Flow-MER Basin-scale Evaluation and Research Plan

Commonwealth Environmental Water Office (CEWO): Monitoring, Evaluation and Research Program

Version 3.0, 23 July 2021

Australian Government

Commonwealth Environmental Water Office

FLOW Monitoring Evaluation Research

The Flow-MER Program

Flow-MER is the Commonwealth Environmental Water Office's (CEWO) on-ground Monitoring, Evaluation and Research Program. The Program's objective is to monitor and evaluate the delivery of Commonwealth environmental water in the Murray-Darling Basin. It provides the CEWO with evidence to inform our understanding of how water for the environment is helping maintain, protect, and restore the ecosystems and native species across the Murray-Darling Basin. This work will support environmental water managers, demonstrate outcomes, inform adaptive management, and fulfil the legislative requirements associated with managing Commonwealth owned environmental water.

The Flow-MER Basin-scale Project is being undertaken from 2019 to 2022 and is led by CSIRO in partnership with the University of Canberra, and collaborating with Charles Sturt University, Deakin University, University of New England, SARDI, Arthur Rylah Institute, NSW Department of Primary Industry, Australian River Restoration Centre and Brooks Ecology & Technology. The Program delivers to the Commonwealth Environmental Water Office, Department of Agriculture, Water and the Environment.

Citation

Barbour E., Thompson R., Pollino C., Flett D., Bennett, J., Brooks, S., Campbell, C., Doody, T., Dyer, F., Guarino, F., Hladyz, S. Hitchcock, J., Lester, R., Lovett, S., McInerney, P., McGinness, H., Moggridge, B., Nolan, M., Sengupta, A., Stratford, D., Stuart, I., and Wassens, S. (2021) Flow-MER Basin-scale Evaluation and Research Plan. Flow-MER Program. Commonwealth Environmental Water Office (CEWO): Monitoring, Evaluation and Research Program, Department of Agriculture, Water and the Environment, Australia.

Contributors

Susan Cuddy, Pat Gudhka, Galen Holt, Luke Lloyd-Jones, Ashley Macqueen, Jason Thiem, Charles Todd, Zeb Tonkin, Emma Woodward, Brenton Zampatti.

Acknowledgement of country

The Flow-MER research team acknowledges the Traditional Owners of the lands and waters of Australia, and in particular the Traditional Owners of the lands and waters of the Murray Darling Basin. The river and its tributaries are known by many names including; Millewa (Ngarrindjeri name for the main Murray channel in South Australia), Baarka (Barkindji; Darling River, inland New South Wales (NSW)), Warring (Taungurung; Goulburn River, Victoria), Kolety (Wamba Wamba; Edwards River, inland NSW), Kalari (Wiradjuri; Lachlan River, inland NSW), Murrumbidjeri (Wiradjuri; Murrumbidgee River, inland NSW) and Guwayda (Kamilaroi; Gwydir River, northern NSW), amongst others. While the European names will be used here, the authors recognise the important associations and history of the Indigenous names for rivers and streams in the Murray–Darling Basin. The authors express our respect for Elders, past present and emerging amongst the Nations of the Murray–Darling Basin

Copyright

Cover photograph

Aerial view of Straw-necked ibis colonies in the Booligal Wetlands.
Credit: Will Higgisson (University of Canberra)

Important disclaimer

The information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, the Flow-MER Program (including its partners and collaborators) excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it. The Flow-MER Program is committed to providing web accessible content wherever possible.

If you are having difficulties accessing this document please contact CEWOmonitoring@environment.gov.au..

Contents

Figures

Tables

Abbreviations and acronyms

Abbreviation/acronym	Definition
ANAE	Australian National Aquatic Ecosystem
ARRC	Australian River Restoration Centre
Basin-scale	MDB scale analyses of data under LTIM, EWKR and Flow-MER
CAMBA	China Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EWKR	Environmental Water Knowledge and Research Project (2014-2019)
Flow-MER	The CEWO Monitoring, Evaluation and Research Program (2019-2022)
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
JAMBA	Japan Australia Migratory Bird Agreement
LTIM	Long-Term Intervention Monitoring Program (2015-2019)
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MDFRC	Murray-Darling Freshwater Research Centre
MDMS	Monitoring Data Management System
MER	Monitoring, Evaluation and Research Program (2019-2022)
MVP	Minimum Viable Product
NGO	Non-government organisations
NSW	New South Wales
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
SA	Selected Areas under the LTIM and Flow-MER programs
SARDI	South Australian Research and Development Institute SARDI
SAG	Science Advisory Group
SE&C	Stakeholder Engagement and Communication
SRA	Sustainable Rivers Audit
TBA	To be announced
UC	University of Canberra
UNE	University of New England
QA	Quality Assurance
QC	Quality Control

1 Introduction

1.1 Commonwealth Environmental Water

The Commonwealth Environmental Water Holder (CEWH) is responsible under the *Water Act 2007* for managing Commonwealth environmental water holdings. The holdings must be managed to protect or restore the environmental assets of the Murray-Darling Basin, and other areas where the Commonwealth holds water, to give effect to relevant international agreements. The *Water Act* sets out obligations on the CEWH to report on the contribution of Commonwealth environmental water to the environmental objectives of the *Murray–Darling Basin Plan (2012)* ('Basin Plan' or 'the Plan').

The Basin Plan sets out the principles for monitoring and evaluating the effectiveness of the Plan. These principles are reflected in the Commonwealth Environmental Water - Monitoring, Evaluation, Reporting and Improvement Framework[1]. Monitoring, evaluation and research support the efficient and effective use of water for the environmental and demonstrating environmental outcomes from watering activities.

1.2 The Flow-MER program

The Commonwealth Environmental Water Office (CEWO) invests in monitoring, evaluation and research activities delivered through an integrated program called the Monitoring, Evaluation and Research (Flow-MER) program. This program builds on work undertaken through the Long-Term Intervention Monitoring (LTIM) and Environmental Water Knowledge and Research (EWKR) projects (2014–2020) to monitor and evaluate the contribution of Commonwealth environmental water to environmental outcomes in the Murray-Darling Basin.

The Flow-MER program:

- monitors and evaluates ecological responses to Commonwealth environmental water in seven Selected Areas and at basin-scale, using established metrics and methodologies
- undertakes best-practice science in seven (7) Selected Areas (Figure 1) and at basin-scale to research ecological processes and thus improve capacity to understand and predict how ecosystems respond to water management
- demonstrates outcomes from Commonwealth environmental water and documents via a regular reporting schedule and engagement and extension activities
- facilitates a regular, timely and effective transfer of relevant knowledge to meet the adaptive management information requirements of Commonwealth environmental water decision-makers
- Flow-MER monitoring, evaluation and research is undertaken for six (6) Basin Themes based on ecological indicators developed for the LTIM project and described in the Environmental Water Outcomes Framework[2]. This framework describes the scientific rationale for the selection of ecological indicators to address the environmental objectives contained within Chapter 8 of the Basin Plan and addressed in the Basin-wide Environmental Watering Strategy[3]. Each Theme has a set of foundation or

[1] https://www.environment.gov.au/ewater/publications/ewater-monitoring-evaluation.html

[2] https://www.environment.gov.au/water/cewo/publications/environmental-water-outcomes-framework

[3] https://www.mdba.gov.au/publications/mdba-reports/basin-wide-environmental-watering-strategy

evaluation questions described in Foundation Reports[4] developed under LTIM, and updated in the Foundation Report Updates 2020[5] and 2021.

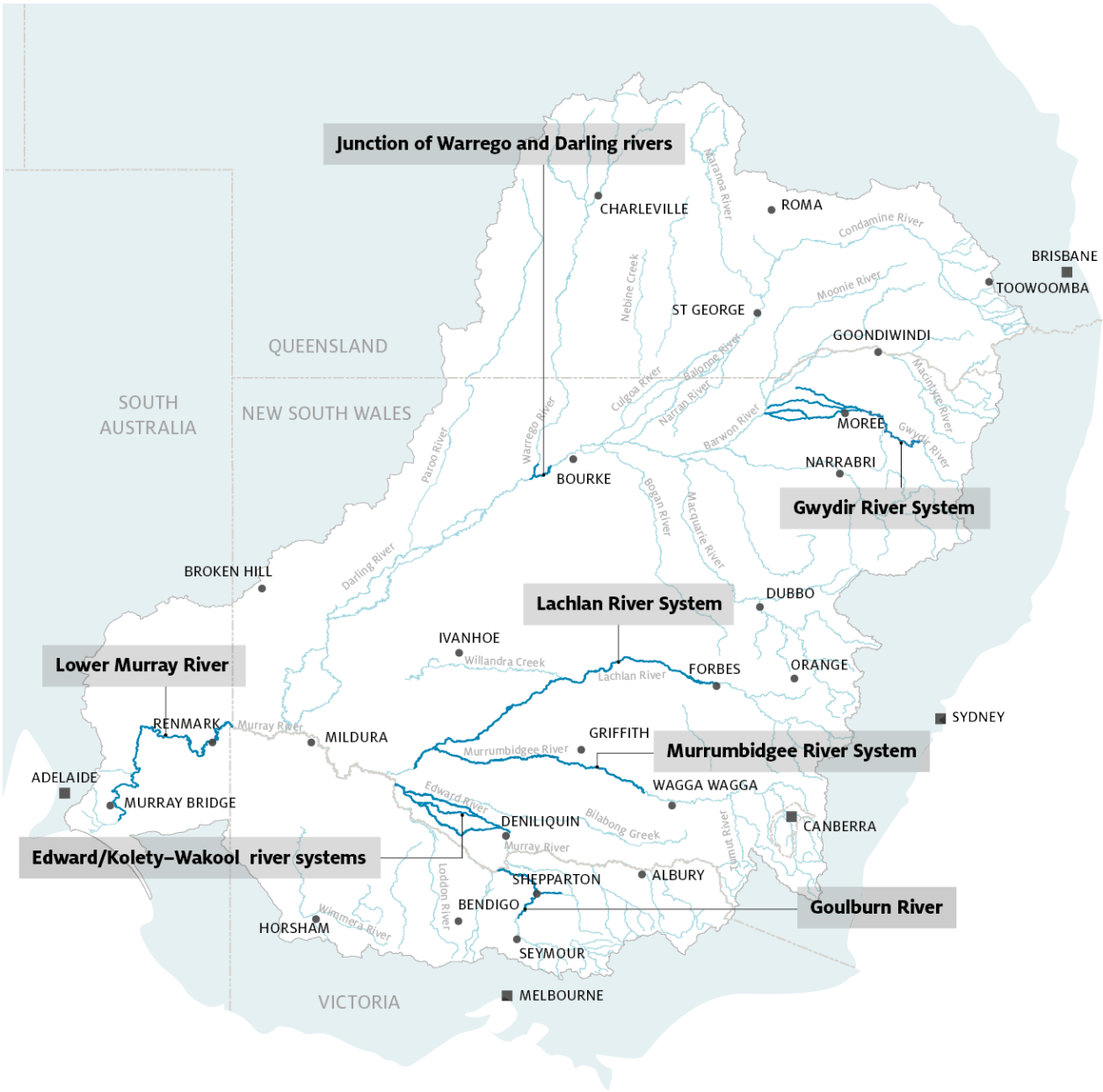

Figure 1 Selected Areas established for long-term monitoring of the effects of environmental watering under the LTIM Project and Flow-MER Program (2014-present)

[4] https://www.environment.gov.au/water/cewo/monitoring/ltim-project

[5] https://www.environment.gov.au/water/cewo/publications/foundation-report-update-2020

1.3 The Basin-scale Flow-MER project

The Basin-scale Flow-MER Project is a three-year, $7.7 million investment in evaluation and research to enable reporting on the outcomes of Commonwealth environmental water and support adaptive environmental flow management over time. The purpose of the project is to:

- demonstrate the outcomes of Commonwealth environmental water across the Basin
- support adaptive management of Commonwealth environmental water
- support the Commonwealth Environmental Water Holder to fulfil legislative requirements under the Basin Plan.

The Basin-scale Flow-MER project integrates the Basin-scale Evaluation (formerly the LTIM project) with the Flow-MER research (formerly the EWKR project).

A continuation of evaluation and research activities is needed to:

- demonstrate outcomes from Commonwealth environmental water
- inform environmental water management
- fulfil legislative reporting obligations
- build on our knowledge of the contribution of water for the environmental to the aquatic health of the Murray-Darling Basin.

The Basin-scale Flow-MER Project extends existing Basin-scale monitoring, evaluation and research activities in a single integrated project. The project delivers two inter-related streams of activity to meet this purpose:

Basin-scale Evaluation is undertaken in conjunction with the Flow-MER Selected Area projects. These Projects provide data at the Selected Area-scale that is used in the Basin-scale Evaluation. Basin-scale Evaluations[6] of environmental outcomes from environmental watering have been undertaken by the LTIM Project up to and including the 2019–20 water year. Through contact with Selected Area project teams the Basin-scale project team shares approaches and understanding of area-to-area variability to ensure that the Basin-scale Evaluation is scientifically robust, efficient and effective. Basin-scale Research activities complement Basin-Scale Evaluation activities.

Basin-scale Research invests in new and ongoing research to support environmental water management and inform and enhance Basin-scale Evaluation. Basin-scale Research under Flow-MER commenced in July 2019. The research portfolio continues and builds on research undertaken under the EWKR program, in addition to investing in new projects designed to improve our scientific understanding of ecological responses to environmental watering. Research is being undertaken throughout the Basin. Research projects have already informed and enhanced the Basin-scale Evaluation and will continue to do so over the next year. Research was developed in consultation with Selected Area project teams and the Science Advisory Group established for the Basin-scale Flow-MER Project. Basin-scale Research activities complement Basin-Scale Evaluation activities.

This revised version of the Evaluation and Research Plan (version 3.0) differs from that in previous years in that it does not provide detailed summaries to research projects, but instead refers to the Flow-MER Basin-scale Annual Report 2021; Part II Research Synthesis (Thompson et al. 2021).

[6] https://www.environment.gov.au/water/cewo/monitoring/ltim-project

1.4 Flow-MER program themes

The Flow-MER Program is organised around Basin Themes that are based on ecological indicators developed for the LTIM project. The indicators were originally identified through a consultation process which included consideration of the objectives of the Murray-Darling Basin Plan, expected environmental outcomes at the seven Selected Areas and feasibility of implementation. These are described in the Environmental Water Outcomes Framework[7].

Basin Themes were created to address each of these indicators, referred to in LTIM as 'Basin Matters', and a set of foundation questions were generated. These questions are provided in Basin Matter Foundation Reports[8], with updates provided in the Foundation Report Updates 2020[9]. The questions addressed by the six Basin Themes in the 2019-20 evaluation are below.

Biodiversity Theme

Ecosystem diversity

- What did Commonwealth environmental water contribute to ecosystem diversity?
- Are the ecosystems in scope for Commonwealth environmental water management representative of aquatic ecosystems in the Basin?
- Is Commonwealth environmental water supporting representative ecosystems?

Species diversity

- What did Commonwealth environmental water contribute to species diversity?
  - What was the contribution of Commonwealth environmental water to the diversity and abundance of waterbirds, frogs, turtles, and other water-dependent vertebrates?
  - What was the contribution of Commonwealth environmental water to threatened species and ecological communities?
  - What was the contribution of Commonwealth environmental water migratory species listed under international agreements (Bonn Convention, CAMBA, JAMBA or ROKAMBA) benefited from Commonwealth environmental water?
  - What was the contribution of Commonwealth environmental water to Ramsar wetlands In the Murray Darling Basin?

Hydrology Theme

- What did Commonwealth environmental water contribute towards the restoration of the hydrological flow regime?

[7] https://www.environment.gov.au/water/cewo/publications/environmental-water-outcomes-framework

[8] https://www.environment.gov.au/water/cewo/monitoring/ltim-project

[9] https://www.environment.gov.au/water/cewo/publications/foundation-report-update-2020

Water quality and Food webs[10] Theme

- What did Commonwealth environmental water contribute to patterns and rates of ecosystem respiration?
- What did Commonwealth environmental water contribute to patterns and rates of primary productivity?
- What did Commonwealth environmental water contribute to dissolved oxygen levels?
- What did Commonwealth environmental water contribute to salinity regimes?

Vegetation Theme

Evaluates vegetation diversity in response to Commonwealth environmental water in both the short term (<1 year) and longer term (1–5 years):

- What did Commonwealth environmental water contribute to plant species diversity?
- What did Commonwealth environmental water contribute to vegetation community diversity?

Fish theme

- What did Commonwealth environmental water contribute to sustaining native fish at the Basin-scale?

1.5 Standard methods

The Basin-scale Evaluation quantifies the extent to which expected outcomes from Commonwealth environmental water are achieved. This is based on conceptual models that frame three activities: development of predictive capacity; improved understanding of flow–ecology relationships; and reporting of the outcomes of Commonwealth environmental water. Monitoring data is collected within Selected Areas as shown in Table 1 and where applicable (see below) it is used in the Basin-scale Evaluation (this is described in Gawne et al. 2013). Standard methods[11] have been adopted to ensure that data collected at the Selected Areas can be integrated and analysed for the Basin-scale Evaluation. Additional publicly available data is also used where available to supplement data provided by Selected Areas.

LTIM defined three categories of monitoring based on whether the data could be utilised for Basin-scale Evaluation or for evaluation at the Selected Area, or both. Data from each category is to be collected using standard methods (although for Category III methods, while standardised, may be specific to the Selected Area). Data collected across Selected Areas is shown in Table 1.

The Categories are:

- **Data required** for quantitative Basin-scale Evaluation. Mandatory monitoring by each Selected Area using standard methods. Data **required** to be reported for Basin-scale Evaluation.
- **Data optional** for the Basin-scale Evaluation. Optional monitoring by Selected Areas using mandatory standard methods. Where collected, data to be available for Basin-scale Evaluation.
- **Optional monitoring** by Selected Area using locally appropriate methods. Where collected, data to be available for Basin-scale Evaluation.

[10] The Food Webs Theme under EWKR has been added to this Theme for the Flow-MER Program.

[11] https://www.environment.gov.au/water/cewo/publications/cewo-ltim-standard-methods

Table 1 Data collected by Selected Areas (shaded) for input to the Basin-scale Evaluation (Appendix A – Data Management Plan)

Data type by Basin Theme		Warrego-Darling	Gwydir	Murrumbidgee	Edward/Kolety-Wakool	Lower Murray	Lachlan	Goulburn
	Hydrology (Channel)							
Water Quality and Food Webs	Stream Metabolism - BASE model outputs							
	Stream Metabolism - Discrete Data							
	Stream Metabolism - Logger Data							
	Water Quality - Daily Data							
	Water Quality - Hourly Data							
Vegetation	Vegetation Diversity (Recruitment)							
	Vegetation Diversity (Species Abundance)							
	Vegetation Diversity (Community Structure)							
	Tree stand condition							
Fish	Individual Fish - River and Wetland							
	Adult Fish Catches - River and Wetland							
	Larval fish data							
	Fish movement							
Species Diversity	Waterbirds Diversity							
	Waterbird Breeding - Colony measures							
	Waterbird Breeding - Subsample measures							
	Macroinvertebrates							

2 Basin-scale integration approach

2.1 Overview

The Flow-MER Program spans across disciplines, involves people from research and non-research backgrounds, involves uncertainties (reducible and irreducible) and is delivering in an applied, or operational, context. These characteristics are managed using an integrated approach. The Basin-scale Flow-MER Project integrates monitoring, evaluation and research to deliver value by:

1. ensuring investments in research deliver outcomes to evaluation;
2. investing in modelling methods to build a cohesive approach to evaluation of outcomes across multiple Themes; and
3. investing in communication and engagement to bridge Basin-scale and Selected Area projects and more broadly to the stakeholder community.

The outcomes of integration are an improved demonstration of the contribution of Commonwealth environmental water to basin-scale outcomes, to support adaptive management, and to deliver scientific rigour to enable stakeholders to have confidence in, and utilise, information collected through the Project. Requirements for successful integration of monitoring and evaluation programs are:

1. clear framing of the problem being addressed and criteria for measuring success of the evaluation and research,
2. integration methods and models that have scientific rigour and sufficiently represent complex, real world problems and,
3. new knowledge and outcomes of research and evaluation are used in stakeholder engagement and communication and are an input to decision-making.

These requirements are being met by:

- Transition: This project builds on efforts in LTIM and EWKR, where a clear problem framing and evaluation criteria for success was established. This framing is used in the Basin-scale Flow-MER Project, capturing the capability and knowledge developed in LTIM and EWKR.
- Models: A modelling 'Cross-cutting Theme' seeks to deliver against the technical requirements of integration. The Theme delivers methods and models which incorporate existing knowledge with new knowledge from evaluation and research, to deliver an understanding of basin scale outcomes.
- Visualisation: A visualisation Cross-cutting Theme provides both static and interactive visualisation tools to support communicating evaluation outcomes across the project. Establishment of a user reference group with CEWO commencing in the final year of the current project will ensure interactive tools better meet stakeholder needs.
- Science excellence: A rigorous science review processes has been established and includes the external review of evaluation theme and synthesis reports, as well as the review of research activities by a scientific advisory group containing world-leading experts in ecological monitoring and evaluation.
- Engagement and Impact: To ensure the outcomes of the evaluation meet the decision-making needs of the CEWO and the broader stakeholder community, a Stakeholder Engagement and Communications 'Cross-cutting Theme' will commit significant focus, capability and resources to communication and engagement (refer to Appendix B – Stakeholder Engagement and Communications Plan and Appendix C – Indigenous Engagement Plan). Through engagement, we seek to deliver impact through new knowledge to support management of water for the environment.

2.1.1 Transition from LTIM/EWKR to the Flow-MER program

The transition to the Flow-MER Program was sensitive to transitioning capability, knowledge and methods from the LTIM and EWKR projects. The Basin-scale Flow-MER Evaluation and Research Plan has established governance, communication and coordination processes. These have been used to coordinate within the Basin-scale Project, considering transition, and to enable stakeholders from across the Flow-MER Program to contribute to project planning. An objective of the Basin-scale Project remains the achievement of integration across Themes, scales and Selected Areas. The project-team structure is designed to enhance evaluation and research activities and promote integration (Table 2).

The development of this plan was informed by information from EWKR on underlying processes and mechanisms which determine responses to environmental flows, together with basin-scale analysis methods and models arising from LTIM and data collection and analysis methods from the Selected Area Flow-MER Projects. In the development of this plan, a series of internal 'Theme Scoping' documents were developed to structure capability, synthesise knowledge, evaluate continuity of methods and propose a Theme plan. From this, the following outcomes were achieved.

For **Monitoring**, there is agreement on continuity of Category 1 methods to ensure that the benefits of long-term, consistent monitoring at Selected Areas are realised.

For **Evaluation**, the focus has been on understanding LTIM, and defining where improvements in methods can be made. The first year of the Basin-scale Flow-MER Project (2019–20) focussed on refinement of evaluation approaches and revision of Basin Matter Foundation reports[12] (where needed), in collaboration with the LTIM team. Data management has focussed on efficient and effective use of Selected Area data for Basin-scale Evaluation (Appendix A). Having completed the 2019–20 evaluation, the team is now further reviewing evaluation approaches to support the 2020–21 evaluation. The LTIM monitoring and evaluation activities are continuing relatively unchanged at Basin and Selected Area scales in the Flow-MER Program.

Table 2 Mapping of activities and Themes from LTIM and EWKR into the Flow-MER Program

	Previous programs		Current program
	LTIM	EWKR	Flow-MER
Activities	Selected Area Monitoring		Selected Area Monitoring
			Selected Area Research
	Basin-scale Evaluation	Basin-scale Research	Basin-scale Evaluation
			Basin-scale Research
Themes	Hydrology		Hydrology
	Metabolism and Water Quality	Food Webs	Water Quality and Food Webs
	Vegetation Diversity	Vegetation	Vegetation
	Fish	Fish	Fish
	Ecosystem Diversity		Ecosystem Diversity
	Generic Diversity	Waterbirds	Species Diversity

For **Research**, the focus has been on co-development of research projects across Basin Themes and Selected Areas, and targeting research investment towards integrated analyses, development of scalable approaches and identification of system-wide knowledge gaps. Research projects continue some activities from EWKR, continuing to grow our understanding of ecological responses to Commonwealth

[12] https://www.environment.gov.au/water/cewo/monitoring/ltim-project

environmental water across the Basin, and how we can synthesise these using models. New data management requirements are being implemented for Basin-scale Research to ensure best practice, sharing and continued access to data is achieved (Appendix A).

2.1.2 Integration through modelling and visualisation

One approach to achieve integration in the Basin-scale Flow-MER Project is through modelling. Modelling is being used to synthesise and generate new knowledge to inform the management of Commonwealth environmental water. A Modelling Cross-cutting Theme has been established and is providing enhanced ability to demonstrate the contribution of Commonwealth environmental water to achieving basin-scale outcomes, considering Selected Areas and areas of the Basin outside of the Selected Areas.

Models provide significant value for decision making through integrating across different types of data and knowledge to support improved system understanding (Figure 2). They also provide capacity to experiment, and test 'counterfactual' scenarios with and without Commonwealth environmental water. Whilst all models have associated uncertainties, these uncertainties are being incrementally reduced throughout the Flow – MER Program. Model development can also improve on existing understanding of where uncertainties exist, and what data (and other information) can be used to reduce these. The modelling work is being developed iteratively, and consequently aligns with adaptive management allowing for improvements as new data and knowledge becomes available. It is important to note that some uncertainties may not be reduced or eliminated given system complexity, where variability in climate, runoff and ecological response are inherent within ecological system.

For the Basin-scale Flow-MER Project, modelling approaches for evaluating outcomes to Commonwealth environmental water have drawn on existing approaches, including those developed in the EWKR Project. Basin-scale modelling will provide a basis to:

- identify knowledge gaps and recommendations on how to address these
- enable integration of hydrological information with ecological models for evaluating ecological outcomes for a range of scenarios
- extend predictive approaches to areas of the Basin outside of Selected Areas.
- integrate across multiple Themes.

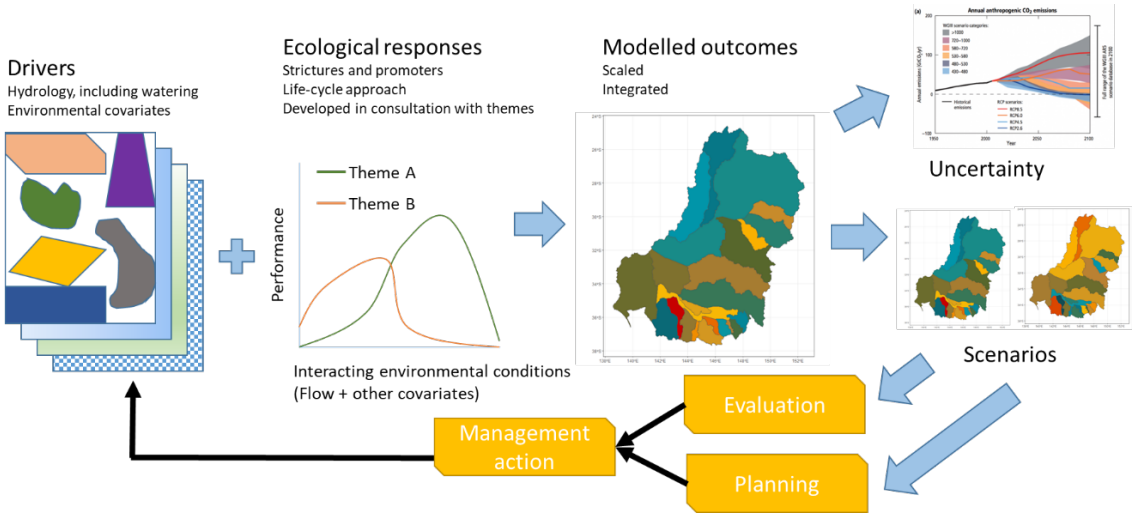

Figure 2 The drivers and strictures modelling framework being developed for the Flow-MER project seeks to integrate across different project Themes and Selected Areas to generate an integrative model of outcomes in time and space. Different scenarios (e.g. with and without environmental water) can then be compared to assist with planning and evaluation

A critical challenge in integrating many different streams of data into a coherent and accessible framework is the challenge of effectively visualising data spatially, temporally and from the perspective of multiple outcomes. A Cross-cutting Data Management and Visualisation Theme has also been established to develop data management infrastructure and ensure adequate data management, as well as to enhance the projects capability to effectively communicate evaluation outcomes across the project. Visualisation is being used to support the synthesis of Commonwealth environmental water outcomes in static reports, as well as through the development of an interactive web-based tool (Figure 3). This involves integrating data from across Themes and the results of the basin-scale evaluation and modelling. The goal is to develop optimum means of presenting raw and processed data, modelling outputs and research results to inform the management of environmental water.

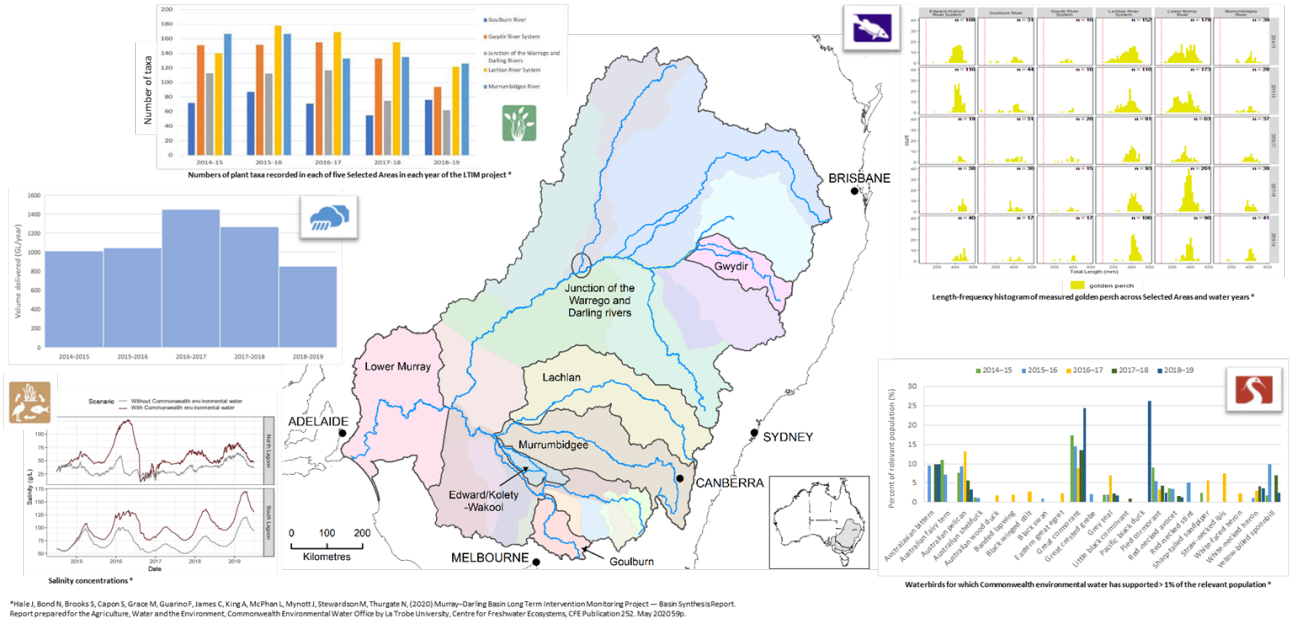

Figure 3 Initial mock-up of visualisation 'dashboard' for Flow-MER Basin-Scale data (Image: Martin Nolan).

2.1.3 Achieving impact through engagement

Through stakeholder engagement and communications, we seek to deliver impact through sharing knowledge. The Stakeholder Engagement and Communications team and the data visualisation and reporting team have developed communication products to suit a range of target audiences. This is as described in the Stakeholder Engagement and Communications Plan (Appendix B).

To achieve integration across science and policy, we recognise the need to establish effective partnerships across the Flow-MER Program. This Plan articulates the process being used to engage with stakeholders in Commonwealth environmental water delivery (including Delivery teams), Selected Areas teams and Indigenous groups within the Basin.

Incorporation of members from the Selected Area teams in the Basin-scale team is one initiative being used to improve knowledge exchange across the Basin. We have developed research projects that spans Selected Areas to promote knowledge sharing and to better understand processes that occur at multiple scales. We are regularly engaging with CEWO through monthly meetings; attending CEWO delivery team meetings and workshops; inviting CEWO to join our monthly evaluation team meetings; and establishing working groups to discuss the visualisation and modelling work. In addition, we are sharing communiqués with selected area teams and contributing to the CEWO Going with the Flow newsletter.

2.2 Project structure and themes

The Basin-scale Flow-MER project delivers evaluation and research using a project structure that enables integration (Figure 4). The Theme structure is applied across both the Evaluation and Research activities described in this plan. The activities are designed to be complementary, and for research to enhance evaluation, as described in the Evaluation Plan and the Research Plan. Cross-cutting activities are included in this plan, to provide a cohesive approach across Evaluation and Research and ensure best practice is applied across the Project.

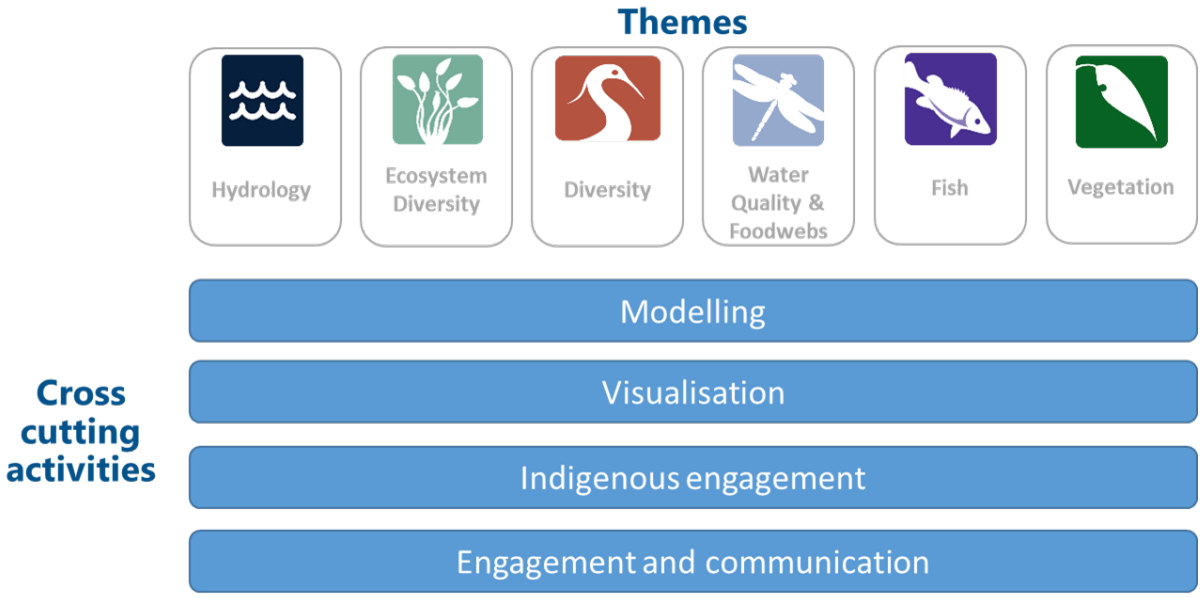

Figure 4 Integration across Basin Themes enabled by cross-cutting activities within the Flow-MER Program

The Flow-MER program brings together Evaluation activities as Thematic summaries and Research activities summarised by individual research projects. This allows an integrated summary of these components of the overall program (Figure 5).

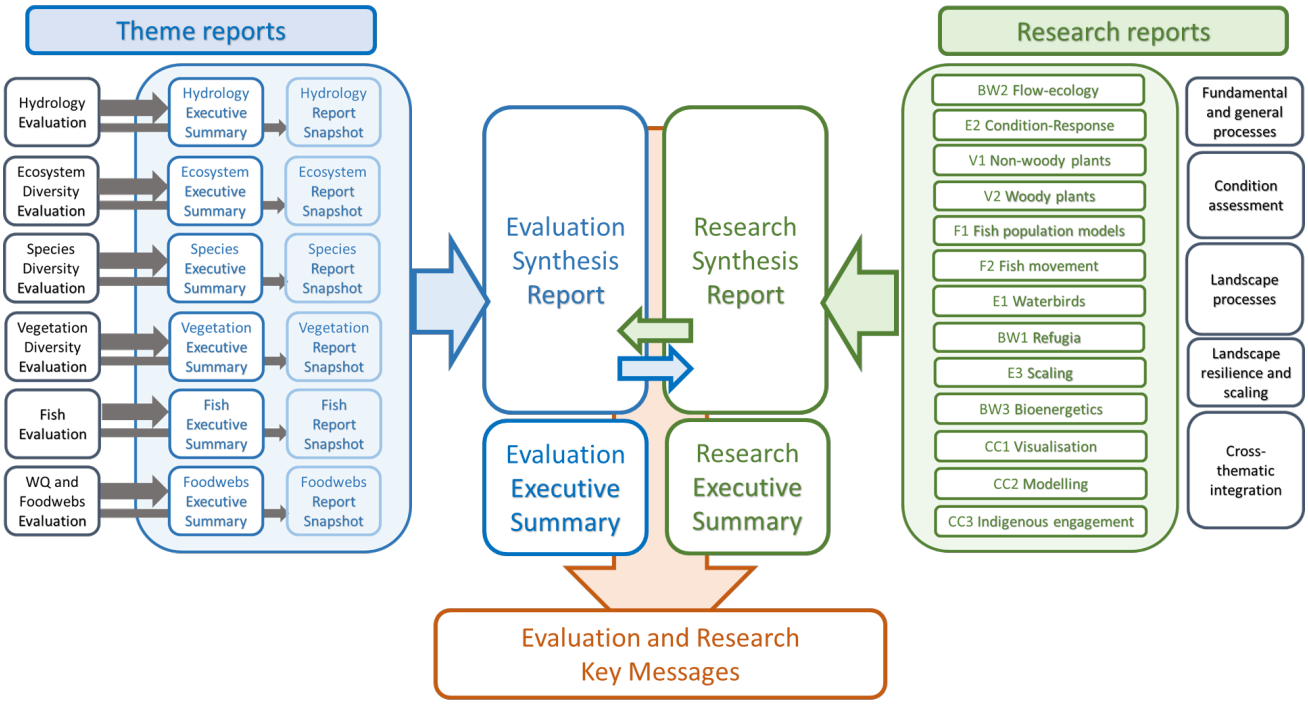

Figure 5 Over-arching reporting and synthesis structure for the Flow-MER Program (2019-present)

3 Basin-scale Evaluation Plan

3.1 Basin Themes and cross-cutting themes

The Basin-scale Flow-MER Project Evaluation Plan is based on the Environmental Water Outcomes Framework[13], LTIM Logic and Rationale[14], the LTIM Evaluation Plan[15], Basin Matter Foundation Reports[16] and Foundation Report Updates 2020[17] and 2021. The Basin-scale Evaluation addresses theme specific evaluation questions using the best available data and knowledge. This in turn supports the assessment of how Commonwealth water actions contribute to the environmental objectives of the Basin Plan (2012). The evaluation method and the links to outcomes associated with each of the Basin Matter Themes are described in more detail below.

3.1.1 Linking the Evaluation Plan to cross-cutting themes

The Visualisation Cross-cutting Theme applies data management protocols developed in LTIM (Appendix A) to ensure that data is effectively collated and managed to enable evaluation activities. The Modelling Cross-cutting Theme is developing a basin modelling framework that explores how data is used to inform the relationship between hydrology and ecological outcomes, the development of a counterfactual modelling scenario to enable comparison between outcomes both with and without Commonwealth environmental water, and improved understanding of outcomes at a basin scale.

The Engagement and Communications Theme provide further capability through synthesising information across themes to provide key messages with targeted communication products to better meet the needs of CEWO and key stakeholders. Example products are as described in the Stakeholder Engagement and Communications plan (Appendix B). The Indigenous Theme is developing specific protocols for engaging with Indigenous stakeholders (conceptually outlined in Appendix C) and will be testing these through case studies across Selected Areas.

3.1.2 Linking the Evaluation Plan to the Research Plan

The Basin-scale Research Plan (Section 4) has been developed to enhance the Evaluation Plan by improving approaches and methods, better scaling outcomes across Selected and non-Selected Areas in the Basin, using approaches that can explore synergies of outcomes between Themes and provide a richer understanding of outcomes of Commonwealth environmental watering. Section 4 identifies outcomes relevant to Evaluation for each research project.

[13] https://www.environment.gov.au/system/files/resources/c8a8d2f6-e455-4126-bf75-0fa0c9147736/files/environmental-water-outcomes-framework.pdf

[14] https://www.environment.gov.au/water/cewo/publications/long-term-intervention-monitoring-project-logic-and-rationale-document

[15] https://www.environment.gov.au/water/cewo/publications/cewo-ltim-basin-evaluation-plan

[16] https://www.environment.gov.au/water/cewo/monitoring/ltim-project

[17] https://www.environment.gov.au/water/cewo/publications/foundation-report-update-2020

3.1.3 Delivery of the Evaluation Plan

The first year of the Basin-scale Flow-MER Project (2019–20) involved appraisal and refinement of data analysis methods in Basin Matter Foundation Reports. The second year of the Basin-scale Flow-MER Project (2020–21) was the first year of the Basin-scale Evaluation with the delivery of Basin Theme reports along with a Synthesis report and Report Summaries to capturing key messages for a wider stakeholder audience.

The evaluation synthesis report, theme reports and report summaries have been externally reviewed to complement reviews by the project leadership team prior to submission to the CEWO. Sharing of the outcomes of evaluation will be done through Annual Forums and in accordance with the Stakeholder Engagement and Communications Plan (Appendix B).

The activities undertaken in each Theme are described in the original Foundation Reports and Foundation Report Updates 2020 and 2021. A brief overview of each theme and key staff is also provided below.

3.2 Hydrology

The Hydrology Theme focuses on the evaluation of the contribution of Commonwealth environmental water to the restoration of the flow regime throughout the Basin, to the benefit of water-dependent ecosystems. The outputs of the Hydrology Theme intersect with other Themes, as well as research projects in the Research Plan. The outcomes will be used to inform the broader evaluation of Commonwealth environmental water at the basin-scale.

The activities for this Theme are undertaken by Enzo Guarino, Ashmita Sengupta and Jodie Pritchard.

3.3 Ecosystem diversity

The Basin-scale Evaluation of Ecosystem Diversity aims to quantify the number, extent and distribution of different water-dependent ecosystem types in the Basin that are influenced by Commonwealth environmental water. This aligns with s8.06 of the Basin Plan. The protection and restoration of different ecosystem types contributes to supporting biodiversity of the Basin (Gawne et al., 2014).

Environmental watering outcomes are likely to vary between different ecosystem types, and the types of ecosystems that receive water vary from year to year in response to water availability and river conditions. The Ecosystem Diversity evaluation assesses outcomes of Commonwealth environmental water to monitored and unmonitored areas, intersecting across hydrology and water-dependent ecosystems.

The Ecosystem Diversity evaluation is led by Shane Brooks.

3.4 Species diversity

The Species Diversity evaluation aims to assess the contribution of Commonwealth environmental water to achieving species diversity outcomes. This evaluation will report species that are likely to have been supported, protected or restored by Commonwealth environmental water, where they are not included in the evaluation undertaken by the Vegetation or Fish Themes.

As described in Gawne et al. (2014), the focus of the evaluation is on major faunal groups, and particularly threatened and endangered species that would be expected to respond to environmental watering actions. Species and communities can be dependent on flow and water regimes for all or parts of their lifecycles. Most of the biota within the Murray–Darling Basin are adapted to cycles of wetting and drying, with many important breeding, migration or germination cues linked to water regime (Brock and Casanova 1997, Young et al. 2001, Roberts and Marston 2011). In a climate of increasing pressures on water resources,

environmental watering actions can play a crucial role in maintaining species and ecosystem diversity (Beesley et al. 2009, Brandis 2010).

The aquatic ecosystems of the Murray–Darling Basin support many nationally and internationally significant plant and animal species (Leblanc et al. 2012). In the Basin Plan (2012), species diversity objectives are described in Section 8.05(3). The Basin Plan aspires to protect and restore biodiversity that is dependent on Basin water resources, by protecting and restoring water-dependent ecosystems that support listed threatened species or listed threatened ecological communities, and representative populations and communities of native biota.

The Species Diversity Evaluation is led by Skye Wassens, with support from Shane Brooks and Heather McGinness.

3.5 Vegetation

The Vegetation Theme looks at the diversity, community composition and structure (e.g. height) of plants and how those attributes change in response to Commonwealth environmental water (Capon et al., 2015). Composition (e.g. species richness) and structure (e.g. height) are important components of vegetation diversity. Vegetation diversity is considered through all phases of the flow regime relevant to a riparian, wetland or floodplain ecosystem (i.e. dry, base flow, fresh, bank-full, overbank). Changes in flow regimes are therefore likely to significantly impact vegetation diversity across multiple scales, from the presence and abundance of local plant species to vegetation composition and structure at ecosystem and landscape scales.

The activities for this Theme are undertaken by Cherie Campbell, Fiona Dyer, Tanya Doody and Martin Nolan.

3.6 Fish

Freshwater fish are important indicators of ecosystem health and have critical life history processes linked to hydrology and hydraulics. They are affected by flow both directly through cues to migration and reproduction and indirectly through effects on water quality and habitat and through biotic interactions such as competition and predation (Gawne et al., 2014). Historically, the Murray-Darling Basin supported a fish community which was dominated by native species, but changes in river flows, barriers and overharvesting have led to a decline in populations. Native fish are a robust indicator species for assessing the outcomes of Commonwealth environmental water.

Activities for this Theme are undertaken by Sally Hladyz, Ivor Stuart, Jason Thiem, Qifeng Yi and Jarod Lyon.

3.7 Water quality and food webs

The three components of aquatic ecosystem - water quality; stream metabolism; and food webs - are integrated by incorporating the movement of energy and materials. Stream metabolism describes the capture of energy in aquatic ecosystems through photosynthesis and the respiration of organic matter. Both photosynthesis and respiration are influenced strongly by water quality (e.g. nutrient availability) and in turn can influence water quality (e.g. oxygen depletion during ‘blackwater’ events). Food webs then provide maps of energy flow from stream metabolism through to higher consumers including fish and birds. The LTIM Project focussed on measurement of patterns of stream metabolism and water quality and relating these to flow events. The EWKR Project explored the ways in which energy flows through food webs, seeking to link flow, metabolism and production of fish and waterbird biomass. The Flow-MER

Program explicitly links stream metabolism, water quality and food webs into a single program, but also provides a linking framework to fish, waterbirds and vegetation.

Water quality is incorporated as part of the Basin Plan to ensure water quality is sufficient to achieve objectives for water-dependent ecosystems, and for Ramsar wetlands, and to maintain their ecological character (Basin Plan, Chapter 9, Part 3, s9.04 (1) & (2)). Water quality is known to respond to changes in flow and is a significant influence on biota. Commonwealth environmental water can be used to contribute to the management of water quality (Gawne et al., 2014).

Stream metabolism refers to the transformation of organic matter and is comprised of two key ecological processes: primary production and decomposition, which generate and recycle organic matter respectively (Gawne et al., 2014). These each have a profound effect on ecosystem character and condition through their influence on the capacity of plants to complete their life cycles and the ability of animals to acquire the food resources needed to survive and reproduce.

Food webs refer to the movement of energy between organisms due to the consumption and generation of biomass (Gawne et al., 2014). It provides an indication of the pathways through which energy which enters aquatic ecosystems via photosynthesis and organic matter processing is transferred to higher consumers, including fish and waterbirds. Food webs in this context do not describe the feeding links between all taxa, but rather provide a map of how energy moves between major components of the ecosystem, e.g. between aquatic invertebrates and fish.

The activities for this Theme are undertaken by Paul McInerney, Gavin Rees and James Hitchcock in collaboration with Darren Giling.

4 Basin-scale Research Plan

Research is critical to supporting effective and efficient use of Commonwealth environmental water. The Research Plan seeks to meet the Flow-MER Program objective of improving the science to support Commonwealth environmental water management. The Flow-MER Program is the primary means by which the CEWO will undertake research to deliver improved methods and a richer evaluation of environmental outcomes from Commonwealth environmental water.

This Research Plan aims to support an improved basin-scale understanding of the contribution of Commonwealth environmental water within and outside of Selected Areas, develop new approaches to evaluating outcomes, support adaptive management and develop a richer understanding of ecological processes and responses to Commonwealth environmental water. The Research Plan has evolved from LTIM and builds on the EWKR research priorities together with a large body of previous work.

4.1 Research prioritisation

Requirements for the research portfolio of projects included:

- Continuation and leveraging of research being undertaken in the Murray-Darling Basin
- Ensuring a pathway for projects to inform the evaluation of outcomes of Commonwealth environmental water
- Building on and complementing strong networks, particularly across Selected Areas
- Focussing outputs on integration, across physical scales as well as across themes of activities.

A research prioritisation and planning exercise was undertaken in Stage 1 during the first half of 2019. Areas of research interest were developed in consultation with the Selected Area Project leaders and were discussed with the CEWO and reviewed by the Science Advisory Group. A set of prospective research projects were developed in consultation with Selected Areas and CEWO staff.

Using an adaptation of the Australian Research Council approach, Theme leaders and researchers ranked the research projects through a collaborative process. The research prioritisation in Flow-MER involved a collective assessment of which EWKR Projects were considered complete, and which would benefit from continuation. A key outcome of the research prioritisation process was an unprompted integration of the outcomes and approaches from EWKR into monitoring, and projects which aim to test hypotheses generated by EWKR in field settings included in Selected Areas. This allowed the identification of 10 research projects to be funded with a further 3 areas identified as requiring research investment to enable other Research and Evaluation activities.

The 13 projects were developed to full research plans and subjected to review by the Science Advisory Group. Based on this review projects could advance to develop an implementation plan in August 2019 or were allowed additional planning time through until December 2019. From this process, a project portfolio was derived which was operationalised through a process of consultation, review, development of operational research plans and appointment of personnel. This process was completed in early 2020.

4.2 Summary of research projects

The research projects prioritised for funding are shown in Table 3. Research outlines and summaries are found in Flow-MER Basin-scale Annual Report 2021; Part II Research Synthesis (Thompson et al. 2021).

Table 3 Flow-MER cross-cutting research projects mapped to project themes, with key leadership personnel shown

Theme[1] and leader(s)	Project and leader(s)	Research summary
Biodiversity **Heather McGinness**	**Waterbird movement tracking** Heather McGinness	Spatial and temporal scales and drivers of waterbird movements and site use across the Basin This project quantifies spatial and temporal scales of waterbird movements and habitat selection across the Murray-Darling Basin. It will use satellite tracking technology and analysis approaches to investigate relationships between waterbird movements, habitat selection, environmental watering, flooding and other variables, building on EWKR waterbird datasets.
	Refugia Joanne Bennett	Identification, characterisation and management of refuge habitat This research team seeks to understand how ecological refugia are distributed across the Basin and the potential for management of these critical areas to support diversity.
	Condition Shane Brooks Joanne Bennett	Understanding how ecosystem condition modulates ecological responses to environmental watering[2] This project identifies ecosystem condition attributes that help to explain watering outcomes in different ecosystem types. The aim is to identify measures of ecosystem condition that can be used to adjust expected outcomes and tailor evaluation to better match the context under which water is being delivered.
	Scaling Shane Brooks Joanne Bennett James Hitchcock	Developing an approach to scaling for evaluating ecosystem diversity This project is developing approaches for scaling up evaluation of watering outcomes from individual habitat patches to the whole Basin. The aim is to develop a multi-scale approach to evaluate diversity at spatial scales aligned to the scale of watering actions.
Vegetation **Tanya Doody**	**Non-woody plant responses** Cherie Campbell Fiona Dyer	Developing condition benchmarks for non-woody vegetation This research is developing a framework of hierarchical condition benchmarks and a process for evaluating success of outcomes for non-woody vegetation at a Basin-scale.
	Remote sensing vegetation Tanya Doody	Remote sensing trends and temporal condition responses of woody vegetation to environmental water This project is determining the critical thresholds of remotely sensed water use to assess the influence of environmental water; determine relationships between vegetation response and water regimes; inform prioritisation of environmental water for woody vegetation; and, quantify links between vegetation change and hydrology.
Fish **Ivor Stuart**	**Fish populations** Charles Todd	Fish population models to inform Commonwealth environmental watering Fish population processes are highly complex and related not just to river flows but many other factors such as habitats, connectivity, fish density and water quality. Population models aim to demonstrate the benefits of environmental water to fish populations.
	Fish movement Brenton Zampatti Jason Thiem	Flow, movement and fish population dynamics in the Murray-Darling Basin This project is developing new models and refining existing models for fish movement of a small number of fish species in the Murray-Darling Basin to inform population level responses to management of flows.

Theme[1] and leader(s)	Project and leader(s)	Research summary
Water Quality and Food webs **Paul McInerney**	**Ecosystem energetics** Paul McInerney James Hitchcock	Developing an environmental water energetics response model This project is developing a bioenergetic model for how food webs respond to flow, initially focussing on refuge habitats, then extend those models to wetlands and flowing water habitats.
Modelling and visualisation **Danial Stratford** **Martin Nolan**	**Flow ecology relationships** Danial Stratford Luke Lloyd-Jones Ashmita Sengupta	Developing flow-ecology relationships for evaluation modelling This project is undertaking data analysis to understand flow-ecology responses and develop these into a scientifically sound modelling method to support Flow-MER evaluation.
	Visualisation Martin Nolan	Cross theme resources for data visualisation This project is integrating data from across Themes to develop data visualisation products for communicating the outcomes of basin-scale monitoring, evaluation and research. The goal is to develop optimum means of presenting raw and processed data, modelling outputs and research results to inform policy and decision making.
	Integrative modelling Rebecca Lester Galen Holt Ashley Macqueen	Integrative Basin Modelling Research The research project is developing an integrative framework and systems thinking for integration across Themes and the Basin. This framework will be developed with a clear line-of-sight to future use as a management tool for both evaluation and research.
Communication and Engagement **Siwan Lovett**	**Indigenous engagement** Bradley Moggridge Emma Woodward	Indigenous engagement research The research project summarises and synthesises Indigenous engagement activities carried out as a part of the Flow-MER program. Insights for effective Indigenous engagement are extracted. A case study in the Gwydir catchment explores the mechanisms for effective engagement and culturally appropriate collection and synthesis of data.

Figure 6 Experimental mesocosms being used for Flow-MER research at the University of Canberra

4.3 Linking research projects to management and evaluation

4.3.1 Spatial and temporal scales and drivers of waterbird movements and site use across the Basin

Waterbird diversity, populations, and breeding, foraging and refuge sites are managed through decisions affecting water, habitat and other pressures. While increasing waterbird populations and maintaining waterbird diversity are important targets for water management and policy in Australia, long-term knowledge gaps exist that affect our ability to manage water and wetlands for waterbird populations at appropriate scales.

The project is employing satellite-tracking to study the movements of waterbirds and analysing the data to discover relationships between movements, habitat use and environmental variables including environmental water. New knowledge will assist managers to better understand waterbird requirements and implications for water and wetland management and policy.

Research outcomes

- New information has been collected describing waterbird movements and habitat use across the Murray-Darling Basin. This has allowed the identification of 'flyways' and key habitats along those flyways for bird migration.
- Spatial and temporal movement and habitat selection information for waterbird species of concern has been collected. This will allow calculation of movement statistics and calculations (e.g. foraging and nomadic/migration distances, home ranges, breeding movements; telling us where, when and for how long should environmental water be allocated to support foraging habitat and food resources)

Next steps

Fieldwork has been undertaken in key locations where significant waterbird breeding occurs. The next stages will involve ongoing monitoring of birds and collation and analysis of data.

Links to management

Information about waterbird movements helps us to understand fluctuations in the diversity and numbers of birds present or breeding both at particular sites and across the Basin, including why waterbirds may not have responded to environmental watering events. It also helps with planning and adaptively managing basin-wide environmental watering and coordination among sites. This project has strong links to the Refugia and Resilience project below.

Links to evaluation

Identification and mapping of flyways and key migratory habitats is the first step towards the use of environmental water to ensure bird movement across the landscape. In the future it is conceivable that an Evaluation metric such as 'number of days that a flyway can be used by a bird species' may be able to be developed.

4.3.2 Identification, characterisation and management of refuge habitat

Refuges are areas that are critical to maintaining the resilience of ecosystems. This project seeks to understand how ecological refugia are distributed across the Basin and the potential for management of these critical areas to support diversity. The aim of the Refugia Project is to understand more about aquatic refugia habitats, their characteristics and the species they support. The work is focussing on the short

(months) and long (years) time frames, so that we can learn more about how refuge habitats change over time and which species use them.

Research questions

- What are the characteristics that define, identify and describe refugia habitats across the Basin?
- What are the biogeochemical processes and food web dynamics of refugia and how do these change over time with disconnection, contraction and then reconnection?
- What are patterns of refuge use and habitat suitability for water dependent species such as fish, turtles, frogs, fisher bats and waterbirds?

Research outcomes

- A literature review has been completed which synthesises definitions of refugia across the Basin, including comparing the different approaches taken by different states.
- Refugia mapping models have been identified which can be used to relate hydrologic metrics to persistence of refugia through time and space. These are currently being used to develop a map of key refugia in parts of the Murray-Darling Basin.

Next steps

- Quantification of occupancy predictors for refugia dependent species
- Identify refugia dependent species and communities and the flow dependencies that support them.
- Recommend flow requirements to maintain and improve refuge availability, access and quality for key biota.

Links to management

Research outcomes Information about where refugia are in the landscape for different species and their watering need would allow targeted watering of key refugial habitats in the driest times.

Links to evaluation

Evaluation activities are required to report against management to support resilience in the Basin. This project is a key element in understanding how resilience may be managed for in the future. In the future evaluation metrics which describe, for example, the percentage of refugia supported by environmental water, are realistic.

4.3.3 Influence of ecosystem condition on responses to environmental water

The aim is to identify measures of ecosystem condition that can be used to adjust expected outcomes and tailor evaluation to better match the context under which water is being delivered. Research is linking species outcomes to the ecosystems that support them and explores how the starting condition of those ecosystems influences outcomes from water for the environment.

Research questions

- How does condition of an ecosystem influence responses to environmental water?
- What are the critical indicators of ecosystem condition with respect to different targets (fish, vegetation, food webs, waterbirds, and frogs)?
- Do we need to understand condition as an ecosystem integrity measure or is it sufficient to understand the antecedent “state” of ecosystems?

- When does condition need to be evaluated over a long duration versus in the present only?

Research outcomes

A review of condition metrics and data in the Basin has commenced and the spatial framework (ANAE) has been identified.

Next steps

- Framework for assessment of condition and resilience
- Potential ecosystem condition indicators
- Relationships between environmental watering, condition and resilience of ecosystems.

Links to management

It is critical to understand when ecosystems can respond to provision of environmental water. This project will seek to develop metrics for assessing the sensitivity to environmental watering through time.

Links to evaluation

There are existing evaluation activities that assess responses of ecosystems and which would benefit from a more sophisticated understanding of why responses may or may not be observed at particular times. For example, it is becoming clear that water temperature is an important factor determining productivity responses to environmental flows.

Figure 7 Non-woody plant communities in the southern Murray-Darling Basin. (Photo: Cherie Campbell, University of Canberra)

4.3.4 Developing an approach to scaling for evaluating ecosystem diversity

This project is developing a multi-scale approach to evaluate diversity at spatial scales aligned to the scale of watering actions. For example, small scales which occur at individual wetlands, up to large scales where the entire river system is impacted by large volumes of water being used to flush rivers and fill adjacent wetlands. This work seeks to enable us to evaluate basin-scale ecosystem diversity at different scales and spatial arrangements of management actions in the Basin. This is intended to help researchers improve the relevance of management advice according to the scale of the ecosystems being focused on.

Research questions

- How diverse are the sampling locations from which we are drawing inference about the role of Commonwealth environmental water in supporting biodiversity in the Murray-Darling Basin?

- Does the spatial scale at which ecosystem diversity is defined change our perception of outcomes from water delivery at local versus catchment scales?
- Can ecosystem types be aggregated to larger spatial scales to improve evaluation of environmental water delivered to wetland and floodplain complexes (i.e. developing a framework for evaluating within and between "patch" diversity where patches can be defined at multiple scales)?
- Is ecosystem diversity, as represented by the ANAE ecosystem mapping, suited for evaluating environmental water contributions to diversity objectives at local scales and catchment scales?
- Does incorporation of the duration of inundation, and time between inundation events change our perception of ecosystem diversity outcomes from different environmental water actions?

Research outcomes

An initial outcome is a data framework for combining information on watering action objectives, timing and duration with inundation extent mapping to improve resolution of spatial and temporal scales of water delivery in the Basin.

Next steps

- Multiscale ecosystem diversity metrics that link to the ANAE classification mapping.
- Improved inundation mapping that captures watering action information.

Links to management

To what degree can we make management decisions at one site based on what we know about another site? This research addresses the degree to which we can generalise our information from one site to inform adaptive management at another.

Links to evaluation

This new data framework will be used for the Flow-MER evaluation starting June 2021.

4.3.5 Developing condition benchmarks for non-woody vegetation

This research aims to develop a framework of hierarchical condition benchmarks and a process for evaluating success of outcomes for non-woody vegetation at a basin-scale. This research will build on the conceptual ideas developed in the EWKR project around vegetation responses at different levels of organisation. It will expand on these ideas to develop benchmarks at different levels of organisation to help determine a point of reference against which to evaluate good condition.

Research questions

- How can we improve the evaluation of outcomes for non-woody vegetation at a basin-scale?
- Can we develop benchmarks against which to evaluate outcomes for non-woody vegetation?
- Can we extrapolate outcomes to unmonitored areas?

Research outcomes

A systematic literature review (of >500 peer-reviewed publications) has been undertaken to address the following questions; 1) How have observed vegetation responses to environmental flows been characterised? 2) How has ecological theory been applied to describe medium to long-term change in non-woody wetland and floodplain vegetation?

To elicit information from stakeholders two online surveys have been undertaken to address the following questions; 1) What are the challenges and limitations to evaluating outcomes to environmental flows for NWV? (Evaluation survey), 2) What does the broad community value about NWV and the functions they provide? (Values survey), 3) How do conceptual and data-driven approaches to the development of condition benchmarks compare? What are the strengths and weaknesses?

Next steps

Use a case-study approach to develop condition benchmarks from multiple perspectives to address how conceptual and data-driven approaches to the development of condition benchmarks compare and what are their relative strengths and weaknesses.

Links to management

Considerable monitoring effort is expended assessing non-woody vegetation, and this ecological community is one that can be effectively managed using environmental water in many locations. However, there are no clear benchmarks for non-woody vegetation condition that would provide simple targets for adaptive management. This research will develop condition metrics which allow an assessment of the effects of environmental watering on this community.

Links to evaluation

This research project will generate a condition framework which is intended to be immediately applicable to evaluation of the effects of environmental watering on non-woody vegetation.

4.3.6 Remote sensing trends and temporal condition responses of woody vegetation to environmental water

This project aims to understand how native woody vegetation responses are related to hydrology across scales, including the basin-scale, and using remote sensing, based on tree water use field studies. This project is being undertaken to determine critical thresholds of remotely sensed water use to assess the influence of environmental water; determine relationships between vegetation response and water regimes; inform prioritisation of environmental water for woody vegetation; and quantify relationships between vegetation change and hydrology.

Research questions

- What do existing remotely sensed models tell us about the antecedent and current condition of long-lived woody floodplain vegetation at regional and basin-scales?
- How can we translate remotely sensed evapotranspiration into basin-wide condition metrics and identification of key thresholds?
- How are vegetation condition and trends related to hydrology across scales?
- What was the condition of long-lived woody floodplain vegetation prior to the involvement of Commonwealth environmental water and how has this changed?

Research outcomes

- Preliminary regression models have been developed relating measured field evapotranspiration to remote sensed values for two tree species, in two environments.
- A preliminary visualisation of how tree condition changes annually across two key locations has been developed for Chowilla Floodplain and Barmah Forest

- An innovative, fine scale (20 m) method to map fractional tree canopy cover across the Murray-Darling Basin has been developed.

Next steps

1. Continue updating models and develop a higher resolution data set to allow for a more robust remote sensing estimates of evapotranspiration.
2. Use condition outputs to compare against the MDB tree stand condition tool outputs for the same moment in time. Analyse small case studies of watering actions and tree condition responses in area where comparative field data is available.
3. Investigate thresholds of change after which it has taken tree condition substantial time to recover.

Links to management

Adaptive management requires simple, robust measures of outcomes at scales relevant to the management intervention. Monitoring the condition of woody vegetation is challenging because of the large scales involved and the lack of simple condition metrics.

Links to evaluation

This research project will generate a condition framework which is intended to be immediately applicable to evaluation of the effects of environmental watering on several species of woody vegetation. This framework would be calibrated to the existing MDBA Stand Condition Tool.

4.3.7 Fish population models to inform Commonwealth environmental watering

Fish population models are a basin-scale tool for assisting water management and are useful in evaluating different watering scenarios, in evaluating the likely outcomes and in helping to set monitoring targets. While population models have been used for the past 10 years to predict fish responses to a range of management scenarios, this research will explicitly link flow management to whole-of-lifecycle responses for a suite of native fish species. Models are in development for Murray cod, Golden perch and Bony herring to determine the benefits of Commonwealth environmental water at local and regional scales. This will improve evaluation methods for analysis of population outcomes.

Research questions

- What is the contribution of Commonwealth environmental water to key native fish population processes including movement, reproduction and survival at the selected area scale?
- How could this contribution be improved to enhance native fish populations?

Research outcomes

- The modelling framework and life-history tables have been developed for the three focal species. Data sharing arrangements are in place to allow collation of data to parameterise the models.
- The Murray Cod model has been developed and tested on the Edward/Kolety-Wakool river system and is being validated. Current modification of input flow data with the inclusion of blackwater events is expected to adjust the population model output to align with the ecological understanding of the Edward/Kolety-Wakool river system.

Next steps

Three population models will be completed in the next year; a Selected Area scale model for Murray cod, and Golden perch and Bony herring models at the basin scale.

Links to management

Population models can be powerful tools for adaptive management in that they can forecast population responses to management scenarios. Well parameterised fish population models could be used to test the impacts of timing and duration of environmental flows or sequences of flows.

Links to evaluations

A key component of the Basin Plan is reporting on native fish populations. Fish models would allow a Basin-scale assessment of trends in native fish populations and the potential role of environmental water in managing those trends through support connectivity, triggering breeding and generating productivity pulses to support fish growth and recruitment.

4.3.8 Flow, movement and fish population dynamics in the Murray-Darling Basin

Flows underpin native fish ecology and the fish movement project is evaluating flow triggers for local and regional scale fish movement to help standardise environmental water among fish species and regions in the Murray-Darling Basin. EWKR formalised linkages between flows and ecological outcomes including fish spawning, recruitment and dispersal within individual regions. This project will scale-up these responses to determine whether they are repeatable and transferable at the population level, then this will be used to develop a predictive tool to inform ecological outcomes in unmonitored regions. This research project is using otolith microchemistry and fish movement datasets (from acoustic tags) to build a statistical model to determine fish movement, spawning and survival rates in relation to environmental watering. Models are being developed for a small number of fish species to inform population level responses to management of flows.

Research questions

- Are single species movement responses on daily or weekly time-steps repeatable to standardised flows within a river system, and how does this vary among species?
- What is the role of river hydrology in driving emigration and immigration rates in fishes in Murray-Darling Basin rivers, and how does this vary by life-history stage and species?

Research outcomes

The microchemistry data has determined different chemical ‘signatures’ for different catchments. It is possible to measure the ‘signature’ of different growth bands within the fish otoliths and therefore determine where the fish has been feeding. Initial results, in combination with the tagging data, have shown that fish can move very large distances within the Basin, often associated with high flow events. It is also clear that some parts of the Basin act as ‘nursery’ areas that support fish populations elsewhere.

Next steps

Collation of an integrated time-series fish movement dataset and analysis of the influence of flow on the movement of fish at basin scale.

Links to management

Fish populations are connected to one another via movement of individuals along river systems. These fish movements are likely to be an important part of resilience and recovery from disturbance events such as blackwater events and dry-down. Understanding fish movement allows managers to manage for fish passage, support important refugia for migrating fish and to understand the potential for landscape scale fish movements to provide resilience for populations.

Links to evaluation

A key component of the Basin Plan is reporting on native fish populations. There is the potential to create metrics for fish connectivity through the Basin that could be used to evaluate the effective use of environmental water to facilitate fish movement and support resilience of local populations. The movement data here will assist in interpreting the processes which are driving patterns seen in the evaluation data already collected.

4.3.9 Developing an environmental water energetics response model

This project is undertaking research to develop an energetics response model to predict the trophic carrying capacity of rivers and wetlands in response to environmental water delivery. The project team is developing a bioenergetic model for how food webs respond to flow, initially focussing on refuge habitats, then extending these models to wetlands and flowing water habitats. The research is designed to fill gaps identified in the development of the EWKR food web model and to improve the certainty of scientific predictions for ecological outcomes.

Research questions

- How does environmental watering influence the flow of energy through to vertebrate consumers such as fish and birds?
- How can energetics response model support prediction of the trophic carrying capacity of rivers and wetlands in response to environmental water delivery?

Research outcomes

- A review of outputs from EWKR was completed in mid-2020 and allowed the identification of the bioenergetic modelling framework going forward (EcoPath with EcoSim). Training of staff for this software was undertaken in late 2020.
- A major experiment was completed in late 2020 which used a manipulation of food quality to understand whether energy limitation might prevent golden perch larvae from surviving the transition from larvae to juvenile. There is evidence of clear differences in growth rates depending on food quality, providing preliminary support for the idea that food limitation may be important in limiting fish recruitment to the next life stage.

Next steps

- Compile known physiological rates for key taxa in the basin
- Develop EcoPath model framework.

Links to management

It is now well understood that environmental flows can be used as a cue to trigger native fish breeding and becoming evident that some flow conditions may favour larvae (for Murray cod and golden perch) both

physically and in terms of what food resources are available. It is likely that this research will, in the near future, inform adaptive flow management to support breeding and subsequent life history transitions.

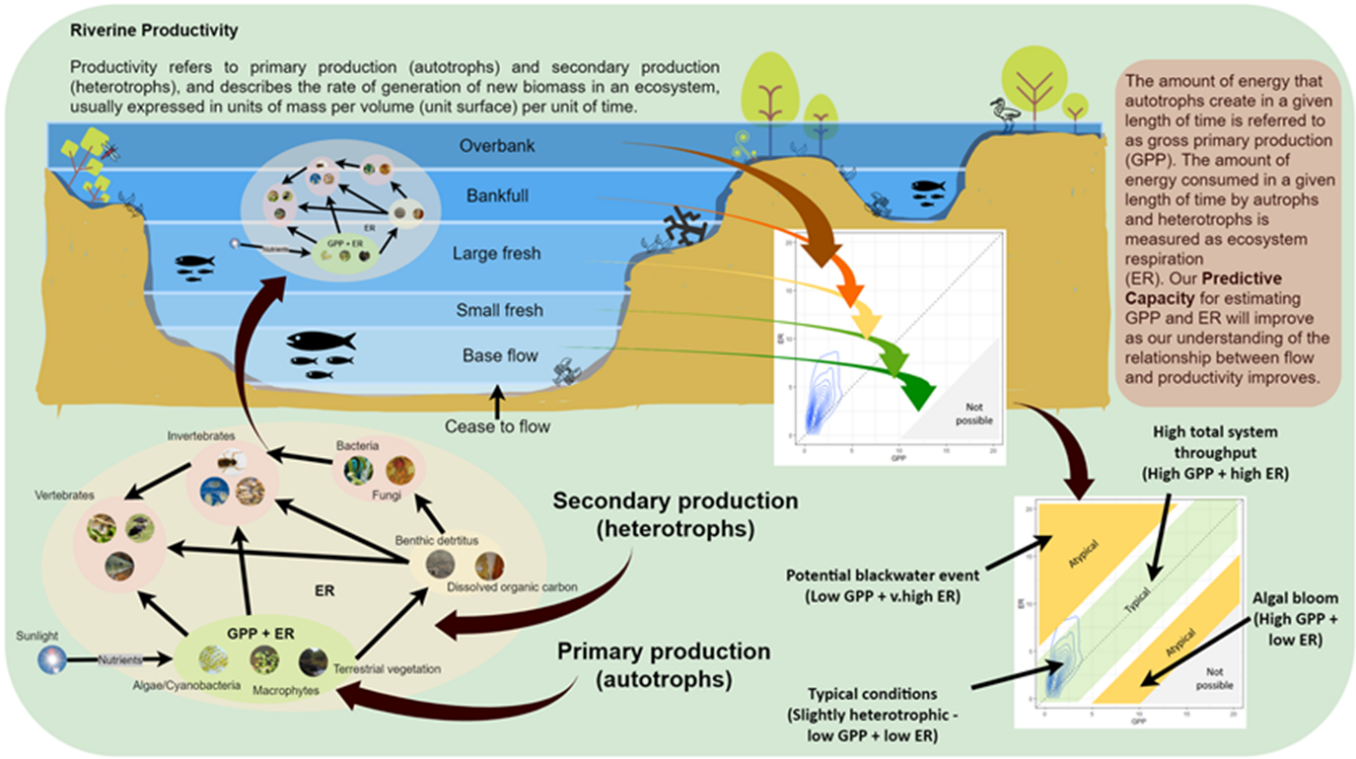

Figure 8 Conceptual model summarising energy pathways in an Australian river.

4.3.10 Understanding flow-ecology relationships to predict responses to watering

The Flow-ecology relationships activity seeks to understand relationships to flow, integrate across themes, quantify expected outcomes for key indicators, enable extrapolation and report outcomes at basin-scales. This is being achieved by undertaking a series of sub-activities that include describing hydrology, undertaking analysis of Flow-MER data and development of predictive models. Predictive models incorporate a broad range of environmental indicators from across themes and enables assessment of outcomes from sub-annual event scale to multidecadal cumulative outcomes of flow regimes for both observed and counterfactual flows.

Research questions

- What are the relationships between flow and ecological outcomes?
- How can these relationships be conceptualised and expressed in a common framework for use across Selected Areas and between Themes with suitable indicators, parameters and input data?
- What model features, components and structures are required for a common method to be fit-for purpose (considering data inputs, desired outputs and spatial and temporal scales)?

Research outcomes

- Evaluation of existing modelling
  - A key outcome of this work was to assess the effectiveness and suitability of different model attributes to be able to assess the CEWO counterfactual flows. This work is complete, and identified key modelling features needed for the CEWO use case as outlined in the report of Oxana and Stratford 2020.

- Generalisable hydrometrics
  - The team has completed the compilation and creation of developing a suite of hydrometrics. The metrics address the need to represent both in-channel and floodplain components of the flow regime, and facilitate generalisability across space to accommodate the comparison between different hydrological settings (e.g. rivers with differences of magnitude in flow). These metrics are used to link hydrology and ecological outcomes and provide inputs for both statistical analysis and predictive modelling.
- Statistical analysis of Flow-MER Theme data
  - Statistical models explore the contribution of flow to achieving ecological outcomes. Vegetation Theme data has been used as a case study which identifies flow components of importance and quantifies the contribution of flow to understory vegetation outcomes.
- Predictive modelling
  - Predict the expected outcomes resulting from flows with and without Commonwealth environmental water, quantify the benefit resulting from watering over different time periods from watering events to flow regimes.

Next steps

- Mechanistic modelling has produced a demonstration for non-woody vegetation which considers change in tree canopy index as a measure of community health. This is based upon selected hydrometrics as inputs which drive change in condition as an outcome of successful watering of forests. Further work with the vegetation theme is delivering a model for non-woody vegetation, representing change in community structure and composition through time rather than outcomes for individual functional groups.
- The project team are working on extrapolation considering habitat types across the Basin and generating outputs across a larger number of gauges. Key ongoing work is developing visualisation tools to communicate the outcomes of CEW at basin-scales. Next steps will include assessment and incorporation of other themes, using work undertaken with the Vegetation Theme as a demonstration for modelling methods.

4.3.11 Integrative Basin Modelling Research

This research project seeks to provide an integrative framework to combine knowledge across Themes and scale from Selected Areas to the Basin. The project builds on existing understanding and continuing knowledge development in the themes and the flow-ecology relationships project to develop a foundation for tools that could be used in future to systematically evaluate the value and outcomes of Commonwealth environmental water, explore scenarios for environmental water delivery, and help understand the reasons for those outcomes. This project incorporates multiple spatial datasets in addition to hydrology to improve understanding of ecological response. Additional drivers being explored include temperature, soil moisture and rainfall. The scaling project led by Shane Brooks and Joanne Bennett is complementary in providing better understanding of the key drivers of response for different vegetation types.

Research questions

Demonstrated framework to model ecological response to environmental watering at the basin scale including:

- How can we characterise the interactions that occur among different species effectively and efficiently?

- What set of variables (e.g. satellite data) will enable us to simulate patterns in ecological response to environmental watering at the basin scale?
- Can we summarise responses across multiple species to integrate and simplify assessment of ecological response at the basin scale?
- What is the best method to extrapolate known responses at Selected Areas during monitored times to other locations and other times?

Research outcomes

- Basic variables needed.
- Demonstrated species responses and interactions.
- Demonstrated capability to incorporate interactions in space and time.
- Demonstrated outputs based on CEWO needs.

Next steps

- Continuing to work with Themes to develop an understanding of species responses to create additional demonstrations with real species and for real locations.
- Continuing to work with river managers to identify how this framework can best assist with their roles, and which types of outputs and visualisation will be most useful.

Links to management

This project will provide a framework to assist with adaptive management of environmental watering via the use of modelled comparisons between potential management or climatic scenarios.

Links to evaluation

This project will provide a framework to assist with the evaluation of the impact of environmental watering via the use of scenario comparisons between current conditions and the counterfactual.

4.3.12 Visualisation dashboard

A critical challenge in integrating many different streams of data into a coherent and accessible framework is the challenge of effectively visualising data spatially, temporally and from the perspective of multiple outcomes. This project is developing data visualisation products for communicating outputs of the basin-scale monitoring, evaluation and research. This involves integrating data from across Themes and the results of the basin-scale evaluation and modelling.

Large volumes of data are collected by LTIM and Flow-MER and methods of maximising the benefit of the collected data is being explored through visualisation. This research addresses how best to communicate results of basin-scale monitoring, evaluation and research. The goal of the research is to develop optimum means of presenting raw and processed data, modelling outputs and research results to inform the management of environmental water.

Research outcomes

- A synthesis of current approaches of LTIM theme and basin-scale reporting is underway.
- The LTIM monitoring data is being explored and methods of visualising the results are being prototyped. This will support visualisation of basin-scale evaluation outcomes.

- A dashboard of spatial data and preliminary visualisations of LTIM data have been trialled. An example of a visualisation dashboard is shown in Figure 3.

Link to management

Considerable data has been collected across the basin on the outcomes of different management interventions. The objective in this project is to allow real time visualisations of that data in order to inform management decisions.

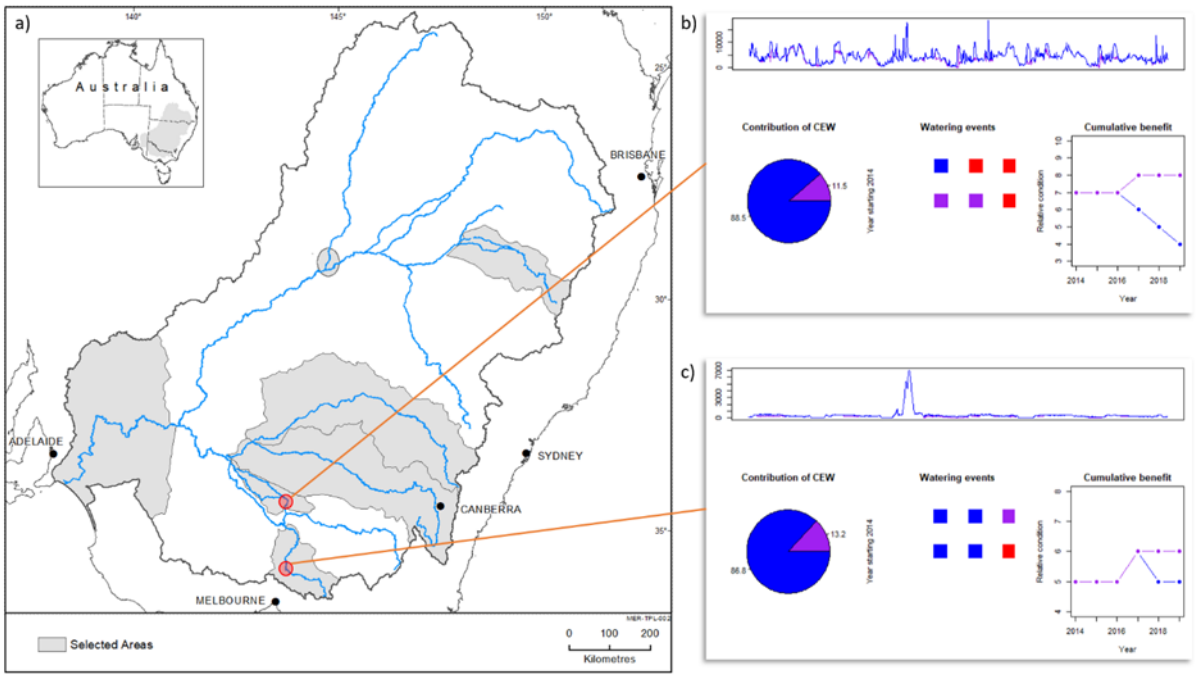

Figure 9 Demonstration of visualisation of cumulative outcomes for condition of redgum floodplain communities Boxes show (from top right) the relative hydrograph for actual and counterfactual streamflow; percentage contribution of Commonwealth environmental water by volume; outcome of annual watering events; and cumulative condition trajectories (Figure: Danial Stratford, CSIRO)

4.3.13 Co-designing engagement with Indigenous peoples for better environmental water delivery

Over the last two decades there has been an identified failing in water management around achieving productive and sustainable partnerships with Indigenous people at a national scale. The alienation of Indigenous people from a role in managing Country since colonisation has had a profound effect on the opportunities for engagement. This project will recognise those challenges in narrative form, but take a prospective view, describing examples of successful engagement around environmental water through case studies developed in partnership with traditional owners on-country, learning from what is working and what has not worked in the past.

The objective of this activity is framing the engagement of Indigenous perspectives on Australian water management with a particular focus on environmental water. This project will meet a need for contextual information and synthesis around Indigenous perspectives on water management to provide a key input to advancing environmental water management.

Research objectives

- To summarise the Indigenous engagement approaches, perspectives and challenges for the seven selected areas with the aim of detailing current activity and identifying emerging opportunities.
- To develop a Case Study on Kamilaroi country in northern NSW which:

– illustrates approaches to engagement.]
– seeks an understanding of how Indigenous communities would wish to be engaged with around environmental water management
– identifies any barrier to engagement
– seeks to identify any cultural values that could be managed for using environmental water.

Research outcomes

An initial review of methods of Indigenous engagement was completed in 2019. A further reflective narrative and analysis of Indigenous engagement around water was completed in late 2020 and published in early 2021 .

Moggridge, B.J. and Thompson, R.M., 2021. Cultural value of water and western water management: an Australian indigenous perspective. Australasian Journal of Water Resources, pp.1-11.

Moggridge, B.J., Betterridge, L. and Thompson, R.M., 2019. Integrating Aboriginal cultural values into water planning: a case study from New South Wales, Australia. Australasian Journal of Environmental Management, 26(3), pp.273-286.

Next steps

- The engagement workshop has been re-scheduled for the 19th of July 2021.
- Additional work on seasonal indicators and the potential to develop watering strategies to restore seasonal indicators is planned for late 2021.

Links to management

Engaging with Indigenous groups is a challenge in many parts of the Murray–Darling Basin. This project seeks to develop approaches which may simplify engagement while protecting cultural values and intellectual property.

4.4 Preliminary insights from research

4.4.1 Opportunities for spatial planning of water delivery

There is an emerging picture from the research program of the potential for much more targeted delivery of environmental water in the landscape to support biodiversity, ecosystem processes and resilience.

The Waterbird movement tracking project has clearly identified ‘flyways’ which support migratory movements of waterbirds. These areas are of critical management importance and understanding both the location and condition of habitat in these flyways will help understand Basin-wide trends in waterbird populations. This result is consistent with the data emerging from the Fish movement project, which has clearly illustrated Basin-scale movements of fish tracking resources. Recognising the critical role of parts of the landscape in supporting biodiversity is also a critical component of the Refugia project, which seeks to develop methods for identification and landscape-scale management of important habitat patches. The Fish population project has developed population models for Murray cod at a single location but is seeking to expend that understanding spatially in a meta-population model that can understand how connections between habitats may allow fish to move between populations. An important step towards that outcome has been refining the ANAE spatial framework through the Scaling research project and bringing this together with inundation modelling completed within the Hydrology theme.

4.4.2 Understanding interactions between watering and ecological condition

While our knowledge of the relationship between water and ecological responses is improving, there remain gaps in how best to represent ecological condition and the way in which current ecological condition and environmental watering interact.

Research within the Non-woody plant responses project is focussing on developing a condition assessment framework to take advantage of the large amount of data being collected on this vegetation type. Woody vegetation condition responses are being assessed by taking advantage of satellite imagery through the Remote sensing vegetation project. Data from vegetation monitoring is being used to develop location-specific flow-condition relationships through the Flow-ecology project. Predicting condition responses to watering is a key objective of the research, but these responses can be highly dependent on the existing ecological condition at a location. These relationships will be examined in the coming year through the Condition research project, while scaling those relationships to unmonitored areas will be investigated in the Scaling project.

4.4.3 Integrating outcomes for basin-level evaluation

Multiple lines of evidence emerging from evaluation of different outcomes and from research projects require a single framework for visualisation, analysis and modelling.

One approach to this has been to seek a common currency for linking multiple outcomes together. The Ecosystem energetics project will link different components of ecosystems together by energy flow to better understand the mechanisms whereby environmental watering may support a range of outcomes. A second and complementary approach is to generate unifying metrics which respond to environmental watering, as is being attempted in the Integrative Modelling project drawing on information from the Vegetation evaluation program. Aa a key element to achieving integration the Visualisation project is developing ‘dashboards’ of information that can begin to act as a frame for representing data in a way that enables application to adaptive management.

Appendix A Data management plan

A.1 Introduction

The Basin-scale Flow-MER Project Data Management Plan provides guidance on protocol and specifications for data management expectations from the Commonwealth Environmental Water Office (CEWO) and CSIRO.

Data protocols apply to all data collected within the Basin-scale Flow-MER Project. The standards and specifications within this plan will:

- clarify ownership of the data
- improve data consistency and availability of information
- enable information sharing within the project and externally, and
- meet legal, ethical and funding requirements.

Data sets are defined here as being spatial (e.g. a shapefile or geodatabase or a Web Feature Service) or aspatial (e.g. database, spreadsheet, model or code). For example, a data set could be a set of gauge data from multiple sites, or a single vegetation spatial layer.

The Basin-scale Flow-MER Project will meet the requirements outlined below, cataloguing and storing information through the Monitoring Data Management system for evaluation data and, where applicable, CSIRO's Data Access Portal (DAP) for research data (https://data.csiro.au).

The Monitoring Data Management System (MDMS) is the CEWO preferred data management portal for evaluation data. Under the Basin-scale Flow-MER Project contract, CSIRO is obligated to using this portal. The SRA aims to provide updates to the Envirosys software that manages the MDMS annually. CSIRO will use and deliver data to the MDMS according to best practices of Data Management, as described in this Data Management Plan.

The DAP is continually updated and enables storage of a diversity of data types. It is the primary portal for storing data within CSIRO, and for managing data available and accessible to a range of audiences. The DAP is CSIRO's institutional solution to best practice data management, and adheres to global best practice, being awarded 'CoreTrustedSeal' certification.

A.2 Ownership and Intellectual Property

All data collected in the Basin-scale Flow-MER Project is owned by the Commonwealth Environmental Water Office. The Principles on open public sector information acknowledges that government-funded and held information is a national resource that should be managed for public purposes.

The Intellectual Property for data and outputs will be vested in the Australian Government and the Commonwealth Scientific and Industrial Research Organisation as per the CSIRO-CEWO Agreement. It will be made part of the creative commons as per Australian Government information policies. Data acquired for use within Flow-MER Program should have a Creative Commons Attribution 4.0 Australia licence (CC BY; Creative Commons By Attribution licence) that allows for the data to be used across Flow-MER Program partner agencies and derived data sets to be published. However, moral rights will be retained by

individuals, with authorship and contributions acknowledged in all associated documentation where appropriate.

A.3 Availability

The Department of the Environment Information Strategy 2013-2017 states

> Open access to Government funded information is the default position of the department with exception only for privacy, security or confidentiality reasons.

Data and information products from the Basin-scale Flow-MER Project are to be discoverable, accessible and re-usable by decision-makers, land managers, researchers and the community. The exception is sensitive data.

Research data will be made available as part of using the CSIRO DAP.

A.4 Accessibility

The Australian Government Public Data Policy Statement requires the CEWO and CSIRO to:

- make non-sensitive data open by default to contribute to greater innovation and productivity improvements across all sectors of the Australian economy
- where possible, make data available with free, easy to use, high quality and reliable Application Programming Interfaces (APIs)
- make high-value data available for use by the public, industry and academia, in a manner that is enduring and frequently updated using high quality standards
- where possible, ensure non-sensitive publicly funded research data is made open for use and reuse
- only charge for specialised data services and, where possible, publish the resulting data open by default
- build partnerships with the public, private and research sectors to build collective expertise and to find new ways to leverage public data for social and economic benefit
- securely share data between Australian Government entities to improve efficiencies, and inform policy development and decision-making
- engage openly with the States and Territories to share and integrate data to inform matters of importance to each jurisdiction and at the national level
- uphold the highest standards of security and privacy for the individual, national security and commercial confidentiality
- ensure all new systems support discoverability, interoperability, data and information accessibility and cost-effective access to facilitate access to data.

The Australian Government Digital Continuity Policy states that Digital information is discoverable when it can be easily found. It is accessible when it can be easily retrieved and read in context and it is usable when it can be easily evaluated or understood, edited, updated, shared and reused as appropriate by those who need it.

Research data will be made accessible as part of using the CSIRO DAP.

A.5 Data standards

Data standards are adopted from the 'Data management guidance document' prepared by Shane Brooks, for the LTIM Project and now the Basin-scale Flow-MER Project.

Data sets derived by the project are to follow the standard methods where applicable. The individual Themes are responsible for carrying out their own QA/QC process to ensure that the data meets the required quality.

Project derived data must be accompanied by appropriate metadata. For project derived data sets, it is the responsibility of the data set author to write the metadata. Standardised metadata should be used where available. For spatial data, for example, the ANZLIC Metadata Profile based on the international metadata standard ISO 19115 is to be used. Where standardised metadata is not available, data should be provided with as much accompanying documentation as possible to enable a metadata statement to be completed prior to publication. A minimum set of metadata elements is required, and these are:

- Title of the data set
- Abstract (summary of the data content including the purpose for which they were collected. A standard project description should also be included (the text for which will be provided by the data management team.)
- keywords
- metadata author contact details, including organisation
- lineage
- data collection history (e.g. methods, scale, sources)
- coordinate reference system (for spatial data only)
- key dates (at least one date must be entered)
- restrictions on use (licensing conditions, see data licences section above)
- other conditions that apply to the use and publication of the data.

All metadata generated in the project will be capture by project teams and reviewed by the data management team. Metadata for research data will be generated as part of using the CSIRO DAP.

A.6 Storage and publishing

The Australian Government Public Data Policy Statement requires data to be published:

- on or linked through data.gov.au for discoverability and availability
- in a machine-readable, spatially-enabled format
- with high quality, easy to use and freely available API access
- with descriptive metadata
- using agreed open standards
- kept up to date in an automated way
- under a Creative Commons By Attribution licence unless a clear case is made to the Department of the Prime Minister and Cabinet for another open licence.

All data, including third party data sets and project derived data sets will be stored on a project centralised storage unless otherwise specified.

All data will be made available publicly and published in accordance with Australian Government policy where applicable.

All teams will have access to each other's data, including third party data sets. Teams will be required to list all of their acquired and derived data sets in their progress reports so that other teams are aware of what is available.

Individual data management requirements for evaluation and research data are described below.

A.6.1 Evaluation data: management through the Monitoring Data Management System

This section outlines continuing arrangements of data, originally collected through the LTIM Project and now the Basin-scale Flow-MER Project. The intent of the Basin-scale Flow-MER Project is to adopt the data management strategy used in LTIM (Brooks; Brooks and Wealands, 2013a; Brooks and Wealands, 2013b).

Selected Areas will continue to manage their own data (ranging from structured to ad hoc) and submit a copy annually to a central database (Monitoring Data Management system; MDMS) that serves as a repository and aggregator for the Basin-scale Evaluation. We recommend each Selected Area has a data manager.

- Data is submitted to the MDMS by Selected Areas using csv formatted tables uploaded via a web interface.
- Expectations are that final data is submitted to the MDMS in a complete (i.e. QA/QC checks, with metadata) and timely fashion, no later than 22 December of each year.
- New data is given preliminary status and undergoes some automatic quality checking (spelling, data ranges, formats). Providers are given feedback via email regarding any errors so they can fix and resubmit, with final quality checked data to be entered by 22 December, annually.
- When uploading is complete the data is manually extracted from the data store and summaries are generated and sent back to data providers to further quality check to ensure the stored data matches the intended data supply before data is moved to final status for sharing.
- Basin team data products are to be stored in the MDMS (e.g. time series flow data). Spatial data and model code will be curated through the CSIRO DAP.

Only final data is shared to the Basin evaluation team and third parties on request.

A.6.2 Research data: management through the Data Access Portal

Where applicable, research data and code collected or developed as part of the Basin-scale Flow-MER Project will be published on the CSIRO DAP (the CSIRO DAP; https://data.csiro.au), with appropriate metadata. Publishing data on the DAP includes a CSIRO internal review processes, to ensure data sets meet high quality standards.

For the purposes of the project, the data uploaded can be managed through restricted access to researchers and the client (data owners) and only made available after publishing.

Research data can also be housed in the MDMS where it complements other monitoring data, is in a simple tabular data, and is made up of multiple locations that need to be aggregated.

In accordance with CSIRO's Recordkeeping Procedure, when uploading data to the DAP, considerations include:

- version control and naming convention

- reproducibility
- documenting the processes used (or the provenance of your working data)
- document which software and version was used for analysis
- standardising data from varied project inputs
- preparing the data for publication
- de-identifying or otherwise processing sensitive data
- providing access to any of the following: website, online service, database, data, or software after the project has been completed
- file format types provided and generated.

A.6.3 Sensitive data storage

All Basin-scale Flow-MER Project Research which requires the involvement or study of humans or their data must comply with the requirements specified in the National Statement on Ethical Conduct in Human Research (2007 updated 2018) and any relevant State and Federal legislative requirements e.g. Privacy Act 1988.

In the Basin-scale Flow-MER Project we will ensure sensitive or confidential data (for example and research involving Indigenous peoples and communities) is stored in accordance with CSIRO's Social Science Human Research Ethics Committee approvals as per the National Statement on Ethical Conduct in Human Research 2007.

This can include (not limited to):

- make arrangements to securely store any culturally sensitive information gathered during the project and to protect participant's privacy
- establish processes to ascertain what is sensitive/confidential e.g. through conducting background literature reviews, talking to previous researchers, interviews with participants, feedback from an Indigenous reference group
- members of the research team are aware of the provisions under Indigenous customary protocols for not-naming or showing images of recently deceased people in publications/reports
- hold discussions with Indigenous research collaborators as to where the research materials will be stored so that they have access, as requested
- prioritise storing or providing mirror copies of relevant materials in local community knowledge centres or keeping places. Where there are no local facilities, copies of recordings and other relevant materials (as discussed) will be made available in hard copy and digital forms to relevant people.

A.7 Freedom of Information

This Data Management plan aligns to the requirements set out in the Freedom of Information Amendment (Reform) Act 2010. The requirements are met through:

- the Data Management Plan itself will be published
- the Data Management Plan has strategies to ensure published data is accurate, up-to-date and complete
- data collected under the Basin-scale Flow-MER Project is considered a national resource and will be published free of charge and available for public use

- data is published under a creative commons license and to our knowledge there are no national or State secrets or privacy concerns that warrant exclusions.

A.8 References and resources

Brooks S Data management guidance document.

Brooks S and Wealands S (2013a) Functional Requirements for LTIM Data Management. Draft Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 2013 December, 8pp.

Brooks S and Wealands S (2013b) Long-term Intervention Monitoring Project Data Management Strategy. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 01.4/2013, June, 26pp.

Digital Continuity Principles, National Archives of Australia.

The Department of the Environment Information Strategy 2013-2017

The Australian Government Public Data Policy Statement

Principles on open public sector information

National Statement on Ethical Conduct in Human Research 2007

Privacy Act 1988

Freedom of Information Act

Freedom of Information Amendment (Reform) Act 2010

Appendix B Stakeholder Engagement and Communication Plan

Stakeholder engagement and communication activities are important for informing stakeholders about the Basin-scale Flow-MER project, within the context of the broader mandate of the CEWO. These activities are also important in enabling stakeholders to have confidence in, and utilise, the information generated through the Project. The Stakeholder Engagement and Communication Plan uses collaborative approaches in recognition of the important role of the CEWO, Selected Area Flow-MER Project teams and environmental water delivery partners in meeting communication objectives.

We are committed to inspiring, enabling and building the collaboration capabilities of Basin-scale Flow-MER team members, CEWO staff and Murray-Darling Basin communities to deliver and communicate meaningful, culturally appropriate and inclusive information on environmental water outcomes. Effective communication and engagement is about the connection between people that allows for the exchange of thoughts, feelings, and ideas, and which leads to mutual understanding.

Activities will be informed by expert scientific advice and based on relationships between the Basin-scale Flow-MER Project team, Selected Area Flow-MER Project teams, the CEWO, State agencies, and community and Indigenous groups. The approaches outlined here are intended to build stakeholder relationships that will support the Flow-MER Program into the future.

B.1 Objectives

- Engage with stakeholders thoughtfully, value knowledge, develop trusting relationships over time, respect cultural and local contexts and promote successful outcomes.
- Collaborate with the CEWO and their environmental water delivery partners to ensure that the outcomes from monitoring and evaluation are informative and meet their needs.
- Explain why Basin-scale Flow-MER is needed to support the delivery of water for the environment so that it can benefit the Murray-Darling Basin's rivers and communities.
- Inform a broad stakeholder audience about the Basin-scale Flow-MER Project to increase community confidence in the science informing environmental watering policy and decisions.
- Work with Selected Areas to increase awareness and understanding of the multiple benefits that water for the environment provides to ecological and human communities.
- Integrate Indigenous culture throughout all activities by ensuring language, place names and cultural references are fundamental parts of our strategy and delivery. Ensure all intellectual property is protected, and agreements established where knowledge transfer occurs.
- Develop a website, plus online and hard copy resources to share the science undertaken through the Basin-scale Flow-MER Project and provide access to scientific information using stories, webinars, workshops, videos and images to attract interest and engage target audiences.

B.2 Stakeholder groups

Figure B.1 Stakeholders in the Flow-MER program

The stakeholders in the Flow-MER program (Figure B.1):

- **CEWO** – we will work with the CEWO and their communication team to deliver Flow-MER outcomes in a form that the CEWO can access and use, to provide insight, knowledge and advice on Basin-scale Flow-MER and to ensure our stakeholder engagement and communication activities align.
- **The Flow-MER Program** – we will support and enable the Basin-scale Flow-MER Project team to engage with stakeholders to both inform and communicate the outcomes of monitoring and evaluation. We will also work with the Selected Area teams to add value to their activities at the Basin-scale.
- **Environmental water managers** – this group includes CEWO environmental water deliver partners and is a beneficiary of Basin-scale Flow-MER. We aim for our work to be relevant, meaningful and able to be applied. We will engage this group through established CEWO and broader partner networks.
- **Indigenous groups** – we seek genuine engagement with Indigenous people throughout our project. The emphasis will be engaging the relevant Indigenous people from the start, and then in an ongoing, culturally appropriate manner over the life of the Basin-scale Flow-MER Project, enabling them to be involved in decision making and telling their water stories.
- **Science community** – this target audience will mainly be reached through existing scientific channels such as professional associations, journals and conferences. The personal networks of the scientists involved in the Basin-scale Flow-MER team will be another valuable way to extend the reach of our work.
- **Water agencies, Non-Government Organisations and land and water managers** – There are already CEWO communication networks in place to reach these groups and we will seek to provide content

that can be shared through these existing relationships. External events will be key opportunities for the Project team to engage with this group.

- **Basin communities and general public** – this target audience will be able to access our website, social media and online resources which will have stories, environmental water information and links to our work. This group of people will also be able to sign up to our monthly email newsletter.

B.3 Stakeholder engagement approach

The International Association for Public Participation (IAP2) developed the Public Participation Spectrum[18] to articulate appropriate engagement approaches as the level of desired participation of stakeholders in a program or project increases. As you move through the spectrum, from left to right, there is a corresponding increase in the level of expectation for participation and contribution from stakeholders. The level of desired participation with a stakeholder group determines the engagement approach to be used and the communication tools required to support engagement.

The goals for participation as described in the IAP2 Public Participation Spectrum are shown in Table B.1. The table also shows engagement approaches to be used for each level of participation in the Basin-scale Flow-MER Project. The highest level of participation is with the CEWO and Flow-MER Program participants. The lowest level of participation is with the general public; however, we acknowledge the importance of doing this. On the following pages, specific engagement strategies are outlined for each stakeholder group.

The engagement approaches for the Basin-scale Flow-MER Project are participatory. This means that for high participation stakeholders, such as the CEWO, participants will co-design the engagement approaches and tools. Over the first three months of the Basin-scale Flow-MER Project (July-September 2019), the project leaders and the Stakeholder Engagement and Communication Team will work with the CEWO, Project partners and Selected Area Project teams to develop a schedule of activities for the coming year (an annual plan). Each year an annual plan will be developed that outlines specific activities for the year and mechanisms to evaluate the success of those activities.

[18] International Association of Public Participation http://www.iap2.org

Table B.1 Engagement matrix for the Basin-scale Flow-MER Project based on the IAP2 Public Participation Spectrum

Increasing level of public impact

INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
Goal of Engagement (IAP2)	Goal of Engagement (IAP2)	Goal of Engagement (IAP2)	Goal of Engagement (IAP2)	Goal of Engagement (IAP2)
Provide public with balanced and objective information to assist with understanding	Obtain feedback on analysis, alternatives or decisions	Work with public throughout process and consider concerns and aspirations	Partner with the public in each aspect of decision-making including development of alternatives and identification of preferred solutions	Place final decision making in hands of the public
MER Engagement objectives	MER Engagement objectives	MER Engagement objectives	MER Engagement objectives	MER Engagement objectives
To inform a broad stakeholder audience about the Flow-MER project to increase community confidence in the science informing environmental watering policy and decisions.	To undertake communication activities that will inform stakeholders about the project and facilitate users to access and understand Flow-MER information and provide feedback on the Flow-MER Program.	To work directly with stakeholders to ensure that their needs are understood and considered and reflected in the Basin-scale Flow-MER Project.	To partner with key stakeholders who are able to progress the objectives of the project.	N/A
Stakeholders	Stakeholders	Stakeholders	Stakeholders	Stakeholders
Basin communities **The general public.**	Science community Water agencies, NGOs and land and water managers Indigenous groups.	Key influencers Environmental water managers Indigenous leaders Science reviewers.	CEWO and environmental water delivery partners Basin-scale Flow-MER project partners Selected Area project teams and project partners.	N/A
Tools – work to inform & disseminate	Tools – work to understand and feedback	Tools – work to meet mutual needs	Tools – work together for results	N/A
Web site information, social media, infographics, maps, data visualisation, presentations, newsletters, publications	Web site, social media, infographics, data visualisation, presentations, newsletters, publications, briefings	Briefings, regular updates, reference groups, key contacts, early involvement in data products, involvement in outputs.	Co-design of projects, shared online calendar, workshops, papers, reports, involvement in outputs, face-to-face meetings.	N/A

B.3.1 Commonwealth Environmental Water Office

The goal of engagement is to collaborate to provide the best chance for the outputs of Basin-scale Flow-MER Project to meet the requirements of the CEWO. We will seek advice from the CEWO when devising project outputs (reports and report summaries) and in making key decisions.

Stakeholder engagement approaches

- Project Steering Committee for project oversight (as needed)
- project deliverables targeted to the needs of the CEWO
- CEWO to regularly brief the Commonwealth Environmental Water Holder
- Basin-scale Flow-MER Project Leaders to meet with the CEWO quarterly to provide updates, with targeted briefings and briefing materials for the Commonwealth Environmental Water Holder, delivery teams and environmental water delivery partners
- CEWO to undertake internal briefings to facilitate an understanding of the science and work of the Basin-scale Flow-MER Project among internal stakeholders
- CEWO and environmental water delivery partners to be invited to participate in the Annual Flow-MER Forum and where applicable, in other meetings and workshops
- CEWO to develop and implement internal communication processes to support project impact and to facilitate appropriate information exchange between the Basin-scale Flow-MER Project and the Commonwealth Environmental Water Holder and key CEWO stakeholders.

Outcomes being sought from engagement

- deliver on Basin-scale Flow-MER Project objectives
- tailoring of Project activities to meet the needs of the CEWO
- uptake of science and information from Project activities.

Barriers to engagement

- getting access to key people (time and availability)
- expectations not understood and/or not met
- breakdowns in communication.

Evaluation of outcomes from engagement

- review of Project deliverables by the CEWO
- feedback on Project engagement and communication activities by the CEWO
- evaluation of Project stakeholder engagement and communication activities.

B.3.2 The Flow-MER Program

This group includes people engaged in delivering to the Flow-MER Program. The goal of stakeholder engagement is to collaborate in decision making. We will consult the Basin-scale Flow-MER Project team and Selected Area teams in preparing annual plans for Stakeholder engagement and communication.

Stakeholder engagement approaches

- project governance

- Basin-scale Flow-MER Project meetings (quarterly)
- annual Flow-MER forum and Theme meetings involving Selected Area Project teams (bi-annual)
- collaboration tools (SharePoint and Confluence), web resources and support from the Stakeholder Engagement and Communication Team
- participation in and documentation arising from updates to Foundation reports, decision registers, issues papers and meeting notes.
- research meetings, conference participation and teleconferences as needed
- shared vision, commitment to the project and support for project objectives and impact.

Outcomes being sought from engagement

- deliver on Basin-scale Flow-MER Project objectives
- co-generation of knowledge to inform environmental watering
- uptake of science and information from Project activities.

Barriers to engagement

- getting access to key people (time and availability)
- expectations not understood and/or not met
- breakdowns in communication.

Evaluation of outcomes from engagement

- review of Project deliverables by the CEWO
- feedback on Project activities by the Selected Area teams
- evaluation of Project stakeholder engagement and communication activities.

B.3.3 Environmental water managers

This group includes the CEWO environmental water delivery partners and they are a primary beneficiary of engagement and communication activities. The goal is to engage them as much as possible in the Project to provide the best opportunity for the outputs of Basin-scale Flow-MER to meet their requirements. Much of this engagement will be in conjunction with CEWO delivery teams.

Stakeholder engagement approaches

- Stakeholder Engagement and Communication Team to work with the CEWO to develop and implement communication processes to support project impact
- Basin-scale Flow-MER Project team to engage with the CEWO delivery teams to identify strategies for engaging with environmental water delivery partners
- Stakeholder Engagement and Communication Team to liaise extensively with environmental water delivery partners to build relationships, establish dialogue, determine their needs and deliver timely, informative and fit-for-purpose communication
- Environmental water delivery partners to be invited to participate in relevant forums, meetings and workshops
- develop targeted communication products, such as Annual Report executive summaries, report cards, data products (e.g. maps etc) and data visualisation products specifically tailored to the needs of this group.

Outcomes being sought from engagement

- deliver on Basin-scale Flow-MER Project objectives
- project outputs to support the information needs of this group
- exchange of knowledge and uptake of information to inform environmental watering.

Barriers to engagement

- getting access to key people (time and availability)
- expectations not understood and/or not met
- difficulty presenting Basin-scale data and information in a manner that is fit-for-purpose for primary users (for example, due to issues of temporal and spatial scale, limits of models etc).

Evaluation of outcomes from engagement

- review of Project outputs by members of this group (including summaries and report cards)
- feedback on Project engagement and communication activities from this group
- evaluation of Project stakeholder engagement and communication activities.

B.3.4 Indigenous groups

This is a diverse and heterogeneous stakeholder group comprising leader and members of Indigenous groups with an interest in environmental water. They have diverse interests and specific cultural, language and communication needs.

Stakeholder engagement approaches

- utilise culturally appropriate engagement and communication mechanisms (Appendix C)
- Stakeholder Engagement and Communication Team to work with Indigenous team members, including in partner organisations, to develop appropriate and targeted engagement strategies and communication activities
- provide opportunities for those interested in having a higher level of involvement in science activities, for example, proposed activities to identify culturally significant plant species
- provide opportunities for those who want to have a higher level of engagement in sharing of knowledge including briefings and targeted communication.

Outcomes being sought from engagement

- deliver on Flow-MER Program indigenous engagement objectives
- build relationships to support knowledge exchange needs of this group
- exchange of knowledge to inform environmental watering activities.

Barriers to engagement

- overwhelm if engagement is not carefully focussed
- underwhelm if engagement ad hoc and inconsistent
- cultural and language barriers to communication
- time and continuity required for long term relationship building.

Evaluation of outcomes from engagement

- review of Project outputs (including communication materials) by Indigenous team members
- feedback on targeted engagement and communication activities
- evaluation of Project stakeholder engagement and communication activities.

B.3.5 Science community

Peer acceptance and recognition of the scientific work underpinning the Basin-scale project adds to the evidence of scientific quality as well as the perception of credibility. These are important to the long-term success of the project and the CEWO's broader mandate. The goal is to consult the broader science community as appropriate through existing science channels.

Groups

- knowledge leaders
- science key influencers including science reviewers
- partner scientists and their external colleagues with overlapping professional interests

Stakeholder engagement approaches

- Basin-scale Flow-MER Project leaders to prepare a science communication plan
- project partners to lead this engagement in accordance with the plan (above)
- individual spokespeople to be identified as required
- project scientists to publish methods and conceptual understanding in reputable science journals and to seek permission from project partners and collaborators to publish the findings of their scientific work as appropriate
- project leaders and project scientists to seek opportunities to represent the science at high-profile, credible and relevant scientific events.

Outcomes being sought from engagement

- deliver on Basin-scale Flow-MER Project objectives
- project outputs viewed as being of high science quality and scientifically credible
- exchange of knowledge to support ongoing improvement of science methodology.

Barriers to engagement

- slow approval processes for science communication
- mixed or miss-messaging
- communicating science targeted to the appropriate audience (i.e. end user, water managers, general public)
- Intellectual Property issues
- poor choice of forums.

Evaluation of outcomes from engagement

- review of Project outputs by Science Advisory Group
- feedback on science presentations at conferences

- evaluation of project stakeholder engagement and communication activities.

B.3.6 Water agencies, NGOs and land and water managers

This is a diverse and heterogeneous collection of stakeholder groups with highly differentiated interests and engagement and communication needs. It is outside of the scope of the Basin-scale Flow-MER Project to specifically address the needs of this diverse group. The goal is to inform key stakeholders through existing networks and to consult and involve key influencers and knowledge brokers (for example, LEOs) who are able to have a broad impact within their networks.

Stakeholder engagement approaches

- Stakeholder Engagement and Communication Team to work with the CEWO to develop key activities to support this group that align with the priorities and activities for CEWO communication and use existing networks and communication channels
- use a range of communication tools including social media, web presence, newsletters, articles in magazines, media, etc. to deliver targeted messages to diverse stakeholder groups
- target key influencers and knowledge brokers (LEOs) for a higher level of engagement including targeted communication materials
- use appropriate communication channels and networks to provide pathways for those interested in having a higher level of engagement
- provide a wide range of communication products suitable for diverse audiences in easily accessible formats in the public domain via a dedicated web site.

Outcomes being sought from engagement

- deliver on broader Flow-MER Program communication objectives
- seek engagement with key influencers and knowledge brokers to value-add communication
- increased understanding of the value of environmental watering and the credibility of the science underpinning environmental watering among key influencers.

Barriers to engagement

- overwhelm if engagement is not carefully focussed
- underwhelm if engagement ad hoc and inconsistent
- varying degrees of participation from various stakeholders and not necessarily willing to be at the ‘table’ together
- wide range of strategies and communication tactics needed to be effective
- access to appropriate information/messaging to share
- need for targeted messaging for each stakeholder group.

Evaluation of outcomes from engagement

- review of communication products by CEWO knowledge brokers and communication team
- feedback on project engagement and communication activities from key influencers
- evaluation of project stakeholder engagement and communication activities.

B.3.7 Basin communities and the general public

This is a large and dispersed group of stakeholders who are outside of the scope of the activities of the Basin-scale Flow-MER Project. The goal is to inform by ensuring communication materials are available to the general public through a range of communication channels.

Stakeholder engagement approaches

- use a range of communication tools including social media, web presence, newsletters, articles in magazines, media, etc. to deliver targeted messages to diverse stakeholder groups
- use passive communication channels and networks to provide pathways for those interested in having a higher level of engagement
- provide a wide range of communication products suitable for diverse audiences in easily accessible formats in the public domain via a dedicated web site.

Outcomes being sought from engagement

- deliver on broader Flow-MER Program communication objectives
- seek engagement with key influencers and knowledge brokers to value-add communication
- increased understanding of the value of environmental watering and the credibility of the science underpinning environmental watering among the interested public.

Barriers to engagement

- limitations of passive communication approaches
- wide range of strategies and communication tactics needed to be effective
- need for targeted messaging for each stakeholder group.

Evaluation of outcomes from engagement

- review of communication products by CEWO knowledge brokers and communication team
- feedback on Project engagement and communication activities from key influencers
- evaluation of Project stakeholder engagement and communication activities.

B.4 Stakeholder engagement and communication team

Stakeholder engagement and communication is a core component of the Basin-scale Flow-MER Project. A Cross-cutting Theme has been created to ensure stakeholder engagement and communication objectives are met and a dedicated team has been put in place to ensure resources are focussed in this area.

The Stakeholder Engagement and Communication Theme is led by Siwan Lovett (ARRC) and includes Pat Gudhka (ARRC), Brad Moggridge (UC) and Emma Woodward (CSIRO). These key personnel will work with the project leaders, Theme leaders and other members of the project team on focussed communication activities. The team add specialist expertise in stakeholder engagement, deep networks in Basin communities and the capability to engage a wide cross-section of stakeholders in government, communities and Indigenous groups.

The team have consulted with a wide range of stakeholders to inform the development of the Stakeholder Engagement and Communication Plan. Engagement has included the CEWO Flow-MER team, delivery teams and communication team, Selected Area teams, key influencers in the target stakeholder groups as well as personal connections in Basin Communities.

In addition to the mechanisms described above, Project leaders, Theme leaders and the Project coordinator use the governance structure, reporting deliverables and meeting schedule set out in this plan to underpin extensive engagement with primary users including the CEWO and delivery partners, as well as the project team and Selected Area teams and collaborating organisations. The project leaders also include science communication in their planning to ensure that adequate attention is paid to the very important role of science engagement, publishing, presentation and communication in furthering the objectives of the Basin-scale Flow-MER Project.

Each year, the Stakeholder Engagement and Communications Plan will be reviewed to ensure outcomes are delivered and the CEWO can value add to the communication efforts. While activities are collaborative, Table B.2 summarises responsibilities for each stakeholder group.

Table B.2 Communication responsibilities

Stakeholder Groups	Project leaders and Coordinator	Theme leaders and senior scientists	Stakeholder Engagement and Communication Theme	CEWO
CEWO	X			X
Flow-MER Program	X	X	X	X
Environmental water managers	X	X	X	X
Indigenous Groups			X	X
Science community	X	X		
Water agencies, NGOs and managers	(X)		X	X
Basin communities and the public			(X)	X

B.5 Activities

B.5.1 Collaborate as a capable, confident communications team

We will value our strengths and share ideas about how we can best deliver our goal of inspiring and enabling the Basin-scale Flow-MER Project to achieve great results. We will spend time together as a team, face-to-face, online and via the phone to ensure we support each other, allocate tasks and manage our portfolio of communication and engagement responsibilities.

Deliverables

- a Stakeholder Engagement and Communication team who are enjoying their work and inspiring others to do the same - leading by example
- accessible and approachable team providing support and advice to the wider Flow-MER Program.

B.5.2 Develop engagement and communications infrastructure

Develop a website, social media platforms (Facebook, LinkedIn, Instagram) and explanatory brochures/postcards/fact sheets explaining Flow-MER and why it is important. Over time, the content of these will move from raising awareness, to sharing findings, implications of findings for management, and recommendations for ongoing environmental water investment. Storytelling will be a key engagement and communications approach, along with photographs, infographics and maps that people can explore.

Stories and content generated across the Flow-MER Program may also be shared on other related websites such as the Commonwealth Environmental Water Holder, Victorian Environmental Water Holder, CSIRO, Institute of Applied Ecology, Australian River Restoration Centre and partner websites. The underlying principle for all Basin-scale Flow-MER Project communications is that one story is used multiple times, and on many platforms, to extend reach and cater to a wide range of audiences.

To enable this to happen, stories will be made available in a range of formats so that they can be easily shared and used on different website platforms and media. We will also develop relationships with key partner communications personnel so that they can tailor content so that it is meaningful for their networks.

Deliverables

- website with Themes, Basin-scale, Selected Areas (Places) tabs featuring stories and engaging content
- social media platform to share stories (Facebook, LinkedIn, Instagram), linked to CEWO, CSIRO, UC and other partner agencies
- shared online calendar for Flow-MER Program and CEWO to use so that engagement and communication opportunities can be maximised at local and basin-scales
- Video content, infographics, maps, data visualisation (working with Flow-MER Cross-Cutting Themes) are possible ways to engage with people and share findings
- place based postcards with images, people and projects underway at specific sites, fact sheets and guides to explain environmental watering and to share findings across the Basin-scale Flow-MER activities can all be used to raise awareness and engage target audiences. It is likely these products will be developed in partnership with Selected Areas teams and Basin Themes.

B.5.3 Communications support for the Basin-scale Flow-MER project team

Provide support and advice to the Basin-scale Flow-MER team as they develop and deliver their engagement and communication strategies, organise activities and interact with stakeholders. We will be in close contact with the teams so that we know about the work they are undertaking and can build engagement and communications activities throughout, rather than at the end of projects. We will be focusing on ways to achieve both local and Basin-scale communication and engagement outcomes, while at the same time retaining the authenticity of local community connections and culture.

Deliverables

- communication collaboration and support via workshops, email, phone calls, editing and design
- active sharing of engagement ideas and outcomes
- Indigenous connection understood and culturally appropriate ways of engaging determined.

B.5.4 Build strong and meaningful partnerships with Indigenous groups in delivering water for the environment

Our Indigenous engagement and communication strategies at Selected Area and Basin-scale needs to build on current strengths, relationships and networks, as well as supporting and developing engagement capability in areas requiring assistance. We want the Basin-scale Flow-MER Project to strive to deliver messages of environmental water benefits with community and cultural outcomes. Some areas have had Indigenous people excluded for many years, this is an opportunity for Traditional Owners to reconnect with their Country and be involved in Caring for Country and Water.

We would like to learn about and build upon where successful Indigenous engagement is being demonstrated. In every case culturally sensitive and appropriate engagement approaches will be used (Appendix D). We will seek co-investors to develop products and approaches specifically for sharing Indigenous insights and knowledge.

Deliverables

- Locally developed protocols on respectfully engaging Traditional Owners
- Newsletters (tell a Deadly Story)
- Videos of water flowing and Traditional Owners on Country
- Activities during Reconciliation Week and NAIDOC Week.

B.5.5 Synthesise knowledge for Basin-scale understanding

One of our key roles will be to synthesise knowledge from the Selected Areas and Themes to provide Basin-scale understanding about the outcomes of environmental watering research, monitoring and evaluation. Each year we will work with the Basin-scale Flow-MER team to develop communications outputs that contain key messages drawn from our research and monitoring and evaluation activities. This knowledge will be used to underpin website stories, policy briefings and input to the Annual Forum.

We will also look at ways to present synthesised knowledge through digital storytelling, exploring content using new technology. Additional funds will be sought to explore innovative approaches to communication.

Deliverables

- up to four synthesis stories per year drawn from the Selected Areas and Themes that will be shared multiple times via web, social media, pod cast, policy briefing. The first two stories (2019) will share findings from LTIM and EWKR
- in collaboration with cross-cutting teams, explore how to present our research findings in innovative ways (e.g. interactive maps)
- report summaries with links to full reports will be a valuable way of reaching the scientific community in Australia and internationally.

B.5.6 Forums / gatherings / conferences

Each year the Basin-scale Flow-MER Project team will use the Annual Flow-MER Forum and other conference and meeting opportunities to share findings from across the portfolio of activities. We will target environmental water managers, and anyone interested in the work we are doing. We will use a mix of presentations, on-country interpretive walks, and social events.

In addition to these events, we will target relevant conferences and workshops for Basin-scale Flow-MER Project team members to attend. For example, in 2020 the Australian Stream Management Conference, and in 2021 the Society for Freshwater Science Conference. Both conferences can be supported by tailored communications products.

Deliverables

- forums, events and gatherings
- branded content and supporting materials for a consistent and professional look and feel.

B.6 Deliverables

Table B. provides an outline of proposed activities and deliverables. These will be finalised in an annual communication plan to be prepared and approved by Project Leaders in the first quarter of each year.

Table B.3 Communication activities and deliverables

Activity	Proposed deliverables	Timeline
Collaborate as communications team	One visit to regional location for team meeting Monthly catch ups on phone, skype Online coordination tool	Trip coordinated with a Flow-MER team Monthly catch ups Daily coordination
Communications & engagement infrastructure	Interactive, sophisticated, story-based Flow-MER website Editing and publishing 7 x articles each quarter on the Flow-MER website, integrated research across Selected Areas and Basin Themes Quarterly email newsletter to existing Flow-MER community email list Social media story sharing on Facebook and Twitter Flow-MER Fridays webinar series held every second quarter. Hard copy resources – postcards, fact sheets, guides depending on content and priorities.	Live 2020 Monthly creation, collation and distribution of articles Two social shares per week on Facebook plus post boosting Quarterly creation and distribution of email newsletter Hard copy resources – editing, design, printing
Communication support for Basin-scale Flow-MER team	Time with Selected Areas to explore synergies Indigenous engagement support and guidance	Each Selected Area will have time annually with the SE&C team Each Selected Area will have time annually with the Indigenous Inclusion Lead
Meaningful Indigenous engagement	Locally developed protocols on respectfully engaging Traditional Owners Newsletters (tell a Deadly Story) Videos of water flowing and Traditional Owners on Country Activities during Reconciliation Week and NAIDOC Week	Protocols developed 2020 Content for monthly email newsletter, also used on the Flow-MER website Reconciliation Week and NAIDOC presence
Synthesise basin-scale knowledge	Synthesis stories from across the Basin Themes developed and shared Briefings with environmental water agency, NGO and other interested stakeholders Data visualisation, maps, interactive ways of accessing new knowledge in collaboration with cross-cutting team	Synthesis stories developed monthly and shared via website, and quarterly newsletter Briefings Time allocated to working with cross cutting teams
Forums, events and gatherings	Communication and engagement events (format TBA) Branded content and supporting materials for a consistent look and feel. Training in storytelling, facilitation and presentation skills.	Events (TBA) Template for PowerPoint presentations Training on an as needs basis (and costs covered outside SE&C budget)

B.7 Ethics

All stakeholder engagement activities for the Basin-scale Flow-MER Project are subject to CSIRO's Human Ethics policies. CSIRO undertakes a wide range of research and project activities to inform and improve the health, welfare, sustainability and productivity of people, communities, regions and industries. Where these activities require the involvement or study of humans, their data or their tissue then this work must undergo ethics review and receive approval before the commencement of any activities or collection or receipt of data. Ethics approval cannot be granted retrospectively.

Human participation in research can include:

- taking part in surveys, interviews or focus groups
- undergoing psychological, physiological testing or treatment
- being observed by researchers
- researchers accessing personal documents or other materials
- the collection and use of body organs, tissues or fluids or exhaled breath
- researchers having access to information as part of an existing published or unpublished source or database, including government or customer datasets, online forums and social media.

All human research conducted by CSIRO and our subcontractors or partners must comply with the National Statement on Ethical Conduct in Human Research (2007 updated 2018)[19] and any relevant State and Federal legislation e.g. Privacy Act 1988[20].This is a requirement of CSIRO's Ethical Conduct in Human Research[21] policy and applies to our research both within Australia and overseas. All work undertaken will require meeting of the requirements of the National Statement. This will be a requirement for contracting any research with human participation.

All Indigenous Engagement will adhere to the Indigenous Engagement Plan (Appendix C).

[19] https://nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018

[20] https://www8.austlii.edu.au/cgi-bin/viewdb/au/legis/cth/consol_act/pa1988108/

[21] https://my.csiro.au/Policy-Portal/Research-ethics/Ethical-Conduct-in-Human-Research

Appendix C Indigenous Engagement Plan

C.1 Acknowledgement of Traditional Owners and Country

CSIRO and Commonwealth Environmental Water Office acknowledge the Traditional Owners of Australia and pays respect to the past, present and future Elders of the nation.

C.2 Introduction

The Indigenous Engagement Plan provides direction on the expectations of CSIRO and the Commonwealth Environmental Water Office (CEWO) to ensure effective and authentic integration of Indigenous priorities, values and aspirations in the Basin-scale Flow-MER Project.

Indigenous people are key stakeholders in the future of environmental water in the Murray-Darling Basin. All research undertaken in the Murray-Darling Basin impacts Indigenous peoples, and CSIRO and CEWO recognise and respect the knowledge Indigenous peoples have in managing Australia's land, water, biodiversity and cultural heritage.

C.3 Ethics approvals

All Basin-scale Flow-MER Research or other activities that involve humans or the use of human data must undergo review and receive approval by CSIRO's Social Science Human Research Ethics Committee before project commencement or the receipt of any data (these approvals are then reciprocal for all University Ethics Committees).

This will ensure that the project complies with the requirements specified in the National Statement on Ethical Conduct in Human Research (2007 updated 2018) and any relevant State and Federal legislative requirements e.g. Privacy Act 1988.

This includes research that involves community and Indigenous engagement in participatory action research, surveys, interviews, or observation, access to personal documents or materials, and access to people's information via an existing published or unpublished source or database.

C.4 Principles for Indigenous engagement

CSIRO and CEWO expect that all Basin-scale Flow-MER Project activities are carried out with respect for Indigenous peoples' priorities, values and aspirations. All relevant research projects are required to include planning for building meaningful partnerships with Indigenous peoples.

The Australian Institute of Indigenous and Torres Strait Islander Studies (AIATSIS) has developed *Guidelines for Ethical Research in Australian Indigenous Studies* which supplies principles

> to ensure that research with and about Aboriginal and Torres Strait Islander peoples follows a process of meaningful engagement and reciprocity between the researcher and the individuals and/or communities involved in the research.

Under the Guidelines, Aboriginal and Torres Strait Islander peoples are full participants in research projects that concern them, share an understanding of the aims and methods of the research, and share the results of this work. At every stage, research with and about Indigenous peoples must be founded on a process of meaningful engagement and reciprocity between the researcher and Indigenous people. It should also be recognised that there is no sharp distinction between researchers and Indigenous people. Indigenous people are also researchers, and all participants must be regarded as equal partners in a research engagement.

C.5 Pathways and mechanisms

Basin-scale Flow-MER Project Team members are expected to engage using the AIATSIS *Guidelines for Ethical Research in Australian Indigenous Studies* which include the following categories:

- rights, respect and recognition
- negotiation, consultation, agreement and mutual understanding
- participation, collaboration and partnership
- benefits, outcomes and giving back
- managing research: use, storage and access
- reporting and compliance.

In practice, this would include the following (not limited to) procedures:

- acknowledge Indigenous peoples in the Murray-Darling Basin as the Traditional Owners and Custodians of the land
- acknowledge and recognise the diversity of Indigenous peoples and communities in the Murray-Darling Basin, including their different languages, cultures, histories, perspectives and aspirations
- ensure that Indigenous people are equal participants in research projects. Where possible and applicable, facilitate co-design of research projects
- ensure that the appropriate Ethics Approvals are in place for any consultation and communication processes (including processes on consent, participation, Intellectual Property etc.)
- where possible, research should benefit Indigenous peoples locally and generally. For example, Indigenous people who contribute (traditional knowledge, practices and innovations, cultural expressions and intellectual property) to a research project should receive fair and equal benefits
- acknowledge that all information shared by participants is shared with government and public and can be attributed or anonymous
- use existing governance structures to channel engagement, such as Land Councils, Murray Lower Darling Rivers Indigenous Nations (MLDRIN), Catchment Management Authorities and Local Government and community bodies
- ensure sensitive or confidential data (for example and research involving Aboriginal and Torres Strait Islander peoples and communities) is stored in accordance with CSIRO's Social Science Human Research Ethics Committee approvals as per the National Statement on Ethical Conduct in Human Research 2007 [see Sensitive data storage section in Basin-scale Flow-MER Project Data Management Plan (Appendix A)].

Please also refer to the Basin-scale Flow-MER Project Stakeholder Engagement and Communications Plan (Appendix B) which includes information on stakeholder engagement.

C.6 Intellectual Property rights

Article 31 of the *Declaration on the Rights of Indigenous Peoples* (2007 United Nations) states Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts.

CSIRO and CEWO expect that all Basin-scale Flow-MER Project activities will acknowledge Indigenous people and all information, views or knowledge they share with Basin-scale Flow-MER Project researchers is shared with government and public whether attributed or anonymous.

Intellectual Knowledge protocols in research include (but are not limited to) the following:

- discuss what Intellectual Property means and agree on how it will be managed during the project (including consent, publishing and data storage)
- utilise release forms for the recording, filming or photographing Indigenous culture, sites and larger landscapes
- include attribution and provenance of data (records the names of people, communities and clan/ language groups)
- ensure acknowledgements and credits remain traceable in databases or records so that connections with the original sources of Indigenous knowledge are not lost
- discuss the possible secondary use of any data generated through the project, and
- acknowledge that all information shared is shared with government and public and can be attributed or anonymous.

C.7 References and resources

The Department of the Environment and Energy's Engage Early guidelines also provide guidance on engagement and consultation of Indigenous peoples.

Department of Aboriginal and Torres Strait Island Partnerships – Protocols for Consultation

United Nations – Declarations on the Rights of Indigenous Peoples

Share our Pride

National Statement on Ethical Conduct in Human Research (2007 updated 2018)

Privacy Act 1988.

Guidelines for Ethical Research in Australian Indigenous Studies

https://flow-mer.org.au

Australian Government

Commonwealth Environmental Water Office

Partners

CSIRO

UNIVERSITY OF CANBERRA

Collaborators

Charles Sturt University

DEAKIN UNIVERSITY

BROOKS.eco ECOLOGY & TECHNOLOGY

Arthur Rylah Institute for environmental research

Government of South Australia

Department of Primary Industries and Regions

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

une University of New England

NSW GOVERNMENT

Department of Primary Industries

ARRC Australian River Restoration Centre