistance)
			• Population condition (ecosystem recovery)	
Water quality (Basin Plan S. 9.04)	Chemical			• Salinity*
				• Dissolved oxygen*
				• pH*
				• Dissolved organic carbon^
	Biological			• Algal blooms

APPENDIX E: OVERALL AND SPECIFIC BASIN PLAN OBJECTIVES

Overall Basin Plan objectives	Objective specifics	LTIM reference
to protect and restore water-dependent ecosystems of the Murray-Darling Basin (Basin Plan, Chapter 8, Part 2, 8.04(a))	<p>Chpt 8, Part 2, 8.05</p> <p>(1) This section sets out particular objectives relating to the protection and restoration of the water-dependent ecosystems of the Murray-Darling Basin.</p> <p>(2) An objective is to protect and restore a subset of all water-dependent ecosystems of the Murray-Darling Basin, including by ensuring that:</p> <p>(a) declared Ramsar wetlands that depend on Basin water resources maintain their ecological character; and</p> <p>Note: See paragraph 21(3)(c) of the Act.</p> <p>(b) water-dependent ecosystems that depend on Basin water resources and support the life cycles of species listed under the Bonn Convention, CAMBA, JAMBA or ROKAMBA continue to support those species; and</p> <p>(c) water-dependent ecosystems are able to support episodically high ecological productivity and its ecological dispersal.</p> <p>(3) An objective is to protect and restore biodiversity that is dependent on Basin water resources by ensuring that:</p> <p>(a) water-dependent ecosystems that support the life cycles of a listed threatened species or listed threatened ecological community, or species treated as threatened or endangered (however described) in State law, are protected and, if necessary, restored so that they continue to support those life cycles; and</p> <p>(b) representative populations and communities of native biota are protected and, if necessary, restored.</p>	Biodiversity
to protect and restore the ecosystem functions of water-dependent ecosystems (Basin Plan, Chapter 8, Part 2, 8.04(b))	<p>Chpt 8, Part 2, 8.06</p> <p>(1) This section sets out particular objectives relating to the protection and restoration of the ecosystem functions of water-dependent ecosystems.</p> <p>(2) An objective is that the water quality of Basin water resources does not adversely affect water-dependent ecosystems and is consistent with the water quality and salinity management plan</p>	Ecosystem function

	<p>(3) An objective is to protect and restore connectivity within and between water-dependent ecosystems, including by ensuring that:</p> <ul style="list-style-type: none"> (a) the diversity and dynamics of geomorphic structures, habitats, species and genes are protected and restored; and (b) ecological processes dependent on hydrologic connectivity: <ul style="list-style-type: none"> (i) longitudinally along watercourses; and laterally between watercourses and their floodplains (and associated wetlands); and (iii) vertically between the surface and subsurface; are protected and restored; and (c) the Murray Mouth remains open at frequencies, for durations, and with passing flows, sufficient to enable the conveyance of salt, nutrients and sediment from the Murray-Darling Basin to the ocean; and (d) the Murray Mouth remains open at frequencies, and for durations, sufficient to ensure that the tidal exchanges maintain the Coorong's water quality (in particular salinity levels) within the tolerance of the Coorong ecosystem's resilience; and <p>Note: This is to ensure that water quality is maintained at a level that does not compromise the ecosystem and that hydrologic connectivity is restored and maintained.</p> <ul style="list-style-type: none"> (e) the levels of the Lower Lakes are managed to ensure sufficient discharge to the Coorong and Murray Mouth and help prevent river bank collapse and acidification of wetlands below Lock 1, and to avoid acidification and allow connection between Lakes Alexandrina and Albert, by: <ul style="list-style-type: none"> (i) maintaining levels above 0.4 metres Australian Height Datum for 95% of the time, as far as practicable; and (ii) maintaining levels above 0.0 metres Australian Height Datum all of the time; and (f) barriers to the passage of biological resources (including biota, carbon and nutrients) through the Murray-Darling Basin are overcome or mitigated. <p>(4) An objective is that natural in-stream and floodplain processes that shape landforms (for example, the formation and maintenance of soils) are protected and restored.</p> <p>(5) An objective is to support habitat diversity for biota at a range of scales (including, for example, the Murray-Darling Basin, riverine landscape, river reach and asset class).</p> <p>(6) An objective is to protect and restore ecosystem functions of water-dependent ecosystems that maintain populations (for example recruitment, regeneration, dispersal, immigration and emigration) including by ensuring that:</p> <ul style="list-style-type: none"> (a) flow sequences, and inundation and recession events, meet ecological requirements (for example, cues for migration, germination and breeding); and (b) habitat diversity, extent, condition and connectivity that supports the life cycles of biota of water-dependent ecosystems (for example, habitats that protect juveniles 	
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	<p>from predation) is maintained.</p> <p>(7) An objective is to protect and restore ecological community structure, species interactions and food webs that sustain water-dependent ecosystems, including by protecting and restoring energy, carbon and nutrient dynamics, primary production and respiration.</p>	
to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats (Basin Plan, Chapter 8, Part 2, 8.04(c))	<p>Chpt 8, Part 2, 8.07</p> <p>(1) This section sets out particular objectives relating to ensuring that water-dependent ecosystems are resilient to climate change and other risks and threats.</p> <p>(2) An objective is that water-dependent ecosystems are resilient to climate change, climate variability and disturbances (for example, drought and fire).</p> <p>(3) An objective is to protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna, including during drought to allow for subsequent re-colonisation beyond the refugia.</p> <p>(4) An objective is to provide wetting and drying cycles and inundation intervals that do not exceed the tolerance of ecosystem resilience or the threshold of irreversible change.</p> <p>(5) An objective is to mitigate human-induced threats (for example, the impact of alien species, water management activities and degraded water quality).</p> <p>(6) An objective is to minimise habitat fragmentation.</p>	Resilience
to ensure water quality is sufficient to achieve the above objectives for water-dependent ecosystems, and for Ramsar wetlands, sufficient to maintain ecological character (Basin Plan, Chapter 9, Part 3, 9.04 (1) & (2))	<p>Chpt 9, Part 3, 9.04</p> <p>1. The water quality objective for declared Ramsar wetlands is that the quality of water is sufficient to maintain the ecological character of those wetlands.</p> <p>Note: See paragraph 21(3)(c) of the Act.</p> <p>2. The water quality objective for water-dependent ecosystems other than declared Ramsar wetlands is that the quality of water is sufficient:</p> <p>(a) to protect and restore the ecosystems; and</p> <p>(b) to protect and restore the ecosystem functions of the ecosystems; and</p> <p>(c) to ensure that the ecosystems are resilient to climate change and other risks and threats.</p> <p>Note: See the overall environmental objectives of the environmental watering plan in section 8.04.</p>	Water quality

APPENDIX F: ASSESSMENT OF PROGRESS BY BASIN MATTER EVALUATION

Green – Evaluation on track and likely to be achieved	Yellow – Evaluation will possibly be achieved but dependent on watering conditions or other constraint	Red – Evaluation questions not adequately addressed, or not on track to be achieved.
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This assessment of the Basin Matter and Synthesis reports is very high level and does not constitute a detailed evaluation of the conceptual premise, methods or evaluation techniques. The ratings are based on only two years of LTIM and conditions/results may change in the final years of the program.

Whilst some of the expected outcomes set at the Basin-scale may not be achieved, this in itself is not necessarily a failure, since the knowledge gained from this project will be significant – even if the outcome isn't what was originally hypothesised.

In most cases, identification of some aspect not being on track reflects one or more of the following:

- no measurable objectives/expected outcomes given (e.g. ecosystem diversity);
- outcome unlikely to be achieved due to constraints;
- and/or ecological response not observed as expected.

In these cases, there may be a need to refine objectives and or manage expectations.

Basin-scale evaluation is intended to evaluate the extent to which the expected outcomes of a watering action are achieved and then use the Outcomes Framework to evaluate the extent to which these outcomes contribute to the environmental objectives of the Basin Plan. Each step in the evaluation process will be based on the same starting question, specifically (Gawne et al. 2014):

How does the observed outcome of Commonwealth environmental water compare to both the expected outcome and the outcome predicted to occur in the absence of Commonwealth environmental water?

The following lists the objectives of the project and requirements for reporting – these have been used as guides to assess the progress of the BM team in meeting objectives, evaluation and reporting requirements. Bolded text are the areas in which there is inconsistency between the Basin Matter evaluation reports, and or, requirements have not been met.

The Services in priority order aim to:

- evaluate ecological outcomes of CEW at each Selected Area;
- evaluate the contribution of CEW to the objectives of the Murray Darling Basin Authority's Environmental Watering Plan;
- infer ecological outcomes of CEW in areas of the Murray-Darling Basin not monitored;
- support the Adaptive Management of CEW; and

(v) monitor the ecological response to CEW at each Selected Area.

Annual reports are to include:

Evaluation

a) evaluate **the extent** to which the **expected outcomes** identified in the Basin Evaluation Plan, and identified for environmental watering in the years 2014-15 to 2018—19, **have been achieved**;

b) evaluate the outcomes of environmental water use based on available information using one or more of the following approaches:

i. monitored results;

ii. quantitative evaluation;

iii. qualitative evaluation;

iv. inferred using scientific opinion and the outcomes framework; or

v. inferred using expert scientific opinion and other evidence.

c) clearly identify which of the above approaches was used for the evaluated outcome;

d) for the **expected outcomes identified in the Evaluation Plan**, provide clear answers to each relevant evaluation question;

e) **quantify to the fullest extent possible the marginal benefit of Commonwealth environmental water** and other held environmental water delivered in conjunction with Commonwealth environmental water;

f) the evaluation of expected outcomes (both less than one year and one to five years) **after the first year will need to be cumulative** by considering the evaluation of results from the previous years

g) include, where possible, preliminary findings in relation to **one to five year** expected outcomes (if necessary these may be supported by qualitative results in the earlier years leading to quantitative evaluation in the later years);

Adaptive management

h) use monitoring and evaluation outcomes and expert scientific opinion to provide implications for future management of Commonwealth environmental water and how to improve for the future;

Context

i) provide context of the **environmental conditions across the Basin**;

j) provide brief context to the watering actions and links to the expected outcomes from the watering action and previously evaluated outcomes;

In addition a progress status rating is provided for each Basin Matter (see tables below).

General findings for Basin-scale evaluation: As the objectives, outcomes and KEQ for the Basin-scale evaluation are not SMART (other than time bound) it is difficult to evaluate if they are being achieved/addressed effectively and efficiently. In addition having only two years data also limits the evaluation as many of the Basin-scale

questions will require longer periods of data collection. It will be essential to establish a detailed outcomes evaluation plan (similar to that developed for EWKR project) on which to base the final LTIM Phase 1 program evaluation.

The lack of expected outcomes for ecosystem diversity is seen as a significant issue for the LTIM project as there are very specific objectives for this matter in the Basin Environmental Watering Plan.

Currently there are many unqualified statements such as *almost certainly promoted*, *likely to have been enhanced* used in the reports, most notably in the Synthesis report. This is mostly due to having only two years data.

Additionally, there is no clear plan for how the Basin Matters team will develop, test and implement quantitative models for fish, vegetation and metabolism in the 18 months to the LTIM Project's completion. There is an urgent need for a comprehensive modelling development plan to be developed (See Recommendation 11 in main report).

The progress ratings given in Table 8 are largely, but not entirely, a consequence of the timing of this evaluation.

Table 8. Progress status for each reporting requirement for Basin-scale evaluation.

	Evaluation							Adaptive management	Context	
	a	b	c	d	e	f	g	h	i	j
Hydrology	Specific to BEWS – different to all other Basin Matters	Inundation data limitations	Model development			Limited evaluation in 2015-16	No 5 year outcomes			
Ecosystem diversity	No expected outcomes stated in BM report									
Stream metabolism and water quality	Flows inadequate		Model development							
	Data limitations									
Vegetation			Model development							
Fish		Spawning model not run	Model development							
Generic diversity		Data access						Not addressed		Cross ref to other

		limitations								Basin Matter reports
Synthesis - integrated evaluation	Limited data – no statement re extent outcomes achieved		Not really needed in the Synthesis – have an upfront cross ref to technical appendices	Not specifically addressed – consistency issues			Inconsistency issues. No consideration of 5 year outcomes			

HYDROLOGY

Only two one year expected outcomes for hydrology are included in the outcomes framework: for connectivity and biotic dispersal. There are no stated five year outcomes for this Matter (Gawne et al. 2014). The hydrological outcomes reported on inform the broader evaluation of biodiversity, ecosystem function and resilience at the Basin scale and underpin the outcomes for the other Basin Matters. Basin-scale evaluation for the hydrology Matter seeks to address the following questions:

- What did Commonwealth environmental water contribute to restoration of the hydrological regime?
- What did Commonwealth environmental water contribute to hydrological connectivity?

“The evaluation of flow regimes is based on a comparison of streamflows recorded at these sites during the 2015–16 year (*actual* case) with streamflows that would have occurred in the absence of the Commonwealth environmental water program (*baseline* case).” Stewardson and Guarino (2017), p4

“As such, inundation area linked to Commonwealth environmental water has been classed with low confidence Basin wide and will remain this way until accurate, reliable and accessible inundation mapping is made available to support defensible and robust monitoring and evaluation” Stewardson and Guarino (2017), p7

“Commonwealth environmental water delivery is often coordinated with delivery of water by other environmental water holders; hence, the evaluation considers the combined hydrological effect of all environmental water delivery. Where possible, we also indicate the contribution of the Commonwealth environmental water component to the total hydrological effect of all environmental water” Stewardson and Guarino (2017), p7

Findings: The hydrology evaluation report presents a solid assessment of environmental watering at sites, valley (adapted from SRA) and Basin-scale. The use of the score cards for each valley that received water is a good way to present the information and links the data more closely to the annual watering priorities at the Basin-scale. Two limitations were identified in the interviews – limited data for some areas and also a lack of inundation mapping of wetland and floodplain systems. Neither of these issues are considered likely to significantly hamper the evaluation of CEW to restoration of the hydrological regime or connectivity; however, if addressed, the outputs from the project would be improved.

The Basin-scale evaluation report for hydrology is significantly different to that of the other Basin Matter reports in that it focuses on addressing the annual watering priorities as opposed to specified expected outcomes (see Stewardson and Guarino 2017).

Table 9. Assessment of progress for Basin-scale evaluation of hydrology.

Basin-scale KEQ	Rating	Justification
What did Commonwealth environmental water contribute to restoration of the hydrological regime?		Score card assessment showing how well the Annual Environmental Watering Priorities were met in the valleys receiving Commonwealth environmental water in 2015–16 (See Table 7, pp40-41, Stewardson and Guarino (2017)). Actual KEQ not addressed in the report.
What did Commonwealth environmental water contribute to hydrological connectivity?		Lateral connectivity in which floodplains and wetlands are connected to their parent rivers via overbank flows are limited due to constraints. Also inundation mapping has not advanced to allow anything other than stating a system is wet or dry – also the definition of ‘wet’ varies across Selected Areas. For example wet in the Warrego Darling SA means that ecosystem has been wet in the past 12 months – not necessarily that it is wet at the time of sampling. Extent of inundation is currently only possible.

ECOSYSTEM DIVERSITY

The primary, overall biodiversity objective of the Basin Plan is ***to protect and restore water-dependent ecosystems of the Murray-Darling Basin (Basin Plan, Chapter 8, Part 2, 8.04(a))***. All of the specific Basin Plan biodiversity objectives are based around ecosystem level outcomes – this is not reflected in the LTIM outcomes framework. In addition the biodiversity Basin Plan objectives are written to support Australian obligations under various treaties/conventions/legislation (i.e. Ramsar, migratory species – JAMBA, CAMBA etc., EPBC listed species and communities), with the emphasis being on the representative or subset of *ecosystem type* that support these.

Not assessed at Selected Area-scale, other than in the Gwydir.

Findings: At the inception of the LTIM Project the expectation was that there would be robust inundation data for ecosystem types both with and without Commonwealth environmental water – this has not eventuated. There was also the expectation that Basin-scale evaluation would include an assessment of the types and extent of wetlands inundated by Commonwealth environmental water and use conceptual modelling to infer ecological responses based on the timing, duration and wetland type inundated (Gawne et al. 2014). Several of the other Basin Matters are reliant on this information and therefore evaluation/interpretation of findings to date are limited (Gawne et al. 2017). Recent updates to the ANAE mapping and classification for the MDB will necessitate a revision of outcomes in the first couple of years so that results are consistently presented and provide for multi-year comparisons (Brooks 2017).

The Basin Matter evaluation report provides a useful summary of the extent of watering of ecosystem type and compares the situation 2014-15 with that in 2015-16. It also provides a useful discussion of the lessons regarding adaptive management.

We have recommended (Recommendation 3) that key evaluation questions for ecosystem diversity be developed, with links to representativeness (multiple scales), support for critical life stages, and support of migratory species. These should be included in the Basin-scale evaluation in years 4 and 5 of Phase 1.

Table 10. Assessment of progress for Basin-scale evaluation of ecosystem diversity.

Expected outcome	Basin-scale KEQ (Gawne et al. 2014)	Rating	Justification
None specified in program logic (Brooks 2017)	What did CEW contribute to ecosystem diversity?		Assigned red as no stated expected outcomes and also there is currently a lack of inundation data available which will hamper Basin-scale evaluation. The Basin Plan EWP objectives are quite specific in relation to protecting and restoring representatives of all aquatic ecosystem types found within the Basin, ensuring those that support critical life stages of migratory species covered under international treaties and nationally listed species dependent on environmental water are sustained or improved. The failure to have specified ecosystem diversity outcomes is considered a significant issue for the LTIM project.

STREAM METABOLISM AND WATER QUALITY

Stream metabolism

Basin-scale evaluation will address the following short-term (one-year) and long-term (five-year) Basin-scale evaluation questions regarding stream metabolism (from Grace 2015):

- What did Commonwealth environmental water contribute to patterns and rates of decomposition?
- What did Commonwealth environmental water contribute to patterns and rates of primary productivity?

“Based on the information from the first 2 years of the LTIM Project, it appears that, in line with the Entrainment Model, rates of primary production and ER are unlikely to respond to base flows or freshes on a per unit volume basis when constrained within the river channel.” Grace (2017), p24

“Monitored outcomes of freshes and base flows in the first 2 years (2014–16) did not detect any significant changes in rates of gross primary productivity or ER with the addition of environmental water, although individual positive responses of specific actions occurred at specific sites.” Grace (2017), p41

“As emphasised earlier in this report, no major ‘improvements’ in primary production and ER rates as a result of environmental watering actions were detected due to the types of these watering actions delivered over the first 2 years of the LTIM project.” Grace (2017), p45

“LTIM monitoring did not detect any effect of Commonwealth environmental water on stream metabolism in the southern Selected Areas, which can, in part, be attributed to water being delivered as in-channel flows (base flows and freshes) in the dry years 2014–16.” Gawne et al. (2017), p17

Findings: Concern has been expressed by a number of people interviewed about the likelihood of this indicator being successful in achieving the intended outcomes. In addition some described the Basin-scale objectives as descriptive only and therefore not achievable. More generally the constraints in each of the Selected Areas and types of flows delivered largely restrict engagement of the floodplain and as such limit nutrient inputs to the river channel. Data compliance is an issue with low levels of acceptance at several of the Selected Areas, and problems with data loggers also reduce the amount of data available. We also have some concerns over the ability of the current approach to modelling to be able to achieve the evaluation needed to meet the objectives as currently stated (see Recommendation 11).

If there are no flows of the required magnitude to engage the floodplains in the Selected Areas in which metabolism is being assessed for Basin-scale evaluation then it is considered likely that the outcome will be 'negative' in the sense that there were inadequate flows to promote primary productivity. Although some recent information for the Goulburn Selected Area suggests there is reasonable productivity within the channel.

The 2017-18 Basin Plan annual water priority for river connectivity is to *improve connectivity between freshwater, estuarine and marine environments and improve habitat conditions in the Coorong by optimising and managing inflows through the Lower Lakes* (MDBA 2017). Current assessment of the resource availability scenario for 2017–18 shows all Selected Areas to be wet or very wet in 2017-2018 (MDBA 2017), which may initiate opportunities for entrainment to be assessed. Grace (2017) states that *it is vital that watering actions not occur with the same magnitude and at exactly the same time each year*.

Table 11. Assessment of progress for Basin-scale evaluation of stream metabolism.

Selected Area	Indicator	Rating	Justification
Edward-Wakool	Cat I indicators		Flows not sufficient in Edward-Wakool to inundate floodplains hence influence metabolism (Watts et al. 2016)
Goulburn	Cat I indicators		Higher flows that remain within the river channel are unlikely to introduce significant amounts of nutrients which in turn will constrain primary production (Webb et al. 2017). Discharges greater than 18,000 to 19,000 ML/d are required to connect the main channel of the lower Goulburn River to flood-runners (GBCMA unpubl. cited in Webb et al. 2017). Freshes in the Goulburn were associated with no change or a decrease in rates of GPP and ER per unit volume, which is most likely the result of dilution (Grace 2017).
Gwydir	Cat I indicators not sampled		No data available (Grace 2107)
	Primary productivity Cat III indicators		There is not yet sufficient information on flow–metabolism relationships to determine whether CEW will attenuate the high turbidity in the Gwydir and therefore facilitate primary production or suppress photosynthesis further (Grace 2017).
Lower Lachlan	Cat I indicators		Larger (double river height) translucent flows generated a response in GPP and ER due to increased nutrients – but not effluents. Question remains to be seen if large enough effluents will be delivered to achieve expected outcomes attributable to CEW. No data for two watering actions and the larger translucent flows – only about a third of the data collected could be used in the evaluation (Grace 2017).
Lower Murray	Cat I indicators		Base flows delivered to the Lower Murray were coordinated with weir pool manipulations which enhanced lateral connectivity resulting in entrainment (Grace 2017).
Murrumbidgee	Cat I indicators		No CEW actions targeting in-channel responses of ecosystem function, nutrient cycling or stream metabolism in

			the Murrumbidgee River during 2015–16 (Grace 2017). During 2015–16, primary production and ER in the Murrumbidgee River varied with time at both sites, with little evidence of a strong relationship between flow (freshes) and metabolism. Peak values of these parameters occurred during both (relatively) high and low flows. Mean (and median) values were typical of, if not slightly lower than, other rivers in the Basin.
Warrego-Darling	Cat I indicators		Very high turbidity in the Darling River is likely to have greatly reduced the viable light climate for phytoplankton and benthic algal growth. No CEW targeted stream metabolism outcomes in the Warrego.

Water quality

Basin-scale evaluation will address the following short-term (one-year) and long-term (five-year) Basin-scale evaluation questions regarding water quality (from Grace 2015):

- What did Commonwealth environmental water contribute to pH levels?
- What did Commonwealth environmental water contribute to salinity regimes?
- What did Commonwealth environmental water contribute to dissolved oxygen levels?

“..data collection for pH, turbidity, salinity (electrical conductivity), and nutrient and chlorophyll-a concentrations was sporadic and typically at frequencies of every 2–6 weeks. The lack of continuous monitoring (except for DO and temperature collected using the loggers acquiring metabolism data) is a constraint imposed by the overall project budget. Hence, it is extremely difficult to attribute the effects of watering actions on any parameter other than DO. However, aggregated water quality data are useful to help explain patterns of metabolism at catchment and Basin scales.” Grace (2017), p 13

“In terms of an evaluation of the management of Commonwealth environmental water, there are three considerations:

1. the extent to which watering actions undertaken to achieve biodiversity, ecosystem function or resilience outcomes influenced water quality
2. the effectiveness of watering actions undertaken to ameliorate threats from acute water quality events, including cyanobacterial algal blooms, oxygen-depleted blackwater and acidification
3. the effectiveness of watering actions undertaken to achieve long-term improvements in water quality, including the export of salt.” Grace (2017), p23

“Commonwealth environmental water has the capacity to influence water quality as evidenced by the outcomes in the Gwydir and Edward–Wakool. In the Edward–Wakool, Commonwealth environmental water is believed to have had a beneficial effect by preventing the development of the low dissolved oxygen conditions found in a nearby site which did not receive water.” Grace (2017), p25.

Findings: The 2015-16 data indicated that CEW influenced water quality in the Gwydir and Edward–Wakool. Some of the Selected Areas have not specified water quality KEQs or expected outcomes in the evaluation reports, despite data being collected. It is unclear why there are no KEQs for nutrients. Grace (2017) reported that the water quality data collected was sporadic and mostly at frequencies of every 2–6 weeks, collected at times when other data were collected. In general, there is a lack of continuous data for water quality expect for dissolved oxygen and temperature for evaluation of Basin-scale questions.

There is an apparent discrepancy between the intended approach to evaluation as presented in the Basin Evaluation Plan (Gawne et al. 2014) and the actual Basin Matter evaluation report (Grace 2017). In the Outcomes Framework and Evaluation Plan water quality is variably listed as the primary element of the Basin Matter (See Section 3.4 in Gawne et al. 2014, 18), which links to it being one of the four Basin Plan objectives. Stream metabolism also links to a Basin Plan objective, ecosystem function, as an indicator for assessing one year outcomes. The Synthesis report doesn’t treat water quality as a theme, as it focuses on the objectives of the Environmental Watering Plan;

not the Basin Plan objectives (which includes water quality). It would appear that the intended emphasis has shifted from water quality to stream metabolism. This needs to be resolved.

Table 12. Assessment of progress for Basin-scale evaluation of water quality.

Selected Area	Indicator	Rating	Justification
Edward-Wakool	Nutrients and Carbon – Cat I Carbon characterisation – Cat III Poor water quality events – Cat III		Counterfactual observed where the one site that did not receive CEW developed low dissolved oxygen (Grace 2017).
Goulburn	Dissolved oxygen and temp – Cat I Spot data for EC, pH, temp, DO - Cat III		Not addressed at area-scale.
Gwydir	Water quality Cat I Water quality - water chemistry, nutrient and particulates Cat III		Single location on Gwydir River for Cat I logger data.
Lower Lachlan	None specified in 2015-16 evaluation report, but assume they are as stated in Grace (2015).		Not sure what is being assessed - Can't make a statement re progress if KEQ or objectives are not presented in the report. Nutrients are sampled and discussed in relation to metabolism, but no KEQ/expected outcomes are stated for water quality.
Lower Murray	Dissolved oxygen and temp – Cat I Matter transport: salinity, dissolved nutrients, particulate organic nutrients, chlorophyll a – Cat III		Watering actions were effective in exporting salt and nutrients which would be expected to contribute to 1–5-year improvements in water quality in the Basin (Grace 2017).
Murrumbidgee	Dissolved oxygen and temp – Cat I Water quality – Cat III		On track for both river and wetlands water quality outcomes at Area-scale. Data may not be adequate for Basin-scale evaluation. Not clear which methods are used for water quality – assume they are Cat III methods.
Warrego-Darling	Water quality – Cat I Water quality – Cat III		Dependent on receiving flows. Continuous monitoring of the dependant variables at two sites in the Darling zone.

VEGETATION

Basin-scale evaluation will address the following short-term (one-year) and long-term (five-year) Basin-scale evaluation questions regarding:

- What did CEW contribute to plant species diversity?
 - How did Commonwealth environmental water affect the presence, distribution and abundance of individual plant species?
- What did CEW contribute to vegetation community diversity?
 - How did Commonwealth environmental water affect the composition and structure of particular vegetation communities?

- How did Commonwealth environmental water affect the composition and structure of particular vegscapes?

Findings: Excellent report – clearly articulates intended linkages between Basin Plan EWP objectives, expected outcomes, KEQ and 1 and 1-2 year observed and predicted outcomes. Only a couple of minor issues identified. Need to specify what the primary and secondary expected outcomes are in this report to truly evaluate if expected outcomes have been achieved. As with the other Basin Matters there is no statement of condition prior to watering – the requirement to provide context of the environmental conditions across the Basin is not met.

The report focuses on the Gwydir, Murrumbidgee and Lower Lachlan systems, and the Warrego and Darling rivers. Ten CEW actions with expected vegetation diversity outcomes were monitored across the six Selected Areas during 2015-16. Report provides a good description of what happened with each watering action. Good discussion of the effects of CEW on plant species diversity at Selected Areas broken into river channel systems and wetland and floodplain systems. Also presents a good discussion of the effects of CEW on plant species diversity at the individual Selected Areas.

Summary presented in Table 15 is excellent/ very useful.

Table 13. Assessment of progress for Basin-scale evaluation of vegetation.

Expected 5 year outcome (Capon et al. 2017)	Expected 1 year outcome (Capon et al. 2017)	Basin-scale KEQ	Rating	Justification
Greater plant species diversity	Establishment, growth, spread and reproduction of hydrophilic taxa	What did CEW contribute to plant species diversity?		Data collected to date on track to illustrate influence of CEW on species diversity.
	Mortality, reduced establishment and spread of xeric taxa	<ul style="list-style-type: none"> How did CEW affect the presence, distribution and abundance of individual plant species? 		Measured and observed outcomes refer to exotic rather than xeric – probably okay – but just need to clarify this.
Greater vegetation diversity	Increased richness and productivity of wetland vegetation communities	What did CEW contribute to vegetation community diversity?		Species richness of vegetation communities exhibited mixed responses to wetting both within and between Selected Areas (Capon and Campbell 2017).
	Shifts in composition of floodplain and wetland vegetation communities	How did CEW affect the composition and structure of particular vegetation communities?		No CEW on western floodplain and limited overbank flows in other Selected Areas. Where inundation of wetlands and floodplains did occur CEW contributed substantially to landscape-scale vegetation diversity (Capon and Campbell 2017).
	Increased heterogeneity of vegetation communities at landscape scales	How did CEW affect the composition and structure of particular vegscapes?		Consistently promoted the diversity and heterogeneity of vegetation communities at landscape scales at each Selected Area and across the Basin (Capon and Campbell 2017).

Greater resilience of plant species to drought	Enhanced resilience to drought among plant taxa benefiting from Commonwealth environmental water	No specified KEQ		Species influenced by CEW are predicted to have greater resilience to drought over next 1–5 years and should exhibit greater responses to further wetting (Capon and Campbell 2017).
Greater vegetation resilience to drought	Enhanced resilience to drought among vegetation assemblages benefiting from Commonwealth environmental water	No specified KEQ		Watering in 2014-15 influenced vegetation responses in 2015-16 (Capon and Campbell 2017).

FISH

The LTIM evaluation questions for fish are (Stoffels et al. 2017):

- What did Commonwealth environmental water contribute to sustaining native fish populations?
- What did Commonwealth environmental water contribute to sustaining native fish reproduction?
- What did Commonwealth environmental water contribute to sustaining native fish survival?

Findings: Very good report, quite technical. Stoffels et al. (21070 make a clear distinction between flows and regimes, and the emphasis of the fish Basin Matter evaluation being on long term outcomes pertaining to population dynamics. Fish Basin Matter outputs are planned to increase each year (Stoffels et al. 2107). Excellent synthesis of fish outcomes across the seven Selected Areas, which includes consideration of influences, other than CEW, on the outcomes (Table 3, Stoffels et al. 2017).

Concern has been expressed by some LTIM team members that the intended expected outcomes will not be achieved by Cat 1 methods not likely to achieve outcome.

Table 14. Assessment of progress for Basin-scale evaluation of fish.

Basin-scale KEQ (Stoffels et al. 2017)	Rating	Justification
What did CEW contribute to sustaining native fish populations?		The Fish Basin Matter is not yet in a position to provide robust reporting on the contribution of Commonwealth environmental water to the Basin Plan objectives of recruitment and survival (Stoffels et al. 2017, p51). There was no significant change in the species richness, evenness or nativeness of the fish community in any of the Selected Areas.
What did CEW contribute to		“Note that we have not extended this modelling to undertake a full evaluation of Commonwealth environmental water’s

sustaining native fish reproduction?		contribution to fish spawning across all Selected Areas. The primary reason for not doing this at this stage is that the models are not quite ready for a robust evaluation” ...“We will undertake a full evaluation of the contribution of Commonwealth environmental water to fish spawning in 2016-17” Stoffels et al. (2017), p 35.
What did CEW contribute to sustaining native fish survival?		No single, within-year watering action (i.e. timing, rate of increase, mean discharge, etc. of a managed flow) will be optimal if our objective is to maintain diversity of native fishes

GENERIC DIVERSITY

Not assessed at the Selected Area-scale – general data collated by BM Lead and additional data sourced from other sources such as TLM and Ramsar site monitoring data.

The LTIM evaluation questions for generic diversity are (Hale 2017):

- What did Commonwealth environmental water contribute to species diversity?
 - How did Commonwealth environmental water affect the presence, distribution and abundance of plant, fish, waterbird, frog, turtle and aquatic ecosystem dependent mammal species?
 - What listed threatened species and ecological communities benefited from Commonwealth environmental water?
 - What migratory species listed under international agreements (Bonn Convention, CAMBA, JAMBA or ROKAMBA) benefited from Commonwealth environmental water?

“The main output of the Generic Diversity evaluation is an aggregated list of species and communities that potentially benefited from Commonwealth environmental water each year” Hale (2017), p

The Basin Evaluation Plan stats that the following Basin-scale evaluation questions will be addressed in the Generic Diversity Basin Matter reports:

- Long-term (five-year) question:
 - What did Commonwealth environmental water contribute to other vertebrate populations?
- Short-term (one-year) and long-term (five-year) question:
 - What did Commonwealth environmental water contribute to other vertebrate species diversity?

According to Gawne et al. (2013) this Basin Matter is intended to focus on species not addressed in the other Basin Matter reports – i.e. birds, frogs, turtles, bats etc.

Findings: Very useful report on genetic diversity for both LTIM sites and non-measured sites. The mismatch between the KEQ from the Basin Evaluation Plan and those listed in Hale (2017) shown above may have been due to revisions that we are not privy too. The KEQ from Hale (2017) are much more similar to the specific objectives for water-dependent ecosystems (see Appendix E this report), but we expect populations KEQ to also be relevant as a long term outcome. The Basin Matter blurs the distinction between biodiversity and generic diversity in some spots in the report. Limited evaluation due to only two years data, but considered on track. Inclusion of more data from the Northern basin – in particular Queensland sites would be useful to provide a more balanced picture.

Table 15. Assessment of progress for Basin-scale evaluation of generic diversity.

Basin-scale KEQ (Hale 2017)	Rating	Justification
What did CEW contribute to species diversity?		There is a lack of information on the outcomes of environmental water in the Northern Basin and this may be limiting the list of species and communities that potentially benefited in that part of the Basin. The majority of the report focuses on sites within the Southern Connected Basin, but with a fair bit from the Gwydir. Inclusion of data for the Narran or the Paroo Ramsar sites may improve this balance.

INTEGRATED BASIN-SCALE EVALUATION – SYNTHESIS REPORT

“This analysis will take the form of a procedural and reporting integration of information from Basin Matter outputs and other information sources. Reported outcomes and modelled predictions from the Basin Evaluation of ecosystem diversity, vegetation diversity, fish populations and generic diversity will be integrated to provide an overall evaluation of the influence of Commonwealth environmental water in protecting or restoring the Basin’s biodiversity” Gawne et al. (2013), p27.

Procedural integration is typically based on an agreed set of protocols with all the information accessible in a standard or known format. However, evaluation and reporting may not occur in an integrated manner. Reporting integration is where the various elements of a monitoring program are summarised, analyzed and reported by an appointed group or unit that integrates the various aspects, in this case the Basin Matter team. It does not include standard methods for data collection used in reporting. Data is not necessarily collected for the objectives of integrated reporting – this approach uses what is available from multiple sources (Butcher et al. 2014).

“Due to limitations associated with identifying suitable reference sites, the Basin evaluation will, over the next 5 years, develop quantitative models that predict the outcomes of Commonwealth environmental watering based on the characteristics of the event and the condition prior to watering” Gawne et al. (2017), p5 (This should probably read as over the 5 years of the project).

“Evaluation at the Basin scale requires both an estimation of the overall outcomes across the Basin and then a judgement of their significance and contribution to Basin Plan objectives” Gawne et al. (2017).

“..Basin evaluation is cumulative for 2014–16 and is provided in three parts:

1. integrated Basin-scale evaluation – a summary of the achievements of Commonwealth environmental water under three broad themes of the Basin Plan (biodiversity, ecological function and resilience)
2. contributions to Basin Plan environmental objectives – a tabulation of progress toward these long-term goals in the first 2 years
3. adaptive management – a summary of key ‘lessons learned’ for both improved environmental water outcomes and the LTIM Project.” Gawne et al. (2017),

Findings: A good report; but would be improved by adding more references to the sources of evidence (mostly in the Appendices) and paying more attention to terms used, and consistency between foundation and Basin Matter reports.

1. Reference to BEWS

Currently there is limited reference to the BEWS in the integrated Basin-scale evaluation. The BEWS provides detail on the environmental objectives and targets, with 'quantified expected outcomes' identified for four components: river flows and connectivity; native vegetation; waterbirds; and native fish. Gawne et al. (2017) state that the MBDA has the responsibility to evaluate the contribution of Basin Plan reforms to achieving the targets set in the BEWS, however this is incorrect, or at best misleading (see Section 2.1 for discussion on CEWH obligations under the Water Act).

2. Water Quality as a Basin Objective and/or Basin Matter

The Synthesis Report focuses on three broad *environmental objectives* of the Basin Plan: biodiversity, ecosystem function and resilience (Gawne et al. 2014). It's not apparent why water quality has not been included as it's included in both the Outcomes Framework and the Evaluation Plan as being part of the LTIM Project. We feel Water Quality should be included as a theme for integrated Basin-scale evaluation.

*"This process synthesises the evaluations from the Selected Areas and then uses the CEWO Outcomes Framework to link these to Basin Plan objectives, by translating local or site-scale outcomes into the four high-level environmental objectives under the Basin Plan generically described as Biodiversity, Ecosystem Function, Resilience and **Water Quality**"* Gawne et al. (2017), p6. The problem is the distinction (or lack of) between the *environmental objectives*, *objectives of the MDBA EWP*, and the *Basin Plan objectives*. These are interchangeably used in the foundation documents and Synthesis report and have led to a lack of clarity, especially around how water quality is reported in the LTIM Project.

When introducing the stream metabolism and water quality Basin Matter in the Synthesis report (dot point 3, page 5) instream primary productivity and decomposition, salinity and pH are listed (Gawne et al. 2017, p 5), but not the other indicators for which there are long and short expected outcomes and Basin-scale KEQ. There is limited discussion of water quality throughout the Synthesis report and it is unclear as to why this is the case. There is a need to improve the clarity around the intended evaluation of Water Quality and Stream metabolism across the LTIM Project. It may be that these would be better suited as separate Basin Matters to avoid this confusion; noting that doing so would require the Outcomes Framework, Evaluation Plan and treatment in Basin Matter reporting to be updated. For example within the Outcomes Framework there are no expected outcomes for water quality.

3. Integrated Basin-scale evaluation

There is a need to improve the description of *integrated Basin-scale evaluation* in the Synthesis report. Gawne et al. (2014) states that integrated evaluation at the Basin-scale will be undertaken in as procedural and reporting integration (see above for definitions). This is reflected in the Synthesis report which provides a summary of findings by Basin Matter as they relate to the three themes of biodiversity, ecosystem function and resilience. The nature of the evaluation may change after the third year of data collection, and this could be spelt out more clearly.

4. Consistency between documents

A minor, but frustrating issue is the inconsistency in the order and description of elements between the foundation documents, Basin Matter reports and the Synthesis report. The inconsistency with regard to water quality is a prime example, but there are others. The logic and rational should carry through all documents in a consistent manner, particularly in the Synthesis document as this makes it easier for the reader to, firstly find, and then follow conceptual linkages and discussions.

For example, vegetation diversity has been added as a key evaluation question in the Synthesis report under the biodiversity theme, but it's not in the Basin Evaluation Plan and there is no explanation why it, and not fish outcomes, were included. Another example of inconsistency is.... *"Watering by Commonwealth environmental water in 2015–16 contributed significantly to the biodiversity objectives of the Basin Plan associated with vegetation diversity and is likely to have increased species diversity at the Basin scale over the 2 years"* there are no biodiversity objectives for vegetation per se. Closer peer review of the Synthesis report and related Basin Matter Reports would help capture, and fix these issues.

5. Contribution to Basin Plan objectives – Section 5

This is a very brief summary addressing the main objective of the LTIM Project. It mentions data limitations for 2014-16, but it's not clear how that relates to the objective hierarchy. Statements on the likelihood of achieving the objectives would be useful. There is a need to make a distinction in the summary table as to what is an outcome and what is a prediction.

6. Adaptive management

Gawne et al. (2017) provides a good summary of the adaptive management lessons gained to date in the LTIM Project. The recommendations on how to improve the LTIM outputs largely match our findings.

Table 16. Assessment of progress for Basin-scale integrate evaluation of Biodiversity, Resilience, and Ecosystem Function.

Basin Plan objective	Theme (Gawne et al. 2017)	Contributing Basin Matters	Basin-scale KEQ (Gawne et al. 2017)	Rating	Justification
to protect and restore water-dependent ecosystems of the Murray-Darling Basin (Basin Plan, Chapter 8, Part 2, 8.04(a))	Biodiversity	<ul style="list-style-type: none"> Ecosystem diversity Vegetation Fish Generic diversity 	What did CEW contribute to ecosystem diversity?		A lack of expected outcomes for ecosystem diversity has been discussed elsewhere in this review.
			What did CEW contribute to species diversity?		Gawne et al. (2017 state that in 2014-16 protecting threatened species through environmental water management was a priority – this needs citation. Assigned yellow as it's not clear why fish weren't included.
			What did CEW contribute to vegetation community diversity?		Not clear why this is included in the Synthesis report and fish are not. Assumed to have made a significant contribution.
to protect and restore the ecosystem functions of water-dependent ecosystems (Basin	Ecosystem function	Hydrology	What did CEW contribute to restoration of the		Assessed base flow and fresh components of the water regime in 2014–16 and what would have occurred in the absence of water resource

Plan, Chapter 8, Part 2, 8.04(b))			hydrological regime?		development and extraction. Not sure if this is justified as a restoration of the hydrological regime, but concludes CEW contributed significantly to maintaining base flows and freshes in the southern Basin.
			What did CEW contribute to hydrological connectivity?		
		Stream metabolism	What did CEW contribute to <ul style="list-style-type: none"> • patterns and rates of decomposition? • patterns and rates of primary productivity? 		More complete quantitative evaluations will be undertaken in future years once additional hydraulic data and modelled predictions of what would have happened in the absence of environmental flows become available
to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats (Basin Plan, Chapter 8, Part 2, 8.04(c))	Resilience	<ul style="list-style-type: none"> • Hydrology • Ecosystem diversity 	<p>None specified in Gawne et al. (2017), but they are in Gawne et al. (2014):</p> <p>What did CEW contribute to ecosystem resilience?</p> <p>What did CEW contribute to population resilience?</p>		This section of the report is presented differently to biodiversity and ecosystem function. It cross references the discussions for connectivity and ecosystem diversity; however these sections do not address outcomes for resilience per se. The KEQ listed in the Basin Evaluation Plan are not included in the Synthesis report.
to ensure water quality is sufficient to achieve the above objectives for water-dependent ecosystems, and for Ramsar wetlands, sufficient to maintain ecological character (Basin Plan, Chapter 9, Part 3, 9.04 (1) & (2))	Water quality – not addressed				Not addressed adequately.

APPENDIX G: ASSESSMENT OF PROGRESS OF AREA-SCALE EVALUATION

Green – Evaluation on track and likely to be achieved	Yellow – Evaluation will possibly be achieved but dependent on watering conditions or other constraint	Red – Evaluation questions not adequately addressed, or not on track to be achieved.
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This assessment of the Selected Area reports is very high level and does not constitute a detailed evaluation of the conceptual premise, methods or evaluation techniques. The ratings are based on only two years of LTIM and conditions/results may change in the final years of the program. Whilst some of the expected outcomes set at the Area-scale may not be achieved, this in itself is not necessarily a failure, since the knowledge gained from this project will be significant – even if the outcome isn't what was originally hypothesised.

In most cases, identification of some aspect not being on track, reflects one or more of the following:

- no measurable objectives/expected outcomes given (e.g. ecosystem diversity);
- outcome unlikely to be achieved due to constraints;
- and/or ecological response not observed as expected.

In these cases, there may be a need to refine objectives and or manage expectations.

The following is an extract from the contracts with the Selected Area teams that relate to the objectives and requirements for reporting – these have been used as guides to assess the progress of the Selected Area teams in meeting objectives, evaluation and reporting requirements. Bolded text are areas in which there is inconsistency between the Selected Areas, and or, requirements have not been met.

The Services in priority order aim to:

- (vi) evaluate ecological outcomes of CEW at each Selected Area;
- (vii) evaluate the contribution of CEW to the objectives of the Murray Darling Basin Authority's Environmental Watering Plan;
- (viii) infer ecological outcomes of CEW in areas of the Murray-Darling Basin not monitored;
- (ix) support the Adaptive Management of CEW; and
- (x) monitor the ecological response to CEW at each Selected Area.

Annual reports are to include:

Evaluation

a) evaluate the extent to which the **expected outcomes identified in the Monitoring and Evaluation Plan, and identified for environmental watering in the years 2014-15 to 2018—19, have been achieved;**

- b) evaluate the outcomes of environmental water use based on available information using one or more of the following approaches:
 - i. monitored results;
 - ii. observations;

- iii. quantitative evaluation;
- iv. qualitative evaluation;
- v. inferred using scientific opinion and the outcomes framework; or
- vi. inferred using expert scientific opinion and other evidence.

- c) clearly identify which of the above approaches was used for the evaluated outcome;
- d) for the expected outcomes identified in the Monitoring and Evaluation Plan, **provide clear answers to each relevant evaluation question;**
- e) quantify to the fullest extent possible **the marginal benefit** of Commonwealth environmental water and other held environmental water delivered in conjunction with Commonwealth environmental water;
- f) **the evaluation of expected outcomes (both less than one year and one to five years) after the first year will need to be cumulative by considering the evaluation of results from the previous years**
- g) **provide area evaluation of both Basin and area matters;**
- h) **include, where possible, preliminary findings in relation to one to five year expected outcomes** (if necessary these may be supported by qualitative results in the earlier years leading to quantitative evaluation in the later years);

Adaptive management

- i) use monitoring and evaluation outcomes and expert scientific opinion to **provide implications for future management** of Commonwealth environmental water and how to **improve for the future;**

Context

- j) **provide context of the environmental condition of the Selected Area for watering actions;**
- k) **provide brief context to the watering actions and links to the expected outcomes from the watering action and previously evaluated outcomes;**

In addition, a progress status rating is provided for each of the Area-scale indicators (see tables below). **Note** that none of the latest progress reports for each of the Selected Area indicate any risks to the achievement of the intended project outcomes.

General findings for Selected Areas reports: Overall the Selected Area evaluation reports address Area-scale evaluation questions (predominantly short term) but don't necessarily address the LTIM objectives. Only the Gwydir and Warrego-Darling evaluation reports make reference to the Basin Plan EWP objectives. The Goulburn team report on Basin and Area-scale matters, with most other Selected Area evaluation reports stating this will be done by MDFRC.

The way in which expected outcomes are documented in the evaluation reports varies considerably. Expected outcomes should be either from the MEP or annual watering objectives/acquittal reports for each Selected Area, but need to be restated in the main text of the evaluation reports. Some of the issues lie not with the Selected Area teams, but with the expected outcomes articulated in the water planning documents (e.g. Warrego-Darling and others, where they are not SMART); however all MEP had expected outcomes stated against which the Area-scale evaluation is expected to report against. Having a clear, SMART, objective/expected outcome is fundamental to assessing if and what the CEW contributed to achieving the Basin Plan environmental Watering Plan objectives.

Many of the evaluation reports did not mention the long term outcomes, or they were included but not clearly labeled as being long term outcomes/KEQ. Discussion on the marginal extent to which CEW contributed to outcomes was also variably dealt with across the Selected Area teams.

For reporting on the expected outcomes as per the MEP (Evaluation column d in Table 17) a quick cross check was made between the evaluation reports and the MEPs; a yellow rating indicates one or more KEQ (either long or short, but usually long term) were not addressed in the evaluation reports. For some Selected Areas this may be due to an agreement with CEWO that we haven't been privy too, e.g. was ecosystem diversity still expected to be assessed by the area teams?; was fish condition dropped in the Edward-Wakool?

Overall there is a need for greater consistency in the content of the evaluation reports. The reports should summarise the planning and delivery of CEW, and the associated expected outcomes upfront. These should then be clearly linked to the evaluation questions and indicators, a summary of findings, and recommendations for changes/adaptive management of the monitoring. A key requirement is a statement on whether the flows were appropriate to achieve the expected outcomes. Every KEQ should be answered – even if it is to say no data/no response. A distinction between short and long term outcomes/KEQ is required.

Whilst the Area-scale evaluation as part of the LTIM project as a whole is largely on track, there are definitely some areas in which improvements can be made.

An assessment of risks to achieving outcomes should be clearly stated in each Selected Area annual report.

Adaptive management recommendations were generally well done.

Table 17. Progress status for each reporting requirement for Selected Areas – based on 2015-16 evaluation reports.

Selected Area	Evaluation								Adaptive management	Context	
	a	b	c	d	e	f	g	h		j	k
Edward-Wakool											
Goulburn											
Gwydir											
Lower Lachlan											
Lower Murray											
Murrumbidgee											
Warrego-Darling											

EDWARD-WAKOOL

The overall 'purpose' for managing the Commonwealth's water portfolio in the Mid Murray for 2015–16 was to **protect** the floodplain forest areas where demands are high, while **maintaining** ecological health and resilience of other key sites in the system (Watts et al. 2016, p14). The objective of these two watering events was: 'to

compare the spawning response of cod by applying e-flows into the upper Wakool and Yallakool at the same time and to support the on-going recovery/re-establishment of in-stream aquatic vegetation' (Watts et al. 2016, p15). Four environmental watering actions occurred, with two actions monitored by the project - upper Wakool River and Yallakool Creek (11 November to 30 January) (see Watts et al. 2016, p 19, Table 2.2). Eight watering events were planned.

Findings: Constraints (that is floodplain inundation) are the main issue affecting the ability to achieve the expected outcomes with the watering reported on having little to no effect on the indicators assessed. The way in which the outcomes are presented (e.g. in Table 12.2) is misleading and seems to contradict earlier statements. Most are shaded green but this only indicates a positive response – not necessarily that the objectives of the watering action were achieved.

No selected area evaluation for the fish community was undertaken in 2015-16 only occurring in years 1 and 5 (Watts et al. 2016).

Overall Watts et al. (2016) is a very good, informative report. The project objectives (evaluation questions) are well identified, and adequate details provided on the monitoring, results and their analysis. In particular, the summary evaluation tables for each indicator were very useful. These tables were split into two sections: (a) the CEWO planning and delivery (i.e. what was planned, what outcomes were expected), and (b) Edwards-Wakool monitoring and evaluation questions and outcomes (i.e. LTIM question, observed outcome, evidence, were the flows appropriate to achieve expected outcomes).

It is obvious that a number of the desired ecological outcomes for this system are constrained by either operational or landholder constraints. **Recommend** that a short report be prepared to specifically identify these constraints and what changes would be needed to achieve the ecological outcomes sought.

Table 18. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Edward-Wakool.

Indicator	Expected outcome as per Water Use Minute 10038 and/or CEWO Acquittal report (from Watts et al. 2016).	Area-scale LTIM KEQ	Rating	Justification
River hydrology	<p>Support mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter) through longitudinal and lateral hydrological connectivity</p> <p>Support inundation of low-lying wetlands/floodplains habitats within the system</p> <p>Maintain ecosystem and population resilience through supporting ecological recovery and maintaining aquatic habitat.</p>	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> hydrology of the four zones in the Edward-Wakool system that were monitored for the LTIM project? longitudinal hydrological connectivity? longitudinal hydrological connectivity? in-channel wetted benthic area? area of slackwater, slow flowing water and fast water? lateral connectivity? 		<p>Flows in the upper Wakool River were not large enough to achieve expected outcomes due to flow constraints. It did not increase lateral connectivity or connect low-lying habitats within the system. Note this contradicts assessment of outcome in Table 12.2, p63</p> <p>Flows in Yallakool creek resulted in an increase longitudinal connectivity and in lateral connectivity in some, but not all reaches (Watts et al. 2016).</p>
Water quality and carbon	To support mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter) through longitudinal and lateral	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> temperature regimes? dissolved oxygen concentrations? nutrient concentrations? 		CEW did not influence temperature or nutrient concentrations in 2015-16, but DO was higher in Yallakool Ck. CEW introduced only small amounts of floodplain carbon

Indicator	Expected outcome as per Water Use Minute 10038 and/or CEWO Acquittal report (from Watts et al. 2016).	Area-scale LTIM KEQ	Rating	Justification
	<p>hydrological connectivity</p> <p>To maintain/improve water quality within the system, particularly dissolved oxygen, salinity and pH</p>	<ul style="list-style-type: none"> modification of the type and amount of dissolved organic matter through reconnection with previously dry or disconnected channel habitat? reducing the impact of blackwater in the system? 		from upstream in the Barmah-Millewa forest. Flow management achieved C inputs without a blackwater event. Dilution flows from the canal were not required (Watts et al. 2016).
Stream metabolism	<p>To support mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter) through longitudinal and lateral hydrological connectivity (Water Use Minute 10038) This is related to metabolism but not specifically addressing it.</p> <p>No specific targeted outcomes for metabolism (Watering action acquittal report)</p>	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> patterns and rates of decomposition? patterns and rates of primary productivity affect rates of gross primary productivity and ecosystem respiration in the Edward- Wakool River system? 		Flows were considered too small to have any impact on these variables – responses observed were not attributed to changes in flow (Watts et al. 2016).
Riverbank and aquatic vegetation	<p>To maintain health of riparian and in-channel aquatic native vegetation communities (Water Use Minute 10038)</p> <p>To support the ongoing recovery/re-establishment of in stream aquatic vegetation (Watering action acquittal report)</p>	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> recovery (measured through species richness, cover and recruitment) of riverbank and aquatic vegetation in Yallakool Creek and the mid and upper Wakool River that have been impacted by operational flows and drought and how do those responses vary over time? How do vegetation responses to CEW delivery vary among hydrological zones? percent cover of riverbank and 		CEW contributed to recovery in the mid Wakool and Yallakool Creek, but not in the upper Wakool. Recruitment and cover varied among zones, but were generally higher in those that received environmental flows. Submergent vegetation richness was also higher in those zones that had a history of eflows (Watts et al. 2017).

Indicator	Expected outcome as per Water Use Minute 10038 and/or CEWO Acquittal report (from Watts et al. 2016).	Area-scale LTIM KEQ	Rating	Justification
		aquatic vegetation in Yallakool Creek and the upper and mid Wakool River? <ul style="list-style-type: none"> • taxonomic richness of riverbank and aquatic vegetation taxa in Yallakool Creek and the upper and mid Wakool River? 		
Fish movement	To maintain the diversity and condition of native fish and other native species including frogs and invertebrates through maintaining suitable habitat and providing/supporting opportunities to move, breed and recruit (Water Use Minute 10038)	<ul style="list-style-type: none"> • Were periodic species (golden and silver perch) present in the target reaches during CEW delivery? • Did periodic species remain within the target reaches during CEW delivery? • Did CEW stimulate periodic fish species to exhibit movement consistent with reproductive behaviour? • Does CEW enable periodic species to disperse from and return to refuge habitat? • Does CEW protect periodic species from adverse water quality? 		Summarised result of CEW as facilitating fish movement from zone 3 over very small distances, with most staying within zone 3 (Watts et al. 2016). no evidence from our larval fish monitoring to confirm a spawning response of either species (or bony herring) to water delivery CEW not delivered to deal with adverse water quality issues – not relevant.
Fish reproduction	To provide areas of habitat for Murray cod to move into and spawn, especially where the flows will cover snags that are the preferred spawning and nesting sites of Murray cod. To maintain the diversity and condition of native fish and other native species	<ul style="list-style-type: none"> • Did CEW contribute to increased spawning activity of Murray cod? 		“Irrespective of differences in hydrology and environmental flows in 2015-16 and in all previous years, Murray cod spawning started in mid-October, peaked in November and ended by mid- to late December.” Watts et al. (2016), 170

Indicator	Expected outcome as per Water Use Minute 10038 and/or CEWO Acquittal report (from Watts et al. 2016).	Area-scale LTIM KEQ	Rating	Justification
	including frogs and invertebrates through maintaining suitable habitat and providing/supporting opportunities to move, breed and recruit	What did CEW contribute to: <ul style="list-style-type: none"> • spawning in 'flow-dependent' spawning species (e.g. golden and silver perch? • the spawning of 'Opportunistic' (e.g. Small bodied fish) species? 		Golden perch didn't spawn in 2015-16; localised spawning has not occurred in this system over the past 5+ years and contributed to recruitment (Watts et al. 2016). Constraints may be limiting response for perch species.
Fish recruitment (Murray cod, golden and silver perch)	To provide areas of habitat for Murray cod to move into and spawn, especially where the flows will cover snags that are the preferred spawning and nesting sites of Murray cod. To maintain the diversity and condition of native fish and other native species including frogs and invertebrates through maintaining suitable habitat and providing/supporting opportunities to move, breed and recruit	Did CEW affect the growth rate of Murray cod, golden perch and silver perch during the first year of life?		No discernible pattern or relationship with environmental watering in regards to growth in different zones for Murray cod (Watts et al. 2016). No recruit growth reported for golden perch. Not able to assess silver perch as too few specimens taken.
		Did CEW contribute to the recruitment of Murray cod, golden perch and silver perch?		Murray cod YOY and 1+ individuals suggest annual recruitment in the EW or in nearby systems. No change in Murray cod due to changes in hydrology over the past few years. Not for golden perch. Silver perch results not as clear cut – no eggs or larvae collected, but 0+ and 1+ individuals were collected – most likely immigrants from nearby and not responding to CEW per se.

GOULBURN

River flows in the Lower Goulburn River were lower in 2015–16 than in the first year of the Goulburn LTIM Project – 2014-15. A dry winter and spring led to low volumes of water in storage and reduced environmental allocations. Commonwealth environmental water during 2015–16 contributed to (Webb et al. 2017):

- baseflows, to ensure adequate habitat provision;
- one major spring fresh, delivered in October targeting continued recovery of riverbank vegetation; and
- a smaller autumn fresh delivered in March, to support new lower bank vegetation and improve macroinvertebrate and fish habitat and water quality.

Note: there are no overbank environmental flows allowed in the Goulburn River system.

Findings: A very solid report. It would be helpful to have the expected outcomes (Table 19 below; p8 of Webb et al. 2017) for the Goulburn directly aligned with the indicators and KEQ rather than being presented in a separate section of the report. Having the logic of ‘this is the water we have, here is what we expected to happen, this is indicator we are using, this is the evaluation question and this is what we saw’ in the one spot would be ideal. Having said that, the overall presentation of evaluation questions, results and methods are very well done. In particular the inclusion of the Basin-scale matters alongside the area-scale evaluation is very good – clearly shows both the spatial and temporal scale of the evaluation questions.

Clear advice is given in regards to managing future watering for desired outcomes, or in the case of bank erosion, avoiding issues.

Table 19. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Goulburn.

Expected outcome (linked to flow type/delivery) (Webb et al. 2017, p8)	Indicator	Area-scale KEQ	Rating	Justification
<ul style="list-style-type: none"> • maintain water quality • support native fish condition & macroinvertebrate abundance/diversity • longitudinal connectivity - fish passage • support ecosystem function (e.g. connectivity, dispersal, primary production) 	Physical habitat and bank condition	What did CEW contribute to: <ul style="list-style-type: none"> • provision of productive habitat (e.g. slackwaters) for the recruitment, growth and survival of larval and juvenile fish? • provision of diverse and productive macroinvertebrate habitats? • inundating specific riparian vegetation zones and creating hydraulic habitats that favour the dispersal and deposition of plant seeds and propagules? • How does CEW affect bank erosion and deposition? 		Likely to be on track – based modelling with links being a bit tenuous with only a couple of years data. Strategic ewatering does not appear to have contributed to bank erosion (Webb et al. 2017).

Expected outcome (linked to flow type/delivery) (Webb et al. 2017, p8)	Indicator	Area-scale KEQ	Rating	Justification
<ul style="list-style-type: none"> improved condition and cover of native in-channel vegetation (especially on banks) discourage terrestrial vegetation encroachment on lower bank support ecosystem function breeding and movement of native fish 		<ul style="list-style-type: none"> How does the amount of river bank erosion affect vegetation responses to environmental water delivery? 		
	Stream metabolism	How does the timing and magnitude of CEW delivery affect rates of Gross Primary Productivity and Ecosystem Respiration in the lower Goulburn River?		There was no consistent immediate effect of flow increases (including those from CEW delivery) across the 4 sites on rates of either GPP or ER. However, there was a positive effect of flow rate on total amounts of GPP and ER (Webb et al. 2017).
		How do stream metabolism responses to CEW in the lower Goulburn River differ from CEW responses in the Edward Wakool system where the likelihood of overbank flows is higher and nutrient concentrations are generally much lower?		Goulburn River compared to the Edward-Wakool. The actual CEW and natural flows in the Edward Wakool prevented determination of flow metabolism relationships. In neither system did flows get out of the river channel. Both systems had very low bioavailable nutrient concentrations (Webb et al. 2017).
	Macroinvertebrates	What did CEW contribute to: <ul style="list-style-type: none"> macroinvertebrate diversity in the lower Goulburn River? macroinvertebrate abundance and biomass in the lower Goulburn River? macroinvertebrate emergence (and hence recruitment) in the lower Goulburn River? 		Diversity was not affected by CEW in 2014-15 or 2015-16. Biomass might be affected, but varied in each year, with a decrease in the Goulburn in 2015-16 compared to the Broken. Abundance varied by taxa, and emergence differed between years (Webb et al. 2017). Considered too early to establish contribution of CEW.
	Vegetation diversity	What did CEW contribute to: <ul style="list-style-type: none"> the recovery (measured through species richness, plant cover and recruitment) of riparian vegetation communities on the banks of the lower Goulburn River that have been impacted by drought and flood and how do those responses vary over time? 		The spring fresh flows are expected to be of benefit to species diversity. Short term responses to freshes were limited; the cover of vegetation along the elevation gradient reflects the longer term influence of spring freshes (Webb et al. 2017).

Expected outcome (linked to flow type/delivery) (Webb et al. 2017, p8)	Indicator	Area-scale KEQ	Rating	Justification
		<ul style="list-style-type: none"> How do vegetation responses to CEW delivery vary between sites with different channel features and different bank conditions? 		Differences observed in 2014-15 were not seen in 2015. Need longer data set (Webb et al. 2017).
		<ul style="list-style-type: none"> Does the CEW contribution to spring freshes and high flows trigger germination and new growth of native riparian vegetation on the banks of the lower Goulburn River? 		Increases in cover on banks inundated by freshes in 2014-15 were not observed in 2015-16 – attributed to drier conditions pre sampling (Webb et al. 2017).
		<ul style="list-style-type: none"> How does CEW delivered as low flows and freshes at other times of the year contribute to maintaining new growth and recruitment on the banks of the lower Goulburn River? 		Conditions are not discussed in terms of CEW – just other conditions (local climate, antecedent conditions) in between flows (Webb et al. 2017).
	Fish	What did CEW contribute to: <ul style="list-style-type: none"> the recruitment of golden perch in the adult population in the lower Goulburn River? golden perch spawning and in particular what magnitude, timing and duration of flow is required to trigger spawning? survival of golden perch larvae in the lower Goulburn River? 		Spawning event associated with CEW in 2014-15, but no eggs, larvae or evidence of recruitment in 2015-16. No flows delivered for golden perch spawning in 2015-16 (Webb et al. 2017).
		What did CEW contribute to: <ul style="list-style-type: none"> the movement of golden perch in the lower Goulburn River and where did those fish move to? 		Movement downstream associated with CEW (Webb et al. 2017).

Five environmental watering actions occurred during 2015-16, with combined CEW and NSW ECA water (Southwell et al. 2016). Environmental water was used to provide small flow pulses and longitudinal connection with the Gwydir system at critical times during the dry summer/autumn period. A total of 13,250 ML was delivered (63% CEW, 37% NSW) – this was ca. 10% of the total flow in the system.

“The overall aim of Commonwealth environmental water in the Gwydir catchment during 2015-16 was to consolidate and protect the ongoing environmental recovery achieved over the last three years in anticipation of a potentially low rainfall and inflow period. This was to be achieved by following natural flow cues, and activating access to supplementary water to offset a component of the consumptive extraction up to an approved volume withheld environmental water from Copeton Dam” (Commonwealth of Australia 2015b).

Findings: There was no clear summary of what monitoring was undertaken in 2015-16 in the main report – only in the appendices. The concluding statements made for each indicator in the technical appendices are very useful, but these should have been included in the main report. Still not all KEQ listed are explicitly addresses. It would have been helpful to have the expected outcomes for the watering year linked to the KEQs and outcomes. Would be good to distinguish between short and long term outcomes – stated in a few of the appendices but not consistently. Having said that – most of the matters are on track or likely to be achieved.

This and the Warrego-Darling are the only SA evaluation reports that address the contribution to meeting the objectives of the MDBA Environmental Watering Plan. Currently there is no reference to the BEWS, which is probably the more relevant as targets have been set for catchments, but none of the other SA reports do this either.

The content and presentation in this and the Warrego-Darling Reports are significantly different to the other SA evaluation reports (see BH comments re Warrego-Darling report also). Discussion of several of the indicators are spread over different Appendices and this is a little hard to follow at times – would like to see an overall evaluation of water quality and small bodied fish (as least) at the whole of SA scale. Overall both this and the Warrego-Darling are good reports – just different.

Table 20. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Gwydir.

Expected outcomes	Indicator	Area-scale KEQ	Rating	Justification
Gwydir and Gingham wetlands <ul style="list-style-type: none"> Maintain vegetation condition and reproduction Provide refuge habitat for waterbirds, fish and other aquatic species Maintain ecosystem resilience by supporting individual survival and condition Provide baseflows and 	Hydrology (river)	<ul style="list-style-type: none"> What did CEW contribute to hydrological connectivity? What did CEW contribute to hydrological connectivity of the Gwydir Selected Area channels? 		Contributed to connectivity in the Gwydir, lower Gwydir and Mehi River channels and was responsible for all significant flow in Mallowa Creek during 2015-16. Full connectivity in the Gingham watercourse and Moomin Creek was due to non-eflows. Overall, but expected, connectivity in 2015-16 was markedly reduced compared to 2014-15 (Southwell et al. 2016).
	Hydrology (watercourse)	<ul style="list-style-type: none"> What did CEW contribute to hydrological connectivity of the Gingham, lower Gwydir and Mallowa wetlands? 		Played a key role in inundating the Mallowa wetlands. 2015-16 CEW contributed less to connectivity in the lower Gwydir and Gingham wetlands than in the 2014-15 (Southwell et al. 2016).
	Ecosystem diversity	<ul style="list-style-type: none"> What did CEW contribute to sustainable ecosystem 		Only SA with an expected outcome for ecosystem diversity.

Expected outcomes	Indicator	Area-scale KEQ	Rating	Justification
<p>freshes to increase lateral and longitudinal hydrological connectivity</p> <ul style="list-style-type: none"> Allow for sediment transport, nutrient and carbon cycling. <p>Mallowa wetlands</p> <ul style="list-style-type: none"> Support hydrological connectivity between wetlands Support further recovery of vegetation extent and condition Provide habitat for waterbirds and native aquatic species Contribute to improved habitat quality and increased within ecosystem diversity to support survival of native birds fish and other fauna <p>Mehi River</p> <ul style="list-style-type: none"> To support in-stream ecological function and nutrient cycling, contributing to the health of in-stream habitat and maintaining water quality. 		<p>diversity?</p> <ul style="list-style-type: none"> Were ecosystems to which CEW was allocated sustained? Was CEW delivered to a representative suite of ecosystem types? 		<p>Not sure what is meant by sustainable ecosystem diversity in KEQ.</p> <p>No conclusion in the Appendix.</p> <p>“Within the Selected Area, a total of 122 sites, accounting for 82% of all sites were inundated during the 2015-16 water year. All ecosystem types except F1.11: River cooba woodland floodplain and Lt2.2: Temporary floodplain lake were inundated.” Southwell et al. (2016). This indicate that CEW was delivered to a representative suite of the 149 sites that were sampled – and probably also of all ecosystem types in the Gywdir SA, but the whole of the area-scale evaluation is not included – easy to address.</p>
	Water quality (Cat II)	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> temperature regimes? pH levels? turbidity regimes? salinity regimes? dissolved oxygen levels? 		<p>Expected outcomes for carbon and nutrient cycling are given but not for the parameters with KEQ for water quality per se.</p> <p>Describes how CEW affected the various water quality indicators in Appendix C, sampled at one location in the Gywdir. The argument made is that “this single station has permanent surface water connectivity in a defined channel and all environmental water delivered to the lower Gywdir must pass through this reach” Southwell et al. (2016).</p> <p>Don’t understand why there are separate treatments of water quality and stream metabolism spread over three Appendices – can these be combined into a whole of SA evaluation?</p> <p>(see comment below re Mehi results)</p>
Carole Creek, Mehi River,	Stream metabolism (Cat III)	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> patterns and rates of 		Rates peaked in association with ewater.

Expected outcomes	Indicator	Area-scale KEQ	Rating	Justification
<p>Gwydir River, Lower Gwydir River, Gigham Watercourse</p> <ul style="list-style-type: none"> During dry conditions, provide base flows to protect refugial in-stream habitat and mitigate declining water quality 		<p>primary productivity?</p> <ul style="list-style-type: none"> patterns and rates of decomposition? 		<p>Statements presented in Appendix D regarding water quality in the Mehi would appear to relate to stream metabolism (nutrients) but it's not clear. No Cat I stream metabolism data collected. Cat III indicators for stream metabolism were sampled. Method is supposed to be in the MEP but it's not.</p> <p>(From Appendix on microinverts) "The increase in rates of GPP and ER correspond to higher carbon and phosphorus availability in the 'wet' phase, which are either transported along with the environmental water or released in situ from freshly inundated sediments. This pattern is consistent among sites and suggests the management of carbon or phosphorus concentrations will regulate metabolism in these systems" Southwell et al. (2016).</p> <p>May want to consider reporting metabolism in a separate section rather than in with the microinvertebrates.</p>
	Microinvertebrates	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> microinvertebrate productivity? microinvertebrate community composition? connectivity of microinvertebrate and vegetation communities in floodplain watercourse? 		<p>Water quality Cat III methods also reported on in Appendix D (Southwell et al. 2016). Exceptionally high N and P concentrations in 2014-15 and 2015-16.</p> <p>KEQ re vegetation and microinverts not addressed. Diversity and density of microinvertebrates were influenced by ewater.</p>
	Macroinvertebrates	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> macroinvertebrate diversity? 		<p>No statistically significant effect of ewater on density, richness or diversity, but there was a significant effect on family level community composition (Southwell et al. 2016).</p>
	Vegetation diversity	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> vegetation species diversity? vegetation community diversity? 		<p>Watering action insufficient to inundate substantial areas of wetland vegetation (Southwell et al. 2016).</p> <p>Summary statement that the cover of the weed species lippia decreased with native species cover increasing (from</p>

Expected outcomes	Indicator	Area-scale KEQ	Rating	Justification
				<p>Table 4.1) is only part of the story – the result section of Appendix G states overall cover has been consistent over the two years. Cover varies in response to wetting and drying but no overall gains.</p> <p>CEW influenced vegetation – not a clear answer to the KEQs, but likely to be achieved.</p>
	Small bodied fish and frogs	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> • frog and small-bodied fish populations? • frog and small-bodied fish species diversity? 		<p>Too early to state contribution to populations, but Olive perchlet may be sustained at Gingham waterhole if managed for this species. Only location in the Gwydir its been recorded.</p> <p>Been assigned yellow due to comments re SBNF in Appendix I</p>
	Fish (river)	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> • native fish community resilience? • native fish survival? • native fish populations? • native fish diversity? 		<p>Sets context by reference to previous monitoring – not just LTIM – i.e. refers to SRA and STIM data.</p> <p>SBNF results are reported separately – but would be good to see area-scale evaluation of small bodied fish data - combining findings from the two Appendices. For example in Appendix I the small-bodied species are reported as declining in numbers and all were in low abundance compared with 2014-15 (attributed to dry conditions in the the lower Gwydir catchment 2015-16) (Southwell et al. 2016).</p> <p>Significant difference between years in fish abundances between years, no difference in biomass between channels, but a sig difference between years in biomass. Overall fish community in lower Gwydir is relatively stable but in poor condition.</p> <p>Conclude by stating “any significant and measurable</p>

Expected outcomes	Indicator	Area-scale KEQ	Rating	Justification
				improvement in the fish community is likely to take some considerable time”
	Fish (movement)	What did CEW contribute to: <ul style="list-style-type: none"> • native fish dispersal? • Did environmental water stimulate target species to exhibit movement consistent with breeding behaviour? • Did environmental water facilitate target species to move/return to refuge habitat? What did CEW contribute to: <ul style="list-style-type: none"> • to native fish populations? 		Included reference to short and long term KEQ, but data not yet available – being process in 2016-17.
	Waterbird diversity	What did CEW contribute to: <ul style="list-style-type: none"> • waterbird populations? • waterbird species diversity? • waterbird survival 		Waterbird results support findings from previous monitoring and are responding as expected.

LOWER LACHLAN

Three environmental watering actions were delivered to the Lower Lachlan river system during 2015-16.

The primary expected outcomes of the watering actions were to (catchment scale) (Dyer et al. 2016):

- Provide habitat to support survival, maintain condition of, and provide reproduction opportunities for native fish;
- Maintain the extent and diversity of aquatic and riparian vegetation;
- Support waterbird habitat, and breeding and recruitment opportunities; and
- Maintain hydrological connectivity including end of system flows.

The secondary expected outcomes were to:

- Contribute to ecosystem function; and
- Deliver landscape vegetation diversity and resilience.

Individually, the watering actions were expected to maintain hydrological connectivity, contribute to vegetation condition and diversity, provide habitat and access to habitat for frogs, fish and birds, trigger breeding and recruitment in frogs and generate movement and spawning of golden perch

Findings: This is a very good, informative report. The project objectives (evaluation questions) are well identified, and adequate details provided on the monitoring, and outcomes. However, in the main report there was little detailed information provided on the results and how they were analysed, but this is available in the Appendices. The distinction between action-specific and area-scale questions was well done. Dyer et al. (2016) included reference to 2014-15 as representing baseline conditions. The summary table of evaluation questions and responses clearly indicate which were short and long term questions.

In a few places reference is made to change at the catchment scale but it's not clear if this is distinct from area-scale. For example, "...indicates that the vegetation community within the catchment is responsive to watering" Dyer et al. (2016), p47.

A separate report on waterbirds was provided (Brandis & Lyons (2016), but this information was not incorporated into the Lower Lachlan Area report

Table 21. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Lower Lachlan.

Indicator	Expected outcomes – from Dyer et al. (2016) – (note source of outcomes not attributed in LTIM report)	Area-scale LTIM KEQ	Rating	Justification
Hydrology	<ul style="list-style-type: none"> Improve hydrological connectivity including end of system flows. Contribute to hydrological connectivity in the Booligal Wetlands. Provide habitat to support, maintain condition of, and provide reproduction opportunities for native fish, waterbirds and other aquatic vertebrate species. Contribute to hydrological connectivity. 	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> maintaining hydrological connectivity including end of system flows? hydrological connectivity? <p>What was the effect of Commonwealth environmental water on:</p> <ul style="list-style-type: none"> hydrological connectivity to Murrumbidgee Swamp? providing access to habitat for fish? 		<p>CEW raised water levels by up to 1.5 m connecting in-channel habitats and providing additional habitat for fish. Increased water levels of more than 0.5 m were achieved and considered optimal for golden perch migration and spawning (Dyer et al. 2016).</p> <p>Connectivity to the Great Cumbung Swamp and Murrumbidgee Swamp was achieved and duration extended by about 55 days in Great Cumbung Swamp (Dyer et al. 2016)</p>
Stream metabolism and water quality	None at catchment scale.	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> patterns and rates of decomposition? patterns and rates of primary productivity. <p>There were no LTIM KEQ listed relating</p>		<p>Environmental flows did not result in any consistent responses in either GPP or ER (Dyer et al. 2016)</p> <p>There were no clear patterns in water chemistry associated with delivery of environmental flows.</p>

Indicator	Expected outcomes – from Dyer et al. (2016) – (note source of outcomes not attributed in LTIM report)	Area-scale LTIM KEQ	Rating	Justification
		to water quality, however results were presented. It is assumed that the same Cat I water quality KEQ apply in the Lower Lachlan.		
Fish community	<ul style="list-style-type: none"> Provide habitat to support, maintain condition of, and provide reproduction opportunities for native fish, Trial the augmentation of flow to generate a golden and/or silver perch movement and spawning response. 	<p>What did Commonwealth environmental water contribute to:</p> <ul style="list-style-type: none"> native fish community resilience? native fish survival? native fish populations? native fish diversity? 		<p>Both long and short term KEQ listed in Appendix, but only short term in the summary report.</p> <p>Overall, the fish community still in very poor condition. Results similar to previous year. Focus in dry years should be on maintaining not improving.</p>
Spawning and larval fish	<p>Watering Action 3 had specific objectives concerning native fish with 9378 ML of CEW delivered to:</p> <ul style="list-style-type: none"> Provide habitat to support, maintain condition of, and provide reproduction opportunities for native fish, Trial the augmentation of flow to generate a golden and/or silver perch movement and spawning response. 	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> native fish reproduction in the Lower Lachlan river system? native larval fish growth in the Lower Lachlan river system? native fish populations in the Lower Lachlan river system? native fish species diversity in the Lower Lachlan river system? 		<p>No eggs, larvae or new recruits, and only stocked juveniles of golden perch were collected. It is unlikely that spawning of golden perch occurred in response to the 2015-16 water delivery (Dyer et al. 2016).</p> <p>Expected outcomes only partially met in 2015-16.</p> <p>Non-flow cued spawning evident for Murray cod, flat headed gudgeon, Australian smelt and carp gudgeon (Dyer et al. 2016).</p> <p>Overall evidence of 6 species reproducing attributed to CEW.</p> <p>Not able to assess growth KEQ.</p>
Frogs	<ul style="list-style-type: none"> Trigger breeding and recruitment in frogs 	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> frog diversity and populations? breeding and recruitment of frog species? What was the effect of Commonwealth environmental 		<p>Results suggest that frog diversity has been maintained to pre LTIM levels, except for one species which had been recorded in prior surveys. Calling increased during periods peak flow for both ewater and translucent flows (Dyer et al. 2016).</p>

Indicator	Expected outcomes – from Dyer et al. (2016) – (note source of outcomes not attributed in LTIM report)	Area-scale LTIM KEQ	Rating	Justification
		water on refuge for frogs in the Great Cumbung Swamp and Booligal Wetlands?		Short and long term KEQ addressed. Some indication of breeding at Cumbung Swamp but further data required to say Booligal has potential to act as a refuge – dependent on watering conditions/duration (Dyer et al. 2016)
Vegetation	<ul style="list-style-type: none"> • Maintain the extent and diversity of aquatic and riparian vegetation • Contribute to vegetation condition and diversity 	What did Commonwealth environmental water contribute to: <ul style="list-style-type: none"> • vegetation species diversity? • vegetation community diversity? • the condition of floodplain and riparian trees? • populations of long-lived organisms? 		Unable to ‘disentangle’ effects of CEW and translucent flows. Changes in ground cover species between year 1 and 2 suggest vegetation community within the catchment is responsive to watering (Dyer et al. 2016). Tree condition improved in 2015-16 compared to the previous year and responded to CEW (Dyer et al. 2016).

LOWER MURRAY

During 2015-16, approximately 814 GL of CEW was delivered to the LMR from 1 July to 30 November 2015, and from 2 January to 30 June 2016. This included 15.8 GL of CEW used for wetlands and weir pool raising (WPR) within South Australia, with the remaining ~798 GL flowing through the main channel. Note that in July and August 2015, the CEW consisted largely of return flows from the Barmah–Millewa Forest and flow pulse events in the Goulburn River.

Findings: This was the only evaluation report that included objectives, KEQ and associated hypothesis – well defined/presented. No consideration of Basin-scale evaluation – states MDFRC to address Basin-scale evaluation. Included results for DEWNR objectives for the LTWP. No reference to Basin Plan Environmental Watering Plan objectives or expected outcomes from watering actions (this is the reason some of the ratings are yellow – can’t say if achieved). Only short term 1 year outcomes were evaluated, but each KEQ addressed/answered in terms of contribution by CEW.

Ye et al. (2017) is a useful report that provides a good discussion and summary of the 2015-16 monitoring program and key findings. The report would be improved with the inclusion of a clear summary of what monitoring was undertaken in 2015-16, covering which of the environmental flow events were monitored, why and what indicators in the overview/summary report.

Table 22. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Lower Murray.

Indicator	Expected outcomes	Area-scale LTIM KEQ	Rating	Justification
Hydrology (channel) (Cat I)	Not specified	None specified		Doesn't directly address any specific KEQ, but provides fundamental information for analysis and evaluation of all other indicators (Ye et al. 2017). Expectation that Cat I indicators are evaluated at the Basin-scale by MDFRC.
Stream Metabolism(Cat I)		What did CEW contribute to: <ul style="list-style-type: none">patterns and rates of decomposition?patterns and rates of primary productivity?dissolved oxygen levels?		There were enhanced gross primary production and respiration rates associated with WPR in Weir Pool 5 and return flows from Chowilla, both of which were supported by CEW. Integrated ecosystem net production was near zero, indicating that organic material was derived from aquatic production with little enhancement from external supplies that could have further increased food supplies. Oxygen concentrations did not fall below acceptable levels (>50% saturation) (Ye et al. 2017, Table 1)
Fish (channel) (Cat I)		None specified		There are no KEQ for this indicator at the SA scale; however, fish monitoring data are consolidated to evaluate a number of fish targets of DEWNR's LTWP (Ye et al. 2017).
Hydrological Regime (Cat III)		What did CEW contribute to: <ul style="list-style-type: none">Hydraulic diversity within weir pools?Variability in water levels within weir pools?		Some increase in velocities in winter and spring with CEW. Some variability achieved in weir pools – can't really state if on track as no expected outcomes stated, but suspect this indicator is probably okay.
Matter Transport(Cat III)		What did CEW contribute to: <ul style="list-style-type: none">salinity levels and transport?nutrient concentrations and transport?		Increased salt transport through and out of system, only minor changes in concentrations. Also some transport of nutrients.
		<ul style="list-style-type: none">concentrations and transport of phytoplankton?		No impact on concentrations, but transport did occur
		<ul style="list-style-type: none">ecosystem function?		Increased exchange of nutrients and phytoplankton between critical habitats possibly influenced ecosystem function – but early days.
		<ul style="list-style-type: none">water quality to support aquatic biota and normal biogeochemical processes?		Reduced salinity concentrations in particular may have improved conditions in the Lower Lakes and Murray Mouth (Ye et al. 2017).
Microinvertebrates (Cat III)		What did CEW contribute: <ul style="list-style-type: none">to microinvertebrate diversity?		Peak diversity matched peaks in river discharge and CEW. Most taxa were transported taxa from floodplain or riparian sources (e.g. Chowilla) Ye et al. (2017).

Indicator	Expected outcomes	Area-scale LTIM KEQ	Rating	Justification
Fish Spawning and Recruitment (Cat III)		<ul style="list-style-type: none"> via upstream connectivity to microinvertebrate communities of the LMR Selected Area? 		Likely to be achieved – some indication of taxa being transported from upstream, but could also be from lateral connections (Ye et al. 2017).
		<ul style="list-style-type: none"> to the timing and presence of key species in relation to diet of large-bodied native fish larvae (e.g. golden perch)? 		Relationship could not be determined.
		<ul style="list-style-type: none"> to microinvertebrate abundance (density)? 		Flow including CEW contributed to changes in density of microinvertebrates. Reduced flows had reduced densities (Ye et al. 2017)
		What did CEW contribute to: <ul style="list-style-type: none"> reproduction of golden perch and silver perch? 		Limited spawning and negligible recruitment (to YOY, age 0+) of golden perch and silver perch (Ye et al. 2017).

MURRUMBIDGEE

In 2015-16, sixteen actions delivering a total of 108,328 ML of environmental water to the Murrumbidgee river system, targeting floodplain and wetland habitats and floodplain anabranches and creeks. Four of these events were monitored (Wassens et al. 2016, pp. 7-11). There was no environmental water targeted specifically for the Murrumbidgee river channel (although the channel did get e water through the delivery to the floodplain and wetland sites).

Findings: Adaptive management was well addressed with useful information on possible future changes provided. This is a very good, informative report. The project objectives (evaluation questions) are well identified, and adequate details provided on the monitoring, and outcomes. There was little information provided on the results and how they were analysed. The outcomes were adequately linked back to the evaluations questions. However, there were no clear statements re what CEW contributed – distinction not made. Emphasis in report is on outcomes and future planning for delivery. No extrapolation of findings to whole of SA.

A number of indicators are of questionable value - wetland and riverine water quality do not appear to be responding to CEW – a counterfactual comparison would be useful to determine if this is an indicator worth continuing. Also riverine microinvertebrates do not appear to be linked to peaks in larval fish – or at least there is no obvious pattern – may be a limitation of only a couple of years data and lack of in channel ewater flows. The inclusion of wetland microinvertebrates is also of concern – see comments in the table.

Table 23. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Murrumbidgee (MMEP = Murrumbidgee Monitoring and Evaluation Plan).

Indicator	MMEP and 2015-16 Acquittal Report Expected outcomes (Wassens et al. 2016)	Area-scale LTIM KEQ/predicted outcomes	Rating	Justification
River water quality	Support primary productivity, nutrient and carbon cycling, biotic dispersal and movement; Provide refuge habitat from adverse water quality events.	<ul style="list-style-type: none"> Physicochemical variables remain within range tolerated by aquatic species Nutrient, carbon and chlorophyll-a concentrations within range tolerated by aquatic species Nutrient concentrations sufficient to support ecosystem functions 		<p>Results were described as consistent with prior records and within water quality criteria.</p> <p>Not known if primary production in the Murrumbidgee River is resource-supply limited (Wassens et al. 2016, p15).</p>
Stream metabolism	Provide flows, including restoring natural flow events that are affected by river regulation and/or extraction, to support habitat and food sources and promote increased movement, recruitment and survival of native fish.	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> patterns and rates of decomposition? patterns and rates of primary productivity? 		Preliminary findings show weak relationships between metabolism (GPP and ER) with both flow and temperature. Unknown if expected outcome from watering action was achieved (Wassens et al. 2016, p17). A lack of high scouring flows and lateral connecting flows are likely to limit assessment of this indicator.
Riverine microinvertebrates	Provide flows, including restoring natural flow events that are affected by river regulation and/or extraction, to support habitat, food sources and breeding requirements of waterbirds, native fish and other vertebrates.	What did CEW contribute to breeding and recruitment of riverine native fish by supporting prey?		<p>Differing results in different zones, but findings suggest there may be a mismatch of peak microinvertebrate density and timing of target larval fish (Wassens et al. 2016).</p> <p>No in channel watering (Wassens et al. 2016), so the main element of the expected outcome was not met. The observed responses were from freshes from passing flows – not a dedicated release.</p> <p>Only addresses one aspect of expected outcome, but states that the outcome was met.</p>
Riverine and larval fish	Provide flows, including restoring natural flow events that are affected by river regulation and/or extraction, to support habitat and	What did CEW contribute to native fish reproduction?		Found little association between golden perch spawning and hydrology metrics; a positive association between silver perch spawning and water level was found (Wassens et al. 2016). Should get a

Indicator	MMEP and 2015-16 Acquittal Report Expected outcomes (Wassens et al. 2016)	Area-scale LTIM KEQ/predicted outcomes	Rating	Justification
	food sources and promote increased movement, recruitment and survival of native fish.			<p>better handle on relationships with more data.</p> <p>No in channel watering (Wassens et al. 2016), so the main element of the expected outcome was not met. The observed responses were from freshes from passing flows – not a dedicated release.</p>
Wetland hydrology	None specified – water was delivered to “inundate wetland and refuge habitat” in the Murrumbidgee Catchment Wassens et al. (2106), p29	<p>What did CEW contribute to inundated area:</p> <ul style="list-style-type: none"> • in Yarradda Lagoon? • in core wetland habitats across North Redbank? • in maintaining inundation extents in Tarwillie Swamp of Yanga National Park? • in refuge habitat through the Nimmie-Caira floodways to Waugorah Lagoon and Monkem Creek system? • of the Juanbung Swamp floodplain wetland habitat? • in Hobblers Lake and Penarie Creek? 		<p>Almost half of the inundated area in the Redbank zone can be attributed to CEW. ~85% of the 2015-2016 inundated area in the Nimmie-Caira was combined CEW and NSW environmental water (Wassens et al. 2016).</p> <p>“All Commonwealth water actions achieved the expected inundation objectives for targeted wetland assets” Wassens et al. 2016, p121.</p> <p>Note that inundation objectives were not stated in the section on wetland hydrology – no expected outcome provided.</p>
Wetland water quality	<p>Improve aquatic habitat, water quality and riparian vegetation</p> <p>Support the habitat and breeding requirements of native vegetation, waterbirds and fish</p>	<p>What did CEW contribute to:</p> <ul style="list-style-type: none"> • suitable physicochemical conditions for wetland fauna? • wetland nutrient and carbon concentrations? 		<p>Supported adequate water quality for colonisation by aquatic biota. “There is no evidence that water quality is changing among years in response to repeated watering” Wassens et al. (2016), p128</p> <p>Wetland nutrient and carbon concentrations also within ranges of historical data.</p> <p>Reconsider inclusion of indicator?</p>
Wetland microinvertebrates	Improve aquatic habitat, water quality and riparian vegetation	What did CEW contribute to wetland productivity nutrients and		No idea how microinvertebrates relate to the first expected outcome listed – mistake in the report?

Indicator	MMEP and 2015-16 Acquittal Report Expected outcomes (Wassens et al. 2016)	Area-scale LTIM KEQ/predicted outcomes	Rating	Justification
	Support the habitat and breeding requirements of native vegetation, waterbirds and fish	carbon fluxes, primary productivity (CHL a) and secondary productivity (Microinvertebrates)?		<p>The KEQ is somewhat questionable as well.</p> <p>Would prefer to see indicators directly related to the expected outcome rather than as assumed surrogates. There is no apparent linkage between the microinvertebrate data and the fish and bird data as evidenced by the statement made on p135 “It will be valuable to examine the relationship between the high densities of microinvertebrates and the fish and waterbird species that prey upon them.”</p> <p>“Required microinvertebrate densities for waterbirds and tadpoles are not known.”</p> <p>Question the value of this indicator – in particular as there is a very tenuous link to the expected outcome and the KEQ.</p>
Vegetation diversity	Protect and maintain the health of existing extent of riparian, floodplain and wetland native vegetation communities	<ul style="list-style-type: none"> • Did CEW contribute to vegetation species diversity? • Did CEW contribute to vegetation community diversity? • Did environmental watering influence the types of species present in wetlands? • Did the percentage cover of plant functional groups change in response to environmental watering? 		<p>The KEQ for this indicator reported in the summary Table on page 44 are different to those given in the technical appendices and MEP – just need to be consistent (being a bit picky here).</p> <p>“Overall species richness has remained stable across the monitoring locations, the exception being Yarradda Lagoon where species richness has increased following environmental watering” - attributed to the Nimmie-Caira wetlands having had a history of watering and being unlikely to change diversity or abundance greatly in response to watering.</p> <p>No clear statement as to what/if CEW contributed to</p>

Indicator	MMEP and 2015-16 Acquittal Report Expected outcomes (Wassens et al. 2016)	Area-scale LTIM KEQ/predicted outcomes	Rating	Justification
				community diversity – patterns in community diversity reflected geomorphic zones. Add water to dry wetlands and aquatic plants grow – so yes, functional groups are different in wet and dry wetlands.
Wetland fish	Support the habitat and breeding requirements of native vegetation, waterbirds and fish.	What did CEW contribute to: <ul style="list-style-type: none"> • native fish populations and native fish diversity? • native fish community resilience and native fish survival? 		Native fish diversity maintained, or increased via overbank natural flows. Evidence of dominant spp – bony herring, Aust. smelt and carp gudgeon – breeding. Breeding may have occurred post watering or that smaller fish were washed into the system post natural overbank flows.
Wetland frogs and turtles	Support the habitat and breeding requirements of native fish and other vertebrates.	What did CEW contribute to: <ul style="list-style-type: none"> • other aquatic vertebrates (frog and turtle) diversity and populations? • the provision of habitat to support breeding and recruitment of other vertebrates? • the maintenance of refuge habitats? 		Frog outcomes were achieved, with diversity maintained and populations of southern bell frog persisting in wetlands that were watered.
Waterbird diversity	Support the habitat requirements of waterbirds	What did CEW contribute to: <ul style="list-style-type: none"> • waterbird species diversity? • waterbird species of conservation significance? • waterbird breeding*? 		Waterbird breeding was assessed via complementary NSW OEH waterbird diversity and breeding. Wetlands that received water had more waterbirds than wetlands that were dry – not surprising. Good adaptive management recommendations re future watering options for waterbird outcomes.

WARREGO-DARLING

Four small to moderate flow events containing environmental water flowed down the Darling River during the 2015-16 water year. These occurred in July-October 2015, November 2015, January-March 2016 and June 2016. No environmental water was accounted for in the Warrego River or on the Western Floodplain in the Selected Area. However, a small flow event containing around 4% Commonwealth environmental water from the upper Warrego catchment flowed into the Selected Area during February-March 2016.

A moderate pulse in the Darling River began in June 2016 reaching 4,818 ML/d at the Bourke Town gauge (NSW425003) by 30 June 2016, peaking at 8,542 ML/d on 7 July 2016. Flow events of this size occur less than 20% of the time.

Use of Commonwealth Toorale entitlements is expected to contribute to the following on-park outcomes at Toorale and/or in the Darling River downstream (Frazier et al. 2016):

- support periods of high primary productivity triggered by unregulated flow events and carbon and nutrient cycling
- support wetland and aquatic vegetation condition and diversity
- support waterbird survival and condition and diversity
- inundate and connect in-channel habitat associated with riffles, pools, bars and anabranches to support movement and biotic dispersal
- maintain water quality and carbon/nutrient cycling processes
- provide hydrological connectivity and improve end-of-system flows

Findings: The expected outcomes listed in the Warrego-Darling Evaluation report are, in theory linked to both longer-term and broader objectives set out in the Murray-Darling Basin Plan; however these are not presented as SMART outcomes and are not measurable in their current form. This is a problem with how they are presented in the Annual watering Priorities – Commonwealth of Australia (2014). The annual watering priorities for the Northern unregulated rivers for 2014-15 and 2015-16 were for maintenance of native fish and waterbird refuges. Only one option (option 6) was relevant to the SA and it focused on waterbird refuges on the western floodplain which didn't receive water in 2015-16 (Commonwealth of Australia 2014, p31). Stating that most, if not all, expected outcomes were achieved and that CEW made a contribution to these is in a strict sense not accurate, as there is no indication of what the actual outcome was expected to be. For this reason we have assigned red to a number of indicators. The expected outcomes for this SA need to be written as SMART – for example stating *salinity* or *individual survival and condition (individual refuges and ecosystem resistance)* as expected outcomes, gives no insight at all to what is the expectation of response to watering – they do not meet any of the SMART criteria.

The evaluation questions are not provided in the main report. Frazier et al. (2016) is really a synthesis report that is set at a very high level with little detail provided in the main report. Presumably, the detail is in the Appendices. However, without spending excessive time in reviewing the Appendices, I could not assess the quality of this work (DN: RB did review the appendices to assess progress on objectives – see table below).

I recommend that CEWO require the Gwydir/Warrego-Darling team in future years to provide more detail on: what the evaluation questions for that year are; the monitoring program (i.e. what was measured, when and where); how the results were analysed; what the outcomes were (in terms of the evaluation questions); what adaptive management occurred (if any); and recommendations for future years (i.e. what did we learn and what do we want to do differently).

Appendices could be reduced in size by removing repeated text.

Table 24. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Warrego-Darling.

Expected outcomes for 2014–15 and 2015-16 (Frazier et al. 2016, Table 5.1)	Indicator	Area-scale KEQ	Rating	Justification
<ul style="list-style-type: none"> Individual survival and condition (individual refuges and ecosystem resistance) Salinity Dissolved oxygen pH Dissolved organic carbon Nutrient and carbon cycling Fish reproduction Fish condition Vegetation reproduction Vegetation condition Waterbird survival and condition Waterbird chicks Waterbird fledglings Hydrological connectivity including end of system flows Biotic dispersal and movement Primary 	Hydrology (river)	What did CEW contribute to hydrological connectivity?		Good outcome in Darling River, but less so in Warrego. Achieving connectivity is more dependent on upstream conditions than other SA. Likely to be achieved with relatively small flows.
	Hydrology (northern tributaries)	What did Commonwealth environmental water from upstream tributaries contribute to hydrological connectivity within the Selected Area?		CEW estimated to be around 5%, 4% and 30% in the 2015-16 flows, enhancing in-channel longitudinal connection. Similar to 2014-15, where two CEW events contributed 4% and 25% of flows at the SA. Overall CEW played a small role in promoting the transmission of natural flow events downstream towards the SA (Frazier et al. 2016)
	Hydrology (channel)	What did Commonwealth environmental water contribute to hydrological connectivity?		<p>“Work in coming years will further elucidate the implications of this complexity in channel character for hydrological connectivity, the ecology and ecosystem processes along the lower Warrego River within the Selected Area” Frazier et al. (2016), pC-9.</p> <p>The results presented are about geomorphology – not what CEW has achieved – not clear if this should be considered a separate hydrological indicator – depends on what will be monitored into the future.</p>
	Hydrology (habitat)	What did Commonwealth environmental water contribute to in-channel habitat availability along the Darling River?		CEW contributed to around 30% of benches and anabranch channels being inundated in low flow events. Inundated habitat was considered likely to contribute a small amount of dissolved carbon and nutrients to the river system. Forty two percent of snags were also inundated throughout the year providing additional habitat for fish and other aquatic biota (Frazier et al. 2016).
	Hydrology (floodplain)	What did Commonwealth environmental water and management contribute to hydrological connectivity of the		No CEW reached the Western Floodplain.

Expected outcomes for 2014–15 and 2015-16 (Frazier et al. 2016, Table 5.1)	Indicator	Area-scale KEQ	Rating	Justification
productivity (of aquatic ecosystems)		Western Floodplain?		
	Water quality	What did CEW contribute to: <ul style="list-style-type: none"> • temperature regimes? • pH levels? • turbidity regimes? • salinity regimes? • dissolved oxygen levels? • algal suppression? 		<p>Exec summary states lowering of pH and conductivity – but results in appendix state highest conductivities were associated with the peak flows which had about 30% CEW. Water column pH also rose in the peak flows, whilst other variables showed effects of dilution. Seems to be a mismatch in the interpretation. The other smaller flows only had up to 4.5% CEW.</p> <p>Probably too early in the project to make clear statements re contribution of CEW to water quality.</p> <p>Need to update/specify expected outcomes.</p> <p>Also there are water quality data reported in the microinvertebrate section which are different to those presented under the water quality indicator – on a superficial review it would seem these should be combined???</p>
	Stream metabolism	What did CEW contribute to: <ul style="list-style-type: none"> • patterns and rates of decomposition? • patterns and rates of primary productivity? 		<p>Positive relationships between rates of GPP, ER, NPP and nutrient concentrations, and relatively minor changes in hydrology. Increased rates of GPP and ER were associated with higher discharge, suggesting ewater in the Darling River contributes to improved water clarity and/or increase inorganic nutrients that promote pelagic primary production (Frazier et al 2016).</p>
	Microinvertebrates	What did CEW contribute to: <ul style="list-style-type: none"> • microinvertebrate productivity? • microinvertebrate community composition? • microinvertebrate and vegetation communities in 		<p>Don't understand why vegetation is in the KEQ to do with microinvertebrates?</p> <p>Don't understand why there are separate treatments of water quality and stream metabolism in this section of the Appendices.</p>

Expected outcomes for 2014–15 and 2015-16 (Frazier et al. 2016, Table 5.1)	Indicator	Area-scale KEQ	Rating	Justification
		floodplain watercourse?		There was no significant temporal pattern in Shannon diversity during the sampling period. The two rivers had different communities and successional turnover was observed – however the conclusion that this is attributable to connectivity and CEW is questionable. Further technical review is required and links to expected outcomes (when drafted as SMART) should be made clearer.
	Macroinvertebrates	What did CEW contribute to macroinvertebrate diversity?		First year of data – not monitored in 2014-15. Too early to make conclusions re contribution of CEW.
	Ecosystem type	<ul style="list-style-type: none"> What did Commonwealth environmental water contribute to sustainable ecosystem diversity? Were ecosystems to which Commonwealth environmental water was allocated sustained? Was Commonwealth environmental water delivered to a representative suite of Ecosystem types? 		No watering on the Western floodplain only in channel, so limited number of ecosystem types influenced.
	Vegetation diversity	What did CEW contribute to: <ul style="list-style-type: none"> vegetation species diversity? vegetation community diversity? 		No watering of the western floodplain, so not able to attribute vegetation response to ewater. Heavy rainfall prior to sampling had an effect on results. No discussion of constraints but if CEW doesn't make it onto the floodplain then this indicator is not going to be achieved.
	Fish (river)	What did CEW contribute to: <ul style="list-style-type: none"> native fish community resilience? native fish survival? native fish populations? 		Provides baseline data on fish in the Warrego. No planned CEW, only a small amount derived from an upstream contribution made its way to the SA – 4% contribution. This likely contributed to increased recruitment and abundance in fish post the connecting flow.

Expected outcomes for 2014–15 and 2015-16 (Frazier et al. 2016, Table 5.1)	Indicator	Area-scale KEQ	Rating	Justification
		<ul style="list-style-type: none"> • native fish diversity? 		
	Frogs	What did CEW contribute to: <ul style="list-style-type: none"> • frog populations? • frog species diversity? • frog survival? 		Diversity and abundance post rainfall on floodplain highest. Too early to address KEQ.
	Waterbird diversity	What did CEW contribute to: <ul style="list-style-type: none"> • waterbird populations? • waterbird species diversity? • waterbird survival? 		Abundance and species richness corresponded to habitat and resource availability. No difference between year 1 and 2, and no difference between channel and floodplain sites except in March 2015. Good floodplain results in year 1 attributable to CEW.