NSW GOVERNMENT
Office of Environment & Heritage

Evaluation of the NSW Environmental Water Management Program 2006–2013

Report to the OEH Executive

Prepared by the Environmental Water Governance Team on behalf of the Environmental Water and Floodplains Working Group

Cover photo: Uara Creek aquatic vegetation response to environmental watering. Photo: J. Maguire, OEH.

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Abbreviations

EWAG Environmental water advisory group

EWMP Environmental Water Management Program

NPWS National Parks and Wildlife Service, OEH

NOW NSW Office of Water

OEH NSW Office of Environment and Heritage

SMART Specific, measurable, achievable, relevant, time-bound objectives/targets

Acknowledgments

The Environmental Water Governance Team acknowledges the substantial contributions to this report by the Water and Wetlands Team, OEH Science Division; the Community Engagement Team in Regional Operations; the Project Steering Committee; and members of the Environmental Water and Floodplains Working Group who coordinated comments from their respective work groups.

Cover image by James Maguire, OEH.

Summary

This report is the first medium-term evaluation of the environmental water management program (EWMP) undertaken by the NSW Office of Environment and Heritage (OEH). It covers the period July 2006 to June 2013. OEH is responsible for managing water available in environmental allowances held in storage under rules in water-sharing plans and under licences purchased or created specifically for environmental use.

The EWMP did not begin as a formally designated program but over time combined several discrete programs with common objectives, all responding to the rapidly deteriorating health of inland rivers and wetlands during the Millennium drought. The EWMP is in turn now contributing to a larger program by implementing part of NSW's obligations under the recently released Murray-Darling Basin Plan (the 'Basin Plan'; http://www.mdba.gov.au/sites/default/files/Basin-Plan/Basin-Plan-Nov2012.pdf).

This report is in four parts. Part 1 examines key activities within each component of the EWMP to assess their appropriateness, effectiveness and efficiency (process evaluation). Part 2 uses evidence from information provided by the Water and Wetlands Team in OEH Science and by external consultancies to assess progress in meeting program objectives (summative evaluation). The evidence is biased toward those wetlands with a longer history of inquiry. Part 3 expands on one element of program delivery by examining environmental water advisory groups (EWAGs). EWAGs provide the primary mechanism for community involvement in environmental water management. Part 4 makes findings on the strengths and weaknesses of the EWMP and recommendations to improve it.

The EWMP operates in a complex and uncertain world, featuring many interacting elements, constant change which is often irreversible, nonlinear interactions between elements and no clearly defined boundaries to the systems being managed. Multi-disciplinary research into complexity provides insights to guide future directions for the EWMP. These include a nurturing of creativity, distributed leadership, clearly defined and shared objectives, the use of multiple scenarios to predict impact and benefit, and transparent and constructive communication about successes and failures.

Over time, the EWMP has matured into a credible and effective program, either incorporating or identifying the need for features consistent with managing complex systems. OEH's organisational structure has recognised and consolidated the functions of the EWMP. The next step is to formally recognise it as a priority program to strengthen the current whole-of-organisation input, identify adequate levels of resourcing over realistic time frames and encourage good governance of a valuable public asset.

There is no reason to make substantive changes to the EWMP. The main components are appropriate and likely to continue in the long term. There is evidence to support an improvement in the condition of wetlands, although not yet to the levels before the Millennium drought; there is also evidence that some of the improvement is directly linked to active delivery of environmental water.

The major weaknesses of the EWMP are:

- the lack of formal, inclusive and long-term planning to communicate broadly the scope, intent and constraints for managing environmental water in each water source
- the need for a complementary long-term monitoring program as the basis for assessing how well planning objectives are being met and improving the quality of those objectives.

Funding provided to NSW generally, and OEH specifically, under the Basin Plan Implementation Agreement (http://www.mdba.gov.au/sites/default/files/MDB-Plan-2012-Implementation-Agreement_final_7-Aug-2013_updated-signature-block.pdf) will substantially improve OEH's capacity to address these weaknesses.

Introduction

Purpose

This report evaluates the environmental water management program (EWMP) undertaken by the NSW Office of Environment and Heritage (OEH) in the period July 2006 to June 2013.

EWMP refers to the management by OEH of allocated environmental water. Allocated environmental water includes:

- planned environmental water allowances (or environmental contingency allowances) accrued through the relevant regulated river water-sharing plans [http://www.water.nsw.gov.au/Water-Management/default.aspx] (The NSW Office of Water [NOW] has delegated the use of this water to OEH.)
- adaptive environmental water licences arising from both the purchase of entitlements by governments and the recovery of water through savings generated by infrastructure projects.

Allocated environmental water is managed with other sources of water to deliver environmental objectives and includes water available under access licences purchased by the Australian Government. Other sources of water include unregulated tributary flows, flood-mitigation flows and water ordered to meet extractive demand. These other sources usually make a larger contribution to flows in rivers than does allocated environmental water, particularly in years with median to high rainfall. Separating out the contributions of each source of water to ecological outcomes can be challenging.

Context

The EWMP evolved from a need to address long-standing community concerns about the health of floodplain wetlands in the Murray-Darling Basin. In particular, private landholders were observing a rapid decline in the condition of Ramsar-listed wetlands under their care in the Macquarie Marshes and Gwydir wetlands. The EWMP quickly began to cover other important wetlands in NSW. It recognised that the solution included accessing water additional to that available under water-sharing plans; it also recognised that buying water entitlements from willing sellers was the fairest way to obtain the additional water.

The NSW Government purchased water access licences under the NSW Wetland Recovery Program, NSW RiverBank, and the Rivers Environmental Restoration Program. The Australian Government continues to purchase licences under the Restoring the Balance in the Murray-Darling Basin program and the Sustainable Water Use and Infrastructure Program (http://www.environment.gov.au/topics/water/commonwealth-environmental-water-office/about-commonwealth-environmental-water).

The original NSW RiverBank program was the first dedicated specifically to licence purchase. It was announced on 29 November 2005 and started in July 2006 with funding of $101.5 million over 5 years. It had a specific goal to make a significant contribution to the rehabilitation and protection of stressed rivers and iconic wetlands in NSW. Other programs supported NSW RiverBank's basic goal and objectives. All water access licence purchases under NSW RiverBank and other NSW programs were completed by 2012.

The objectives of NSW RiverBank were to purchase water entitlements and manage them to help:

- improve the ecosystem function of wetlands and rivers, including habitats, for aquatic-dependent biodiversity
- rehabilitate wetland habitat for significant water-dependent biota, including floodplain eucalypts, waterbirds, frogs, reptiles and fish
- meet the nation's international obligations with respect to wetlands and migratory birds
- further the ecological objectives of water-sharing plans
- improve water-management decisions to reflect an understanding of the links between environmental and Aboriginal cultural values.

In 2007, the Australian Government partnered with NSW to extend the scope of NSW RiverBank. It contributed $71.77 million under the NSW Rivers Environmental Restoration Program to purchase additional water entitlements, develop management-focused science, provide infrastructure to improve water management for the environment, engage landholders and regional communities, and purchase and protect significant wetlands. The NSW Rivers Environment Restoration Program was completed in 2011 (www.environment.nsw.gov.au/resources/environmentalwater/110240-rerp-final-report.pdf).

In 2008, the Australian Government created the Commonwealth Environmental Water Holder to purchase water entitlements to return water to the environment of the Murray-Darling Basin and elsewhere. These entitlements are jointly managed with those held by NSW under arrangements agreed on by OEH and the Commonwealth Environmental Water Office. This Office implements a larger-scale program that shares common elements with the EWMP (www.environment.gov.au/aggregation/commonwealth-environmental-water-office).

The EWMP contributes to the NSW Government's strategic plan, NSW 2021, which was released in 2011. In particular, the EWMP supports the goals of protecting our natural environment (Goal 22), increasing opportunities for people to look after their own environments (Goal 23), and involving the community in decision-making (Goal 32).

The Murray-Darling Basin Plan now provides an overarching context (i.e. a top-down approach) for both the EWMP and the Commonwealth Environmental Water Holder (and equivalent programs in other Basin jurisdictions). The recently released Basin-wide Environmental Watering Strategy outlines the rationale for, and objectives and means of, providing water for the Murray-Darling Basin, as well as the expected environmental outcomes (www.mdba.gov.au/sites/default/files/draft-BWS.pdf). As implementation of the Basin Plan evolves, activities within the EWMP will progressively align with Basin-scale requirements.

A simplified framework to provide context for environmental water managed by OEH is shown in Figure 1. Water available from purchased entitlements is combined with other sources of water (planned and allocated) to achieve environmental objectives, as specified in annual plans and consistent with long-term watering plans. This combined use constitutes the environmental water management function undertaken by OEH.

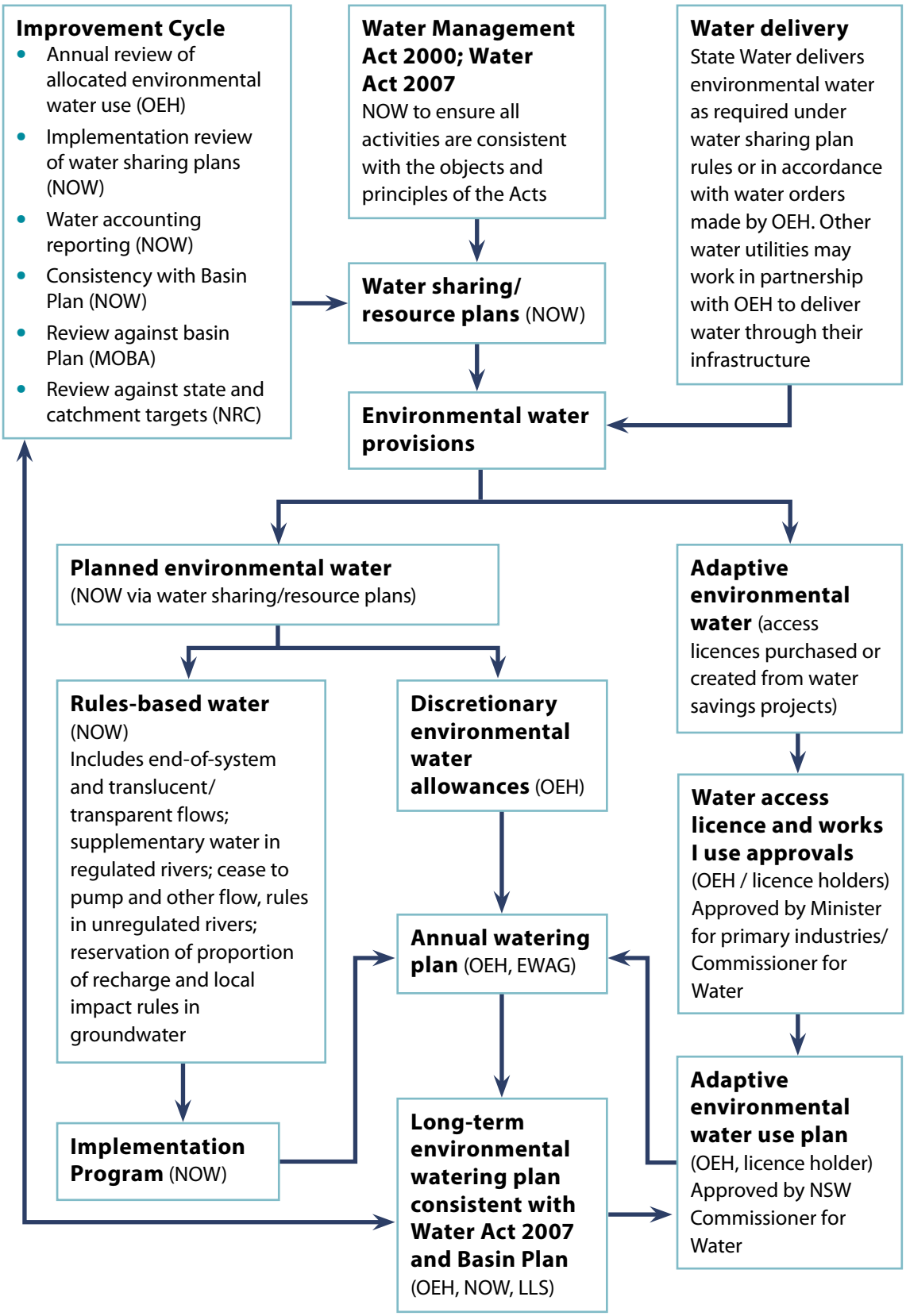


Figure 1: Simplified framework for environmental water management in NSW. EWAG, environmental water advisory group; LLS, Local Land Services; NOW, NSW Office of Water; NRC, Natural Resources Commission.

Approach to evaluation

Evaluation is a key tool to support evidence-based decision-making in government, help government learn and adapt to changing environments, and encourage communication. Ideally, evaluation should take place across the lifecycle of a program and be built into program design.

The EWMP did not begin as a formally designated program with a clear identity. Rather, it combined into a single program the outputs of several discrete programs that shared common objectives. Consequently it did not incorporate a formal evaluation design.

This evaluation investigates how the EWMP has been delivered (in 1 Program details and evaluation) and the environmental outcomes achieved (in 2 Has the EWMP made a difference?). These parts were implemented by the Environmental Water Governance Team of OEH using both qualitative and quantitative methods.

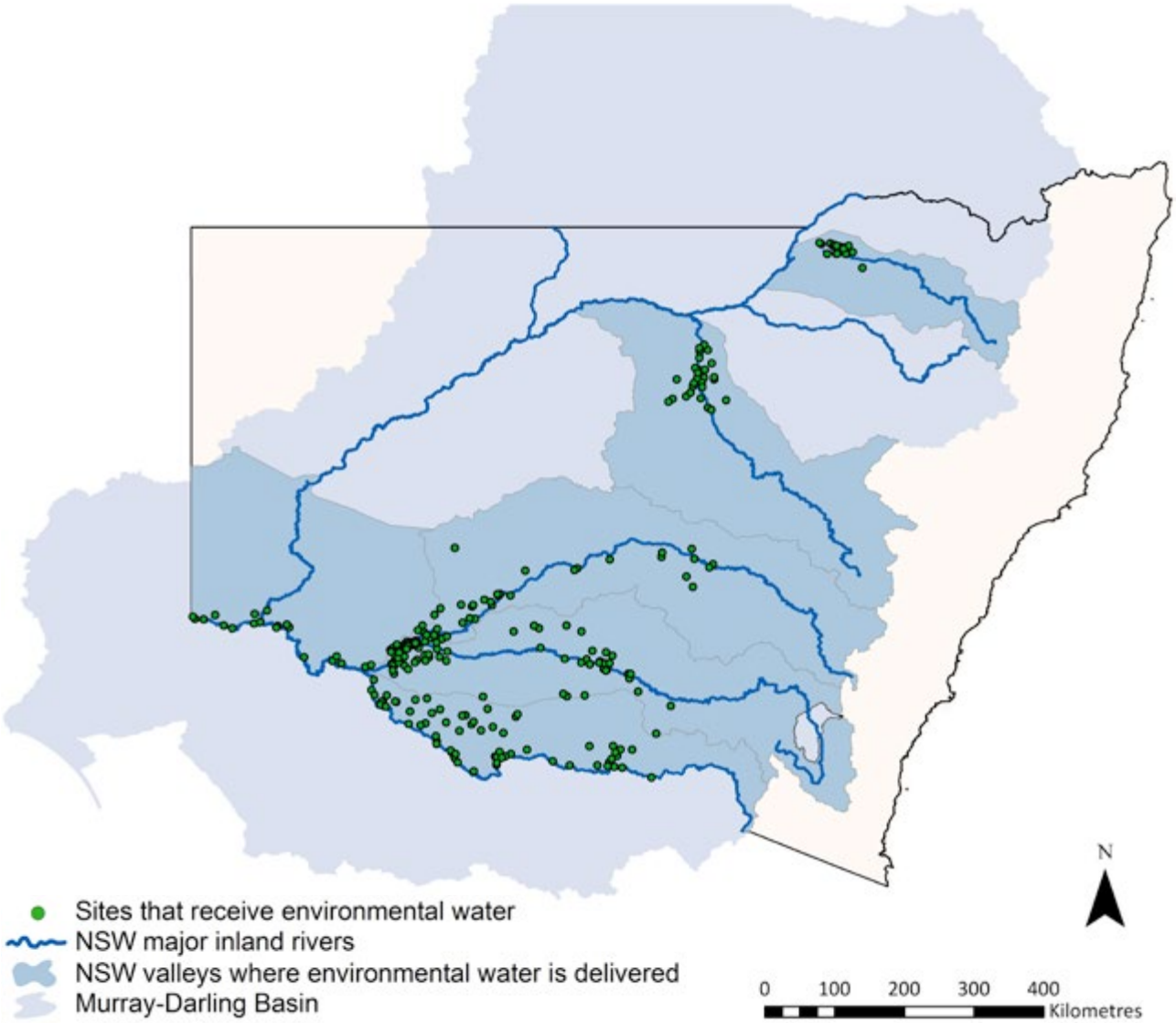


Figure 2: Locations of targets for environmental watering under the EWMP in NSW

Section **1 Program details and evaluation,** key activities within each component of the EWMP are assessed for their appropriateness, effectiveness and efficiency and reported by using 'traffic lights'.

'Appropriateness' refers to the suitability of a component. A green light means the activity as currently delivered is a necessary part of the EWMP. Red means that the activity is no longer required. Amber means that the intent of an activity is valid but there is scope to refine either the form or the delivery.

'Effectiveness' refers to the degree to which objectives or targeted problems are met. A green light means that the activity is as effective as it could be. Red means that the activity is ineffective. Amber means that there is scope to improve effectiveness by extending the coverage or intensity of the activity. In most cases, activities are undertaken effectively where performed but current levels of resourcing limit the extent of their application.

'Efficiency' refers to the ability to perform a task with minimum expenditure of time, effort and other resources. A green light means that the activity is performed as efficiently as possible. Red means that there are obvious inefficiencies in the application of resources. Amber means that efficiencies are possible through better targeting of resources. In most cases, regular scrutiny of all activities will identify ways to improve efficiency.

Section **2 Has the EWMP made a difference?** uses evidence from information provided by the Water and Wetlands Team in the Science Division of OEH and by external consultancies to assess progress in meeting program objectives. Important contributions were also made by Regional Operations and National Parks and Wildlife staff within OEH, and by Charles Sturt and New South Wales universities. Detailed technical information will be available in separate reports.

The evidence for environmental outcomes is derived primarily from wetlands in the Gwydir, Macquarie, Lachlan and Murrumbidgee River Valleys, as these were the target valleys for water purchase. Some information is provided for the Murray and Lower Darling Valleys where relevant. The Living Murray Program administered by the Murray Darling Basin Authority specifically targets the Murray River channel and its significant wetlands (see http://www.mdba.gov.au/sites/default/files/pubs/TLM-2009-Overview-Fact-Sheet.pdf).

Figure 2 shows the locations of watering targets in NSW.

Section **3 Involving the community in the EWMP** expands on one element of program delivery by examining environmental water advisory groups (EWAGs) specifically. EWAGs provide the primary mechanism for community involvement in environmental water management. The Institute for Governance and Policy Analysis at the University of Canberra was contracted to provide an independent evaluation of EWAGs to determine the extent to which they fulfil stakeholder and government expectations of local participation and to examine their effectiveness as vehicles for broader forms of democratic participation in water management.

Section **4 Findings and recommendations** delivers findings on the strengths and weaknesses of the EWMP and recommendations to improve it.

1 Program details and evaluation

1.1 Overview of the EWMP

The EWMP comprises two main elements: purchase of water entitlements and the delivery of allocated environmental water. A number of activities support these elements. Figure 3 shows the relationship between relevant activities undertaken within the EWMP, the controlling activities as specified in legislation and the intended outcomes from implementing the activities.

Program governance

Because of their novelty and broad stakeholder interest, the initial governance arrangements for all contributing programs involved important external input. NSW RiverBank operated under a 5-year business plan and annual implementation plans as approved by the NSW Environmental Trust on advice from a NSW RiverBank Sub-committee. The Sub-committee was chaired by the Chief Executive Officer of OEH and had, as members, independent experts in the fields of aquatic and wetland ecology, environmental water management and water market operations, and representatives of relevant government agencies.

The NSW Wetland Recovery Program and NSW Rivers Environment Restoration Program operated under Project Control Groups supported by subprogram steering committees comprising independent experts and relevant agency representatives.

Under the recent strategic realignment within OEH, governance of the EWMP has become an internal accountability. This shift reflects the changing emphasis from purchasing water entitlements to implementing a credible operational program for managing the purchased water. A new Environmental Water Governance team was established within the Regional Operations Group.

Accountability for environmental water-use decisions rest with the Director, South Branch, Regional Operations Group. A Management Manual modelled on the Incident Control System specifies roles and responsibilities for each activity within the EWMP and includes standardised procedures.

Program delivery

Water access licences are held by the Minister for the Environment and administered by the Chief Executive Officer of OEH on the Minister's behalf. The Regional Operations Group within OEH is responsible for administration of the licences, including the development of plans for their use, the meeting of all licensing and other legislative requirements, the payment of any statutory charges, and the trading of water allocations to meet a proportion of statutory charges.

Management of environmental water is delegated to five regionally based Senior Environmental Water Management Officers covering the Gwydir, Macquarie, Lachlan, Murrumbidgee and Murray – Lower Darling River systems. They work closely with managers of wetland reserves within the National Parks and Wildlife Service (NPWS). They are supported by Wetland Conservation Officers and take advice from EWAGs. EWAGs are chaired by a Local Land Services representative and include membership from among relevant stakeholder groups, other agencies and (in some cases) independent scientists.

EWAGs advise on annual watering priorities and day-to-day decisions during event deliveries. OEH provides administrative support to all EWAGs except for the Lachlan, which was supported by the then Catchment Management Authority (now Local Land Services). Section 1.2 covers the role and performance of EWAGs specifically.

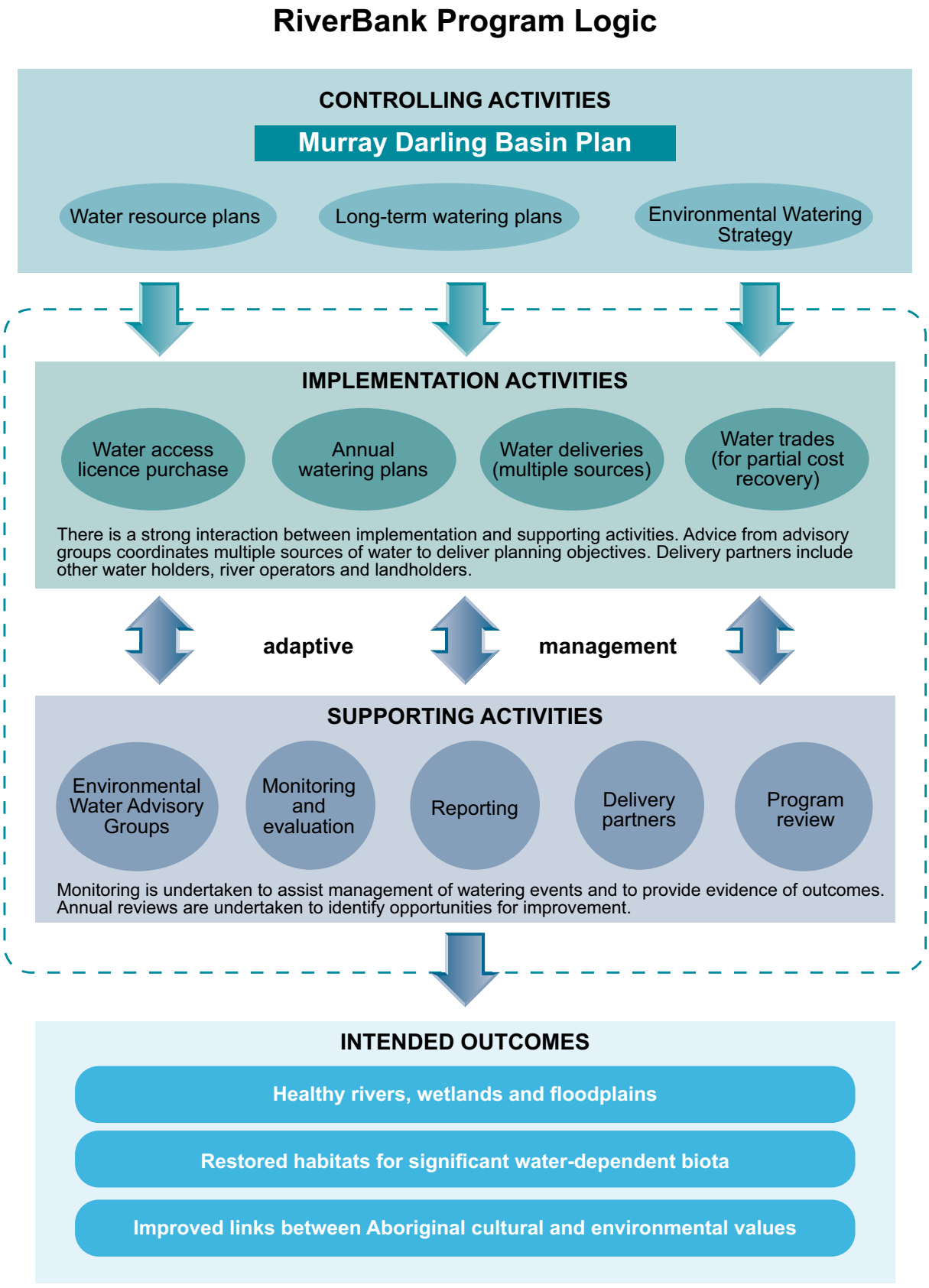


Figure 3: **Simplified program logic for the EWMP, highlighting main elements and relationship to other activities. The EWMP operated within the dashed box and helps to achieve the objectives of the Murray-Darling Basin Plan.**

Program monitoring

Monitoring provides the evidence to determine how well the objectives of EWMP are met. It is also important for informing event deliveries and improving future management actions. There are two types of program monitoring:

- Surveillance monitoring to inform event delivery is done by regional environmental water managers and NPWS staff. This monitoring tracks water deliveries to ensure compliance with water orders. It also observes initial ecological responses to inform any required changes to orders and guide more detailed, specific monitoring activities.
- Monitoring to determine progress toward objectives in most valleys is done by the Science Division of OEH and supported by Regional Operations and NPWS staff. Monitoring in the Murray – Lower Darling is done by NPWS Regional Operations and external contractors. Core monitoring activities assess inundation patterns, changes in the extent and condition of wetland vegetation communities and responses by various faunal groups to water deliveries.

Program review

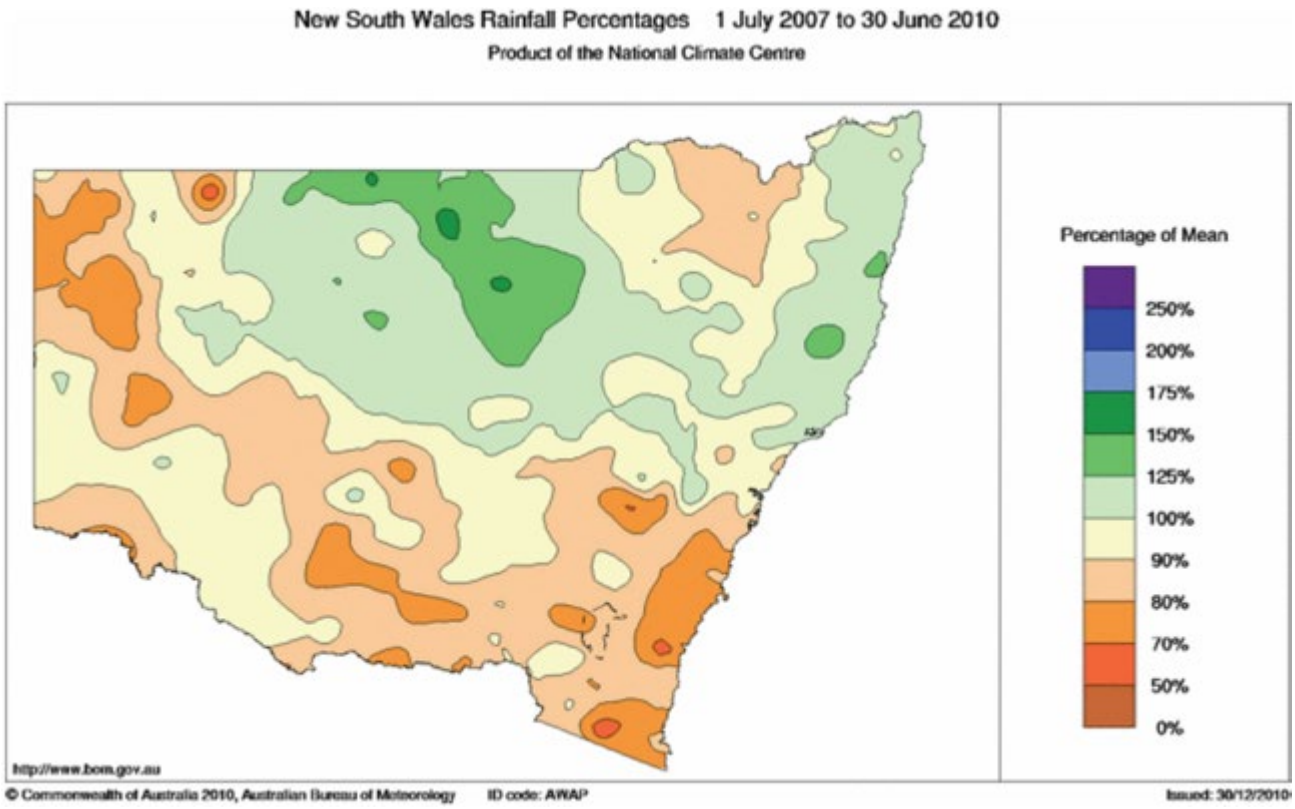
OEH reviews EWMP at two time scales. Annual workshops are held to review the previous year's watering activities and identify where improvements to planning and delivery are required. This report provides the first longer-term evaluation of EWMP to determine progress toward objectives and examine the roles of individual activities in contributing to any progress.

Under the Basin Plan, longer-term evaluations are required every 5 years, with the first due in 2019. Further evaluations of the EWMP will align with Basin Plan evaluations.

Delivery partners

Environmental water delivery requires collaboration between OEH and several partners, including private landholders and irrigation districts. The collaboration occurs primarily via participation in EWAGs and direct communication. Bilateral arrangements exist for key partnerships with State Water and the Commonwealth Environmental Water Holder.

OEH delivers water allocations available under licences held by the Commonwealth Environmental Water Holder as agreed for each event. The Commonwealth Environmental Water Holder can also deliver water independently. Partner agencies within the NSW Department of Primary Industries (NOW, Fisheries NSW) provide advice on annual watering priorities and during water deliveries. SWC is responsible for delivering ordered water on time, to the right place and at specified flow rates. SWC also accounts for the volumes of water used during each event.



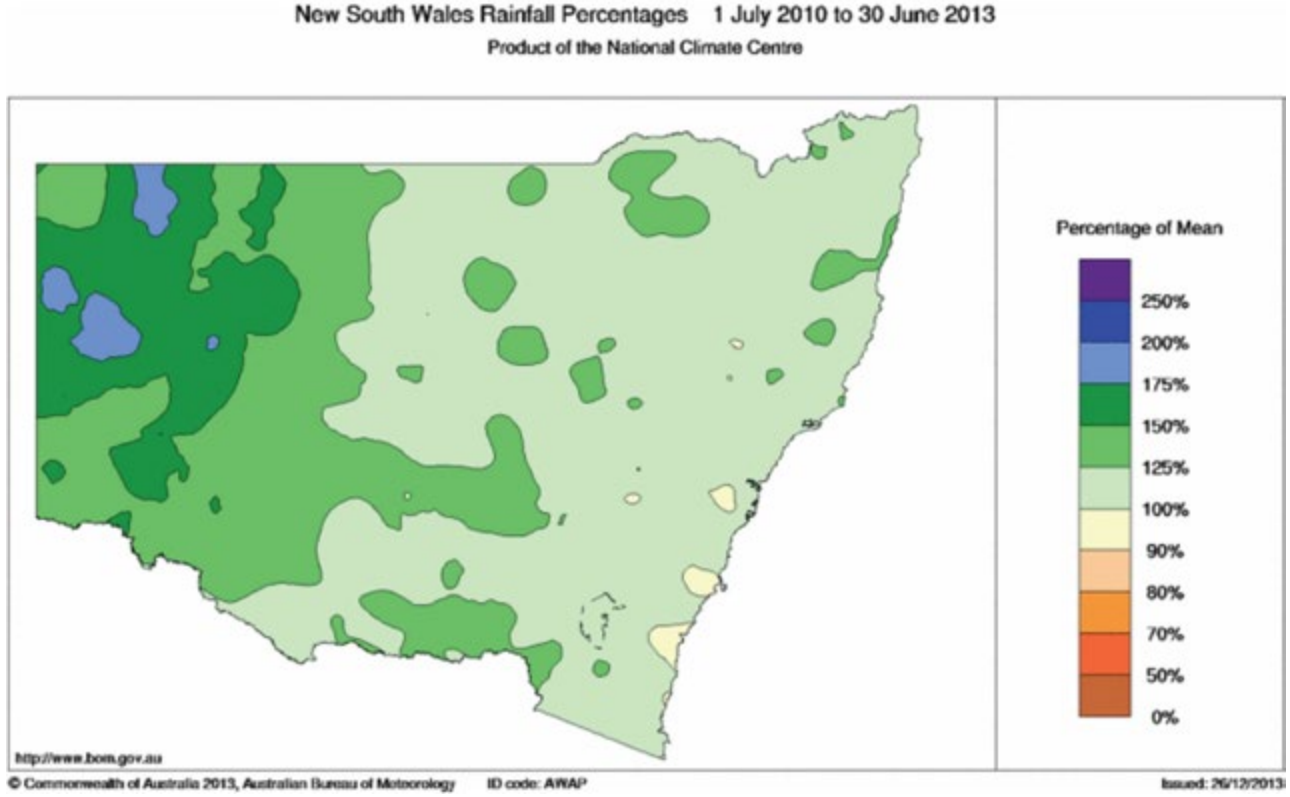


Figure 4: Rainfall (as a proportion of the mean) in NSW during two sequential 3-year periods corresponding to the beginning (top) of the EWMP and the end (bottom) of the Millennium drought (source http://www.bom.gov.au/climate/maps/)

Program evolution

The EWMP began during the Millennium drought, when there was little water available for the environment. Conditions changed substantially in 2010. Water licences received 100% allocations in the 2010–11 water year (see Figure 5). Figure 4 provides an overview of rainfall before and after the breaking of the Millennium drought.

The rapid shift from drought to flood conditions, with records set for both extremes in many catchments during this time, created significant challenges for the developing EWMP. The focus shifted quickly from delivering small volumes of water to critical wetland areas where possible to identifying possibilities and delivering water to an expanded portfolio of targets. Management planning also shifted from specific to multi-site and system-scale actions and incorporated in-stream ecological requirements.

1.2 The EWMP in detail

Water access licence purchase and trade

All water access licence purchases under NSW RiverBank and the Wetland Recovery and Rivers Environmental Restoration Program are complete. Figure 5 shows the annual and cumulative volumes of entitlement purchased. It also shows the volumes of water available under those licences and the water used. (Note that discrepancies between annual entitlements and volumes used are due to carryover provisions.)

Licence purchase was targeted to those regulated valleys of the Murray-Darling Basin with important wetlands under stress from lack of water. Licences were purchased from willing sellers via various market mechanisms.

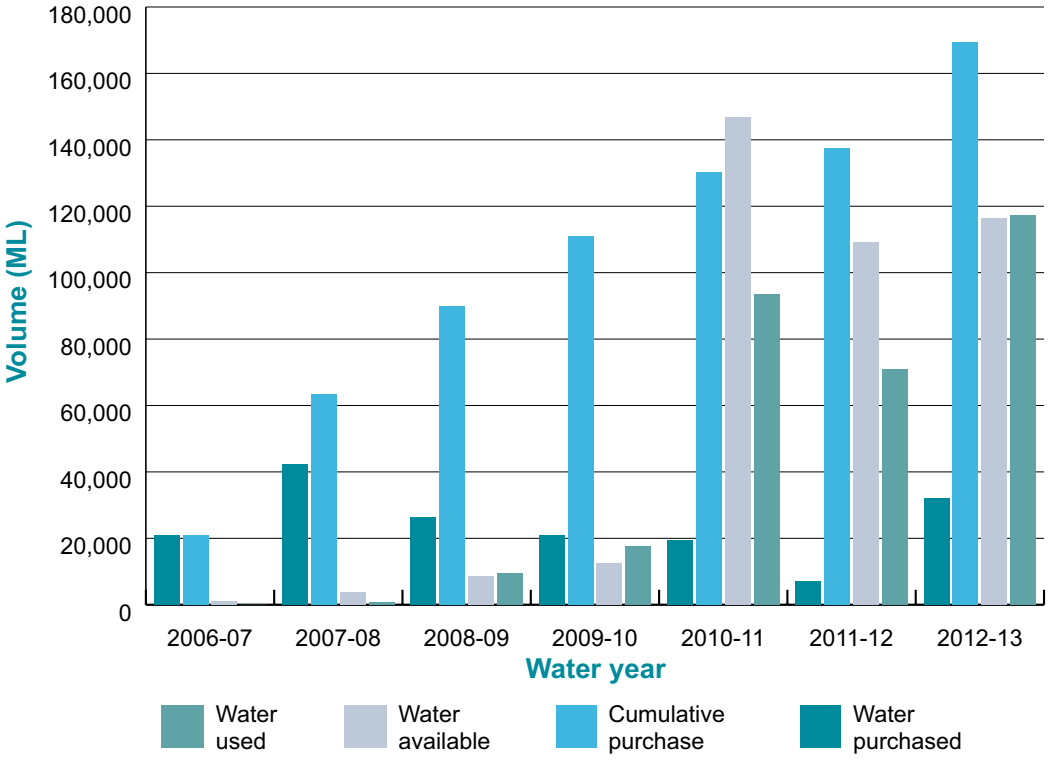


Figure 5: Annual and cumulative entitlement purchases, volumes of water available under entitlement and volumes of water used. Note that discrepancies between available and used volumes are due to carryover provisions. ML, megalitres.

Final reporting and financial auditing of each program occurred consistent with individual business plans and the governance arrangements. Further details on each program can be found at

- New South Wales RiverBank Business Plan (http://www.environment.nsw.gov.au/resources/environmentalwater/100781-riverbank-a.pdf)
- NSW Wetland Recovery Program Final Report (http://www.environment.gov.au/system/files/pages/ca085191-0b83-423b-8aeb-420547e706eb/files/nsw-wetland-recovery-program-final-report.pdf)
- NSW Rivers Environmental Restoration Program (http://www.environment.gov.au/system/files/pages/4cfd9575-598c-4a54-bfc8-d5ee30f62233/files/nsw-rivers-environmental-restoration-program.pdf).

Initial licence purchase targets were adjusted between valleys and over time in response to market conditions and fund availability. Most purchases occurred in the first 3 years (2006–07 to 2008–09), with the bulk of these in the Gwydir and Lachlan valleys. Purchases extended over 4 years in the Macquarie valley. Purchases in the Murrumbidgee occurred over all 5 years and were adjusted to take account of other purchase programs in order to minimise market distortions.

OEH trades a proportion of available water each year to pay SWC and NOW fees arising from holding and using access licences. Trading is done consistent with an approved trading strategy. Criteria for determining which water to trade include the environmental requirements of water-dependent assets in each valley, the expected water use to meet those requirements and the likely prices on offer. Table 1 summarises trading activities and Table 2 summarises the evaluation of water purchase and trading activities under the EWMP.

Table 1: Number of annual trades, volumes (megalitres) traded and revenue raised under the EWMP

	2009–2010	2010–2011	2011–2012	2012–2013
Volume traded (megalitres)	4,502	500	12,600	25,880
Number of trades	6	1	12	47
Revenue raised ($)	–349,320*	126,670	514,004	862,232

* In 2009–10, annual allocation water was purchased for environmental use. The negative number means that more was spent purchasing than was received from selling allocation water.

Table 2: Evaluation of water purchase and trade under the EWMP

Program component: Water purchase and trade	Evaluation assessment		
	Appropriateness	Effectiveness	Efficiency
Water licence purchase	**green**	**green**	**green**
Comment			
Water licence purchases are complete. They were undertaken consistent with approved business plans and audited annually. Target volumes were purchased on time and within budget.			
Allocation trade	**green**	**green**	**green**
Comment			
Revenue targets set in annual trading strategies have been met, without compromising environmental outcomes.			

Planning for water use

Planning by OEH for the management of environmental water occurs at three time scales, namely long term, annual (July–June) and during a watering event; and at two spatial scales, namely water source (river valley) and environmental asset (individual wetland, river reach).

Long-term watering plans are required by the Murray-Darling Basin Plan. The matters to be addressed are specified in the Basin Plan. Long-term plans identify for each catchment its ecological assets and functions, water requirements, the risks and constraints in providing the water, and cooperative arrangements between the states to ensure that the Basin is managed as a whole. These plans are required to be consistent with the Basin-wide environmental water strategy (http://www.mdba.gov.au/sites/default/files/pubs/Final-BWS-Nov14.pdf) being prepared by the Murray-Darling Basin Authority. They will incorporate relevant site-based plans where available (e.g. environmental water management plans being developed by NPWS for wetland reserves).

There are no approved long-term plans currently in place. Under an intergovernmental agreement signed on 27 February 2014 between the Commonwealth and NSW on implementation of the Basin Plan, OEH will prepare long-term plans according to an agreed timetable. The need for long-term watering plans remains appropriate but cannot be evaluated for effectiveness or efficiency.

Annual environmental watering plans consider a range of possible options for the next water year. They take account of asset condition, watering histories, water availability and likely climate scenarios to prioritise watering actions. They are prepared at the valley scale by Senior Environmental Water Management Officers incorporating advice from EWAGs. When approved by the relevant Director, they are posted on the OEH website under 'Basin Plan implementation'. (See http://www.environment.nsw.gov.au/environmentalwater/basin-plan-implement.htm.) Annual plans have been prepared since 2008–09 for the Gwydir, Macquarie–Cudgegong, Lachlan, Murrumbidgee and Murray – Lower Darling Valleys. They specify objectives of watering for particular assets, the volumes of water required to meet the objectives and the means by which evidence is obtained (monitoring) to determine whether the objectives are met.

Annual plans have expanded in scope over time. In 2008–09 they averaged 5.5 pages, peaking at 21.4 pages in 2012–13. This expansion resulted from the need to provide greater contextual information, the increase in possible watering options as water availability and knowledge improved, and the cataloguing of previous years' activities. When long-term plans and an effective outcomes reporting process are in place, the annual planning effort should focus on annual watering priorities only, thereby gaining some efficiencies.

The weaknesses of annual plans have been the level at which watering objectives are set and their limited ability to anticipate rapid change in climatic conditions. Objectives tend to be general in scope, limiting the ability to determine a direct connection between watering actions and the resulting ecological outcomes. The reasons for success may therefore be ambiguous.

Specific, measurable, achievable, relevant and time-bound (SMART) targets for ecological outcomes are advocated but not always applied. Many factors potentially influence the observed outcomes, and our understanding of how each of these factors interacts is often limited. Such shortcomings are now better defined, and the next generation of plans is expected to improve the connections between planning and outcomes.

Event plans (known as Form A) seek to implement watering activities identified specifically in annual plans and usually respond to natural triggers from rainfall. Occasionally environmental conditions can change unexpectedly and provide novel opportunities.

Form As specify watering objectives, timing, volumes required, the source(s) of the water, delivery arrangements, monitoring activities and potential risks of watering, including any likelihood of third-party impacts. They provide the primary point of accountability for environmental water delivery. Table 3 summarises the evaluation of planning under the EWMP.

Table 3: Evaluation of planning under the EWMP

Program component: Planning	Evaluation assessment		
	Appropriateness	Effectiveness	Efficiency
Long-term environmental watering plans (LTEWPs)	green	N/A	N/A
Comment			
To be prepared under arrangements agreed between Commonwealth and NSW; the need for them remains but their scope is not yet resolved. Informal long-term planning approaches are applied in most valleys. (See the Lachland Environmental Water Management Plan at http://www.lrwg.com.au/ as an example.)			
Annual environmental watering plans	green	amber	amber
Comment			
Format in transition. Efficiencies will be gained from aligning with the Basin priority-setting process. Effectiveness will improve when the Basin Watering Strategy and LTEWPs are complete.			
Event delivery plans (Form A)	green	green	amber
Comment			
The original format of Form As has undergone minor modifications to improve links between objectives, monitoring and reporting. There are efficiencies to be gained from using online procedures.			

Water delivery

Delivering water to the environment is the primary purpose of the EWMP. OEH places the water orders with State Water, which is then responsible for delivery. The important relationship between OEH and State Water is managed formally via a memorandum of understanding and by quarterly meetings of a Senior Liaison Group. Effective relationships between organisations exist informally in each valley and strongly influence the success of each delivery.

There are currently 207 sites identified for watering in the Gwydir (20), Macquarie (23), Lachlan (32), Murrumbidgee (84) and Murray – Lower Darling Valleys (48). In 2007–08 there were 21 sites. Sites vary in size and complexity. The tenfold increase in watering sites is due to increases in water availability; an improved understanding of water-delivery options to individual sections of large wetlands and to additional wetlands; and the establishment of better links with wetland managers (private landholders and managers of wetland reserves).

Under low-water-availability scenarios, it is likely that not all identified sites can be provided with an appropriate watering regime. A major challenge for Long-term Watering Plans is to develop a prioritisation approach to match asset water requirements to likely water availability under a range of climate scenarios.

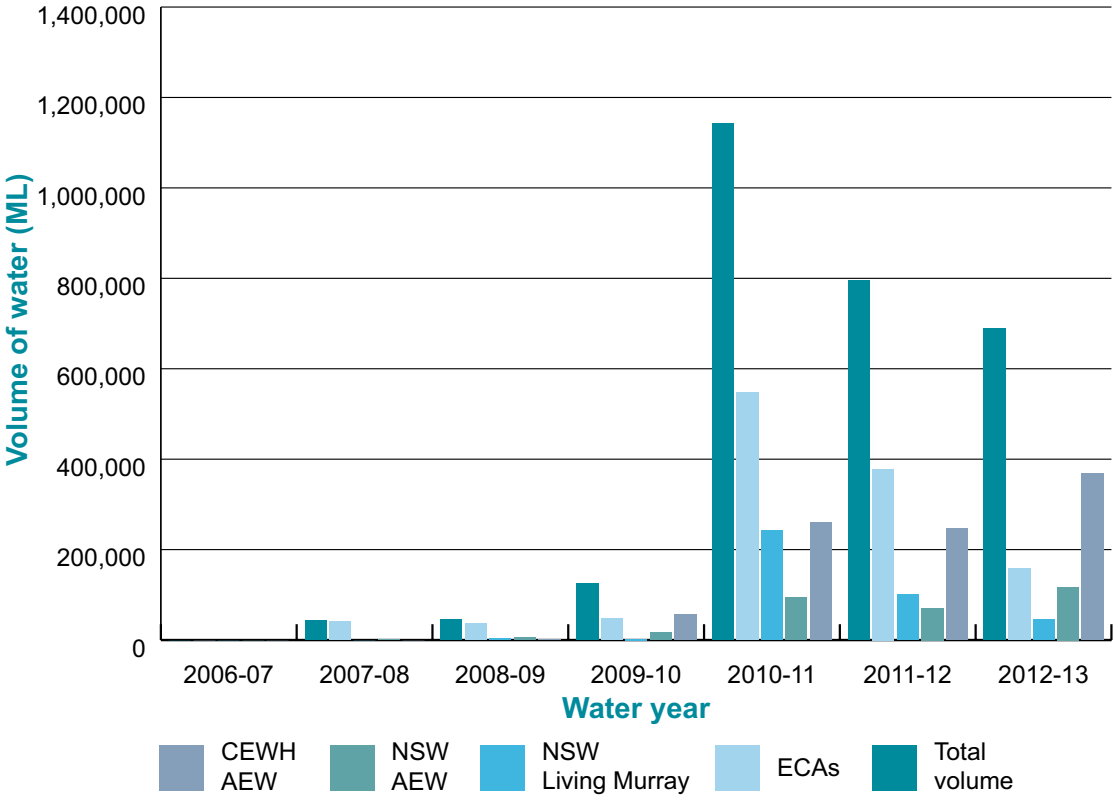


Figure 6: Annual volumes of water delivered to NSW targets from environmental contingency allowances (ECAs), the Living Murray Program, licences purchased by the NSW Government (NSW allocated environmental water, AEW) and licences purchased by the Commonwealth Government (CEWH [Commonwealth Environmental Water Holder] AEW)

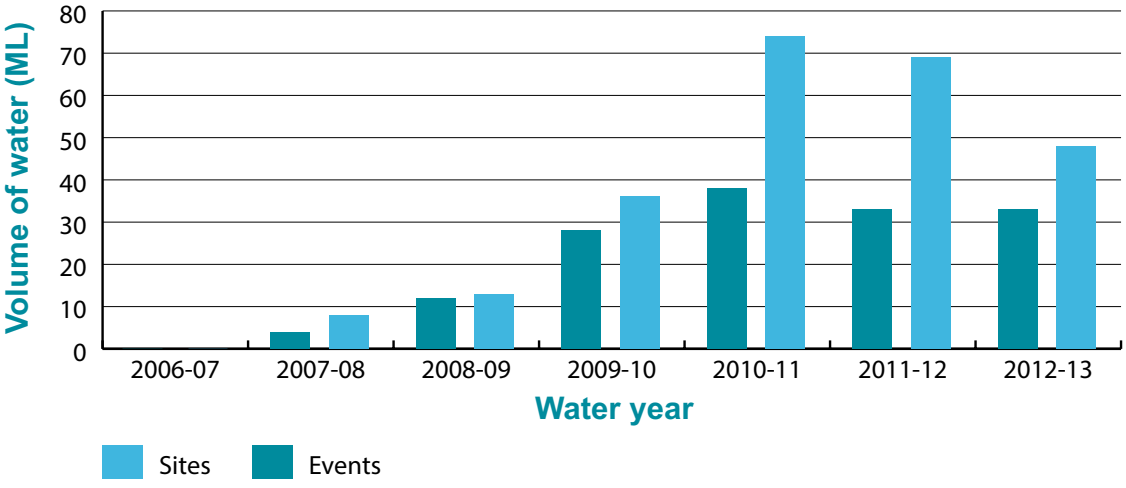


Figure 7: Numbers of events delivered and numbers of sites watered each year in NSW, 2006 to 2013

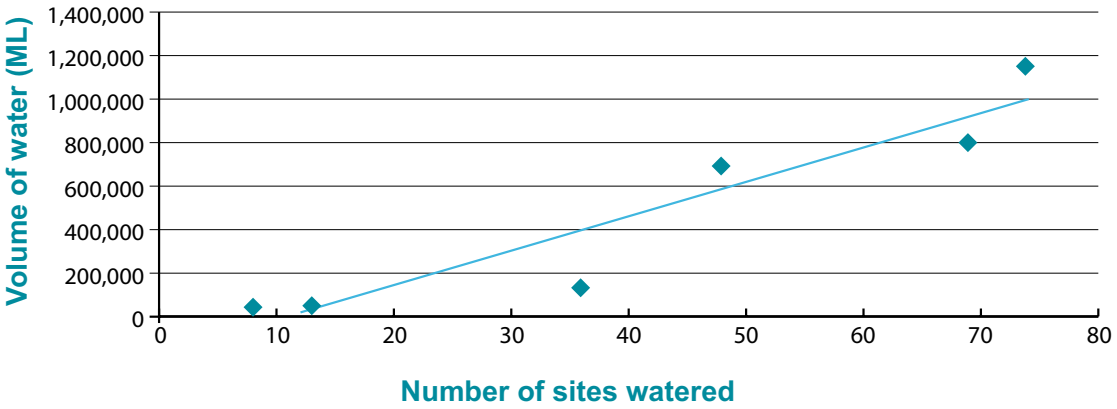


Figure 8: Relationship between total volume delivered and number of sites watered. r^2 is a statistical measure showing how closely the data fit to the regression line. The closer r^2 is to 1 the stronger the relationship is between the two variables. As r^2 is relatively high and close to 1 (0.882) this indicates that as the total volume of water delivered increases so too does the number of sites watered.

Figure 6 shows the total volumes of allocated environmental water delivered by source, and Figure 7 shows the number of events and the number of sites watered each year. Allocations under licences held by the Commonwealth Environmental Water Holder and those under The Living Murray (http://www.mdba.gov.au/sites/default/files/pubs/TLM-2009-Overview-Fact-Sheet.pdf) are also included for comparison.

The environment also received water available under various rules (e.g. sharing of inflows to major storages; providing end-of system flow rates; flood mitigation) in water-sharing plans. This component of planned environmental water was the major source of environmental water in most years, contributing over 50% of total environmental flows. (See Figure 9 for an example of the relative contributions of allocated and other planned environmental water to the Macquarie Marshes since the water-sharing plan started.)

The contribution by water available under licences held by the Minister for the Environment to the total volume of allocated environmental water (held under licence or in allowances) delivered annually averaged 10% (range 2% to 17%); the contribution to the total environmental water (all water not otherwise extracted for consumptive use) was less than 5% (0% to 9%). Water available under environmental contingency allowances in water-sharing plans contributed on average 56% (23% to 98%) to allocated volumes and 21% to total environmental water (9% to 56%).

The first delivery (675 megalitres) of environmental water under licence in the EWMP was to the Macquarie Marshes in 2008–09. (Note that the first delivery of environmental water held under licence occurred in the Murray during 2000. These licences were managed by the Murray Wetlands Working Group at the time. They are now part of the EWMP.) Eight sites were watered in 2008–09 by four watering events totalling 42,440 megalitres. In 2012–13, NSW-held water (117,280 megalitres) and 571,859 megalitres from other sources was delivered to 48 sites in 33 separate events. The relationship between volumes of water delivered and number of sites watered is shown in Figure 8. In general, the more water available, the more sites watered.

When a watering event is complete, a Form B (Event reconciliation report) is submitted to the Environmental Water Registrar of OEH with details on volumes used, area watered, observed ecological responses, risk mitigation measures and any unexpected outcomes. Submitting Form Bs on time (within 4 weeks of event completion) is an important step for reconciling intent and outcomes; in some cases it depends on delivery partners to confirm water-use volumes. Improvements in administrative procedures are required to make sure that this step is completed on time. Table 4 summarises the evaluation of delivery under the EWMP.

Table 4: Evaluation of delivery under the EWMP

Program component: Delivery	Evaluation assessment		
	Appropriateness	Effectiveness	Efficiency
Water ordering	**green**	**amber**	**amber**
Comment Established procedures not consistently followed. Formal process not established for planned allowance water. High dependence on OEH's Environmental Water Registrar being available for timely ordering. Potential efficiency gains possible from using online procedures and broader delegation for access to licence database and water ordering.			
Delivery of ordered water	**green**	**amber**	**amber**
Comment Preparations for ordering water and delivery of ordered water are generally done well. Occasional conflict when there is competition from other water orders for channel capacity. Relationships between OEH and State Water are critical.			
Meeting asset watering needs	**green**	**amber**	**amber**
Comment The ability to meet the long-term watering requirements of all target assets is yet to be tested under low and median water availability scenarios.			
Delivery infrastructure	**green**	**amber**	**amber**
Comment Options for flow management and distribution are constrained by existing infrastructure. A strategic approach to identifying infrastructure needs started under the NSW Rivers Environment Restoration Program. Major works were constructed in Yanga National Park and in Macquarie Marshes Nature Reserve. Will be further addressed by the Murray-Darling Basin Constraints Management Strategy and long-term watering plans.			
Event reconciliation (Form B)	**green**	**amber**	**amber**
Comment Timing and completeness of Form Bs vary. Dependence on State Water to finalise delivery volumes (water accounting) can delay Form Bs. Environmental outcomes are restricted to anecdotal or observational information because of time pressures.			

Monitoring

Monitoring provides information to justify and improve the delivery of environmental water. It has three main purposes:

- to provide real-time information on the delivery of environmental water during an event
- to provide information on the delivery of environmental water and the ecological responses to that delivery for the previous water year
- to improve management and refine objectives for each ecological asset.

Existing monitoring does not cover all watering targets, and specific regional needs are not always addressed. As a result of both the NSW Wetland Recovery Program and the NSW Rivers Environment Restoration Program, the Gwydir wetlands, Macquarie Marshes and Lowbidgee wetlands have had the greatest monitoring investment.

The current monitoring effort relies significantly on collaboration between individuals across various OEH work groups and is an example of deriving efficiencies through a shared purpose. No one group could span the range of activities required to link management, monitoring and communication. It is important to note the underlying commitment by those individuals to the achievements of the EWMP.

Table 5 summarises the evaluation of monitoring under the EWMP, and Table 6 summarises the range and location of monitoring activities relevant to the EWMP and undertaken by, or on behalf of, OEH. Related activities are those that provide foundational information in order to measure progress against a reference point (or benchmark), as well as those that incorporate the outputs from individual activities for use in planning and evaluation elements of the EWMP (models, decision-support tools).

Regional staff perform surveillance monitoring during water deliveries to ensure compliance (i.e. to make sure that the water delivered matches the water ordered in terms of destination, volume and rate). In this way, adjustments can be made, ecological responses that may trigger changes to intended deliveries can be observed, and other staff can be alerted to specific monitoring needs.

Core monitoring activities are mostly coordinated by the Science Division (Water and Wetlands Team) of OEH and undertaken collaboratively with Regional Operations and NPWS. This monitoring function is identified in the Water and Wetlands Knowledge Strategy 2013–17 (http://www.environment.nsw.gov.au/knowledgestrategy/Wetlands.htm), which supports the delivery of OEH's management responsibilities for aquatic ecosystems.

The following core activities undertaken by OEH were selected to provide long-term, cost-effective evidence of the impacts of management actions on the condition of water delivery targets:

- **Inundation mapping.** As allocated environmental water is the resource being managed, inundation mapping is critical for defining the patterns of water delivery (area covered, duration and timing).
- **Wetland vegetation community condition and extent mapping.** This mapping assesses the response by these communities to the patterns of water delivery.
- **Fauna response monitoring.** This monitoring targets specific taxa of conservation significance to provide further evidence of the impacts on flow-dependent biodiversity.
- Evaluation and synthesis of the information derived from the above activities improve our collective understanding of the links between management actions and ecological outcomes. This synthesis is often displayed as a model and encourages both further testing of identified interactions between management actions and ecological responses and extrapolation of the findings to other comparable sites.

The use of models within the EWMP is currently limited. Predictive models have great potential to drive constant improvement in many aspects of the EWMP. Co-development of relevant models by managers and technical experts, improved by incorporating evidence from monitoring outputs, would benefit the EWMP in the medium to longer term.

Regional staff and EWAGs require access to monitoring results in real time to ensure that watering targets are being met and to communicate intent and achievements to the broader community. The longer-term support of the community for the EWMP will be strengthened through this communication. Considerable improvements in communication between scientists, managers and community groups have occurred during the EWMP.

In the medium to longer term, there are considerable opportunities to improve the effectiveness and efficiency of monitoring activities through an integrated approach among collaborating NSW and Commonwealth partners with a shared interest in environmental water management.

Section 2 Has the EWMP made a difference? provides examples of the outputs from monitoring activities and their use in answering key evaluation questions. Further detail is provided in separate technical reports.

Table 5: Evaluation of monitoring under the EWMP

Program component: Monitoring	Evaluation assessment		
	Appropriateness	Effectiveness	Efficiency
Inundation mapping	green	green	amber
Comment			
Critical activity that helps managers with operational water delivery, provides a measure of water delivery success and a surrogate of ecological responses to water delivery. Outputs refined over time. Timing of map availability is sometimes an issue. Inundation frequency combined with vegetation community extent and condition allow the setting of realistic ecological targets for the desired wetland condition.			
Vegetation community extent and condition assessment	green	green	amber
Comment			
Changes in extent mapped from high-resolution imagery obtained every 5 to 7 years. Condition assessed by annual ground survey. Combination is essential to interpret short (event) and long-term (regime) responses. Potential to use other remote-sensing platforms to extend coverage. Efficiency gains are possible if a long-term program is funded to repeat high-resolution imagery capture. Currently the long-term program is under consideration and depends on other activities.			
Fauna response assessment	green	amber	amber
Comment			
Main focus by OEH is on waterbirds (diversity, abundance and breeding) and frogs (diversity and abundance; threatened southern bell-frog population status), with additional information on fish and turtles in some locations. Fish monitoring is generally done by others. Colonial waterbird breeding and bell-frog status are directly linked to water management. Other faunal indicators reflect community values but are not readily linked to water deliveries. Scope to review both effectiveness and efficiency.			
Process and predictive modelling	green	amber	amber
Comment			
Predictive models are likely to become major tools for improving many elements of environmental water monitoring; a strategy is required to realise the potential by ensuring that models are relevant to management.			
Surveillance activities	green	amber	amber
Comment			
Support event management and other formal monitoring activities (see above); critical to provide reassurance when risks are anticipated. Potential to better target surveillance activities and utilise local networks and citizen science more effectively.			
Communicating the results of monitoring	green	amber	amber
Comment			
Rigorous analysis of information collected from formal monitoring programs can delay reporting and disconnect results from the actual watering event. More effective and efficient communication of watering achievements to EWAGs and the local and broader communities is required, as is a formal mechanism for managers to learn adaptively. Relationships between managers and scientists continue to improve.			
Addressing knowledge gaps	green	amber	amber
Comment			
The Water and Wetlands Knowledge Strategy is informed by the needs of the EWMP. The process of maintaining the management focus of the strategy is still evolving. Funding for some critical foundational activities is not available.			

Table 6: Summary of monitoring-related activities undertaken by or on behalf* of OEH since 2006

Theme	Activity	Wetlands to which the activity applies						
		Gwydir wetlands	Macquarie Marshes	Lower Lachlan	Lowbidgee wetlands	Mid-M/ bidgee wetlands	Murray wetlands (non TLM)	Lower Darling wetlands
Define wetland boundaries	Determine functional water management areas in large wetland complexes based on hydrological and ecological criteria	Part	Yes	Yes	Part	Part	Part	No
Inundation mapping from Landsat imagery (floodplain wetlands)	Use inundation frequency index from Landsat archive to establish inundation regime	Yes	Yes	Part	Yes	No	No	No
	Determine total cumulative inundation extent per event	Yes	Yes	Yes	Yes	No	No	No
	Collect low-level oblique photos to assess accuracy from Landsat	Part	Part	No	Part	No	No	No
	Provide real-time imagery to inform environmental water delivery	Yes	Yes	Yes	Yes	Part	No	No
Area inundated (small wetlands)	Visual assessment	Part	Part	Part	Part	Yes	Yes	Yes
Wetland vegetation community response monitoring	Establish reference extent of vegetation communities (regime basis)	Yes	Yes	Part	Yes	Yes	No	No
	Establish reference condition of vegetation communities (regime basis)	Yes	Yes	Part	Yes	Yes	No	No
	Assess changes in extent of vegetation communities (regime basis)	Yes	Yes	Part	Yes	No	No	No
	Assess changes in condition of vegetation communities (regime and event basis)	Yes	Yes	Part	Yes	No	No	No
	Assess response by wetland vegetation to delivered flows (event basis)	Yes	Yes	Part	Part	Yes	No	No
	Establish photopoints	Yes	Yes	Part	Yes	Yes	Yes	Yes
	Install time-lapse cameras	Yes	Yes	Yes	Yes	Yes	Yes	No
	Assess seed-bank viability in disconnected wetlands	Part	Part	Part	No	No	Part	No

Theme	Activity	Wetlands to which the activity applies						
		Gwydir wetlands	Macquarie Marshes	Lower Lachlan	Lowbidgee wetlands	Mid-M/ bidgee wetlands	Murray wetlands (non TLM)	Lower Darling wetlands
Wetland fauna response monitoring	Assess location, size and relative success of colonial waterbird breeding	Yes	Yes	Yes	Yes	Yes	Part	No
	Assess waterbird population diversity and abundance (wetland specific)	Yes	Yes	Part	Yes	Yes	Part	Part
	Assess waterbird population diversity and abundance (regional – annual air survey) (OEH / UNSW)	Part	Yes	Part	Yes	Yes	Part	Yes
	Assess population status of southern bell-frog (OEH / CSU)	N/A	N/A	Part	Yes	Yes	Yes	No
	Assess diversity and abundance of frog populations (OEH / CSU/ UNSW)	Part	Yes	Yes	Yes	Yes	Yes	Part
	Assess diversity and abundance of native fish in wetlands (OEH/CSU/UNE/UNSW/MDFRC/ARI/ DPI Fisheries)	Part	Part	Part	Yes	Yes	Yes	Part
	Assess diversity and abundance of native fish in connecting river channels (UNE/DPI Fisheries/OEH/UNSW/MDFRC/ARI))	Part	Part	Part	Part	Part	Part	Yes
Understanding wetland functioning	Understand nutrient dynamics; release of carbon, phosphorus and nitrogen from sediments	Part	Part	Part	Part	Part	No	No
	Understand food webs: nutrient pathways	Part	Part	No	Part	Part	No	No
	Determine micro-invertebrate population diversity and abundance	Part	Part	Part	Part	Part	No	No
	Understand algal population diversity and abundance	No	No	No	Part	No	No	No
Adaptive management	Improve hydrodynamic and hydrologic models	Part	Part	No	Part	No	No	No
	Improve ecosystem response models	Part	Part	No	Part	No	No	No
	Develop integrated decision-support systems (first generation)	Yes	Yes	No	Yes	No	No	No
	Perform annual review of environmental water management	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The current portfolio of activities reflects existing and expected levels of funding and capacity. Core activities started in Gwydir wetlands, Macquarie Marshes and the Lowbidgee wetlands during 2007 with funding provided under Wetlands Recovery and Rivers Environmental Restoration programs (jointly funded by the NSW and Commonwealth Governments).

* Contributing partners are specified where appropriate. They are the University of NSW (UNSW), Charles Sturt University (CSU), the University of New England (UNE), the Murray-Darling Freshwater Research Centre (MDFRC), Arthur Rylah Institute for Environmental Research (ARI) and NSW Department of Primary Industries (DPI).

Yes – indicates existing commitment and ongoing intent; No – indicates no existing effort or ability to undertake with existing funds; Part – indicates either one-off collection or a limited number of sites, as determined by opportunistic funding availability.

TLM, The Living Murray

Reporting

An annual outcomes report provides the primary means of publicly communicating watering actions and consequent environmental responses within NSW. The first report was published in 2010 (reporting on activities during the 2009–10 year). The format remains largely consistent. There was little watering activity before 2009. Because of the significance of each watering activity during the last years of the Millennium drought, information was made available on these by individual media release.

Informal newsletters produced twice yearly provide additional information. These started in 2008 but have not been produced since December 2012. More recently, information on individual watering events has been placed on the OEH website in near real time, and this form of reporting has replaced the newsletter.

However, the OEH website is not structured to effectively support the EWMP. It does host primary planning and reporting documents, and it positively highlights particular activities. It does not yet provide an accessible archive of watering aims, deliveries and outcomes for individual sites.

Reports, newsletters and information on individual water deliveries are available at http://www.environment.nsw.gov.au/environmentalwater/news-regions.htm.

Some managers prepare valley-specific annual reports to their advisory groups and associated stakeholders. These reports provide greater contextual information than does the annual outcomes report; they also allow some reflection on choices made and any challenges encountered and serve as a general repository for insights and lessons learnt. These reports therefore have the potential to be an important part of adaptive management. However, they are time consuming to prepare and are not routinely prepared in all valleys.

Additional reporting informs corporate performance indicators and meets statutory and other program responsibilities.

There are substantial efficiencies to be gained by selecting common reporting metrics and aligning the timing of reporting needs across programs and purposes. Implementation of NSW's obligations under the Basin Plan is likely to identify these opportunities. Table 7 summarises the evaluation of reporting under the EWMP.

Table 7. Evaluation of reporting under the EWMP

Program component: Reporting	Evaluation assessment		
	Appropriateness	Effectiveness	Efficiency
Annual outcomes report (NSW)	**green**	**amber**	**amber**
Comment The scope and timing are appropriate. Potential to update format to connect with previous years' outcomes.			
Annual report (valley)	**amber**	**green**	**red**
Comment Optional and therefore inconsistently completed owing to resourcing constraints. Those produced are valued by stakeholder groups. Potential to provide evidence of adaptive management. Consider including in mandatory reporting requirements subject to resourcing and meeting stakeholder needs.			
Real-time event reporting	**green**	**amber**	**amber**
Comment Important for stakeholder engagement. Format and frequency yet to be settled. Better use of the OEH website or the creation of a stand-alone single website dedicated to environmental water management in NSW should be considered. Potential to link with long-term watering plans.			
Corporate reporting	**amber**	**amber**	**amber**
Comment Some redundancy and lack of clear purpose of existing reporting. Would benefit from a review to ensure that reporting adds value to the EWMP and that efficiencies are identified.			

Evaluation

An annual workshop is held in autumn to review each year's watering actions and to identify aspects of the EWMP where improvements are desirable. The basic format is a day of presentations from each valley on the planning for, delivery, and responses to watering events, as well as a day spent clarifying and identifying possible solutions to the issues arising. Initial participants were relevant OEH staff only. In later years, staff from partner NSW and Commonwealth agencies and members of EWAGs have participated.

Issues arising are referred for resolution to the recently established Environmental Water and Floodplains Working Group of OEH. Before the formation of this group, this function was performed by three working groups (Operations, Information and Policy). The issue identification and resolution process underpins adaptive management principles.

Adaptive management is also the driver for valley-specific workshops between scientists and managers. The accountability for these workshops is with Science Division of OEH through the Water and Wetlands Knowledge Strategy 2013–17 (http://www.environment.nsw.gov.au/knowledgestrategy/Wetlands.htm). The workshops allow scientists to present the latest research and monitoring information and managers to promote knowledge gaps. The direct interactions between participants are expected to improve the management relevance of scientific investigations and to ensure that the best available information is incorporated into management planning and actions.

An additional activity to support adaptive management involves capturing the experience of water managers in a way that improves learning among existing managers and between existing and future managers. This knowledge transfer currently relies on the annual workshop and other random opportunities. It would benefit from a structured process.

This document provides the first longer-term evaluation of the EWMP. Under the Basin Plan, evaluations will occur both annually and 5-yearly. OEH will align future evaluations with those by the Murray-Darling Basin Authority. Table 8 summarises the assessment of the evaluation process under the EWMP.

Table 8: Assessment of the evaluation process under the EWMP

Program component: Evaluation	Evaluation assessment		
	Appropriateness	Effectiveness	Efficiency
Annual evaluation	**green**	**amber**	**amber**
Comment			
Format of annual workshops needs further attention to improve effectiveness and efficiency. Existing tension between promoting achievements and identifying weaknesses could be resolved by holding separate events with specific participants.			
Long-term evaluation	**green**	**N/A**	**N/A**
Comment			
Evaluation of most environmental outcomes is possible only after several years of management intervention, as acknowledged by the Basin Plan. Detailed evaluation against ecological objectives will occur every 5 years. The first is scheduled for 2019. OEH needs to anticipate resourcing requirements for its contributions to each 5-year evaluation.			
Adaptive management	**green**	**amber**	**amber**
Comment			
Adaptive management principles drive continual improvement. Effective and efficient formats to embed adaptive management in EWMP are not yet settled. Direct interactions between planners, managers and scientists involved in EWMP implementation must be actively coordinated. Regular valley workshops are likely to play an important role.			

2 Has the environmental water management program made a difference?

2.1 Context

The environmental water management program (EWMP) aims to make a significant contribution to the rehabilitation and protection of stressed rivers and iconic wetlands in NSW. This section provides evidence to establish the extent of the contribution.

There are some challenges. Not all watered sites, watering events or environmental features can be monitored with the resources available. Nor is it simple to separate cause-and-effect relationships between the various sources of water. When only allocated environmental water is delivered to meet watering objectives, the observed ecological responses are readily linked to that water source. Under limited circumstances, such conditions apply. However, most watering events involve a combination of sources, making it difficult to link observed responses with individual sources. Over time, most public interest is expected to focus on changes in ecological condition in response to the management of all sources of environmental water, rather than individual contributions.

Monitoring activities undertaken by OEH have historically favoured the large wetland complexes fed by the Gwydir, Macquarie and Murrumbidgee Rivers. The Gwydir wetlands and Macquarie Marshes contain private property listed under the Ramsar Convention. Landholder concerns about declining wetland condition prompted the NSW Government to implement the NSW Wetland Recovery Program, targeting these wetlands specifically. With the purchase of Yanga National Park and the importance of water management in maintaining its ecological values, monitoring extended to the Lowbidgee Wetland complex under the Rivers Environmental Restoration Program.

Monitoring effort on wetlands fed by the Lachlan, Murray and Lower Darling Rivers was less extensive and focused on specific wetlands and values, or took advantage of opportunities to better understand the contribution of water management in meeting program objectives.

This section sets out the evaluation questions, explains the indicators used and provides limited examples of the monitoring outputs to answer evaluation questions. OEH scientists are producing technical reports to provide greater detail on inundation mapping, ecological responses and their integration. These focus on the Gwydir wetlands, Macquarie Marshes and Lowbidgee wetlands. Where information is derived from external consultancies, sources are acknowledged.

2.2 Key evaluation questions

Program objectives for environmental water management

Current best practice encourages evaluation questions to be defined at the start of a program. Such questions require us to be clear on what we want to know before we start. A monitoring program is then developed to provide the answers. The answers allow us to judge the extent to which the EWMP has made a difference in general, as well as the progress toward meeting specific objectives. Various indicators are examined to provide the answers.

Long-term monitoring programs (more than 10 years) are rare. The reality is that establishing reference conditions against which any changes due to water management can be assessed at a representative number of sites, for several identified ecological parameters and under various climatic scenarios, is complex, time consuming and costly. Furthermore, a monitoring program to collect the information to detect impacts may need to run for decades, depending on the parameters of interest. Such conditions are rarely met.

Table 9 states, for the purposes of this evaluation, the questions, their links to the intended outcomes (objectives) of the EWMP, and the indicators used to provide answers. Because these questions were not articulated at the start of the EWMP, some links are weak. Table 6 needs to be updated to inform the next longer-term evaluation of the EWMP, drawing on the experience and accumulated knowledge since the EWMP started.

Section 1.2 briefly assessed each indicator for its appropriateness, effectiveness and efficiency. In this section, examples of the outputs for each indicator are provided to illustrate both their utility as sources of evidence to account for management of water and the deeper insights provided by synthesizing all outputs to better understand ecological interactions. This synthesis provides the basis for refining objectives to ensure that they are SMART and for applying adaptive management principles.

Table 9: Relationship between EWMP outcomes, the questions chosen and the indicators used to determine progress in satisfying program objectives. For consistency with future efforts, the evaluation questions are derived where relevant from those in the Basin Plan Evaluation Framework developed by the Murray-Darling Basin Authority (see http://www.mdba.gov.au/what-we-do/mon-eval-reporting/bp-evaluation-framework).

Outcome	Evaluation Questions	Indicators
Improvement in the health of water-dependent ecosystems in the Gwydir, Macquarie, Lachlan, Murrumbidgee, Murray and Lower Darling River catchments	Have the ecosystem functions of wetlands and rivers improved? Has the condition of water dependent ecosystems improved? How has the EWMP contributed to the protection and restoration of water dependent ecosystems?	• Area of wetland and floodplain inundated • Area of wetland vegetation communities inundated • Changes in extent of wetland vegetation communities • Changes in condition of wetland vegetation communities, including changes in species composition • Colonial waterbird nesting success • Waterbird species diversity (including those with conservation significance) • Southern bell-frog population status • Consistency of EWMP and water-sharing plan ecological objectives • Participation of Aboriginal representatives on EWAGs • Number of watering events with cultural flow objectives
Rehabilitated wetland habitat for significant water-dependent biota, including floodplain eucalypts, waterbirds, frogs, reptiles and fish	How has the EWMP contributed to meeting international obligations for wetlands and migratory birds? How has the EWMP improved habitat for significant water-dependent plants and animals?	
Ecological objectives of water-sharing plans enhanced	To what extent has the EWMP improved the ecological outcomes achieved by water-sharing plans?	
Water management decisions reflect an understanding of the links between environmental and Aboriginal cultural values	Have Aboriginal cultural values influenced water-management decisions? Are there opportunities for Aboriginal perspectives on water management to be heard?	

Managing risks associated with environmental water delivery

Under certain conditions, delivery of environmental water carries the risk of unintended and/or negative consequences. The primary example is so-called 'black water'. Black water results from flooding of leaves and other litter that builds up over time, particularly during extended droughts. Decomposition of this organic matter by microorganisms is a natural and important process, making carbon available to support aquatic food webs. However, when there is abundant organic material, the oxygen demand of the decomposers temporarily creates a hostile environment for other aquatic organisms. Fish deaths can result. Conversely, black water conditions from uncontrolled flooding have been managed in the Murrumbidgee by using environmental water to increase oxygen levels.

Another example of risk is the potential to flood dryland crops when delivering environmental water. This risk applies particularly to the Gwydir wetlands, where cropping has expanded since Copeton Dam was built upstream, changing the pattern of flooding in the wetlands. OEH and Commonwealth Environmental Water Holder funded the development of a strategy involving the local community to jointly develop protocols to minimise any risk of flooding crops.

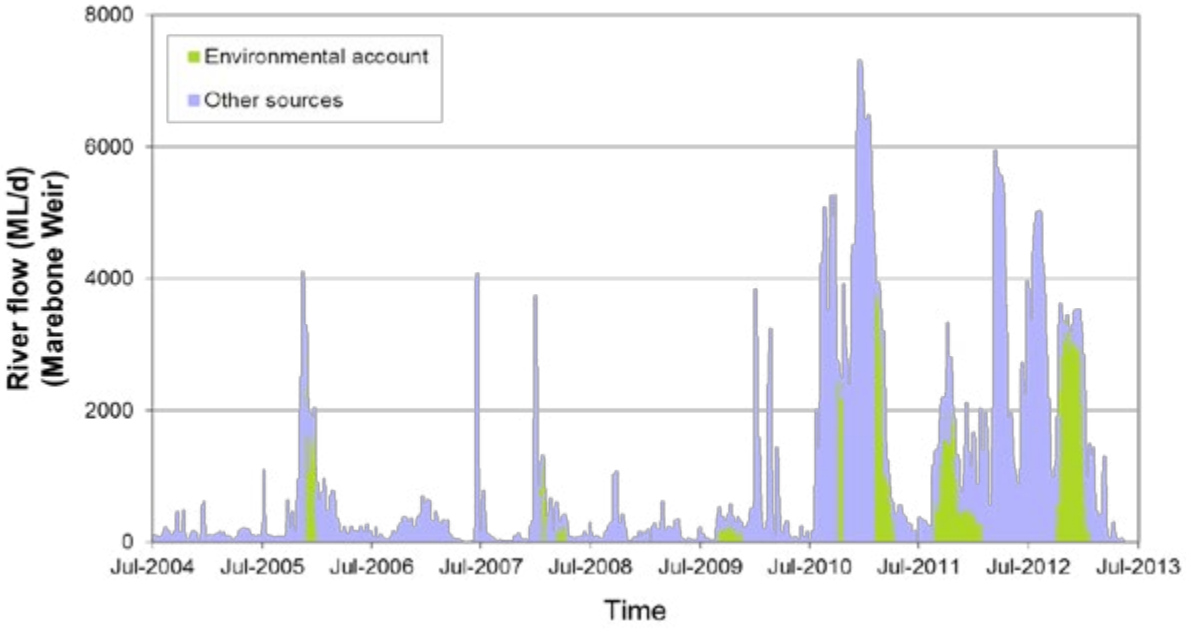


Figure 9: Environmental water usage volumes (green) in relation to those of other water sources, July 2004 to June 2013, for the Macquarie Marshes (July 2004 was the start time of the current water-sharing plan) (source: Debbie Love, OEH).

2.3 The indicators

As outlined in 'Monitoring' section 1.2, the main monitoring activities focus on understanding inundation patterns and describing the response by wetland vegetation communities to those patterns. The key assumption behind this focus is that wetland vegetation is a robust surrogate for other biodiversity, but it is unlikely that this assumption holds for all biodiversity. To mitigate the risk, the responses by selected fauna of conservation significance are also monitored.

Inundation mapping

The area inundated by each watering event was initially mapped to provide a rapid, robust and informative reporting metric for the EWMP. In practice, water delivery is more complex. Not only are there usually multiple sources of water delivered simultaneously, but many events involve several deliveries over extended time periods. The water in a wetland at any given time therefore is a blend of the individual sources and deliveries. Figure 9 provides an example and shows the timing and volumes of environmental water compared with those of other sources of water delivered to the Macquarie Marshes to meet specific environmental needs. Environmental water that was delivered to the Macquarie Marshes during this time was used to target multiple environmental outcomes. These outcomes included extending the duration of flooding in key vegetation communities to complete life cycles, slowing the rate of fall in water levels to maintain waterbird breeding colonies, and achieving flow thresholds that maximise chances for native fish to migrate to and from watercourses.

Mapping inundation patterns is critical for informing annual and longer-term planning and for interpreting ecological responses. Inundation extent is mapped from Landsat imagery. The scale of this imagery balances efficiency (coverage) and effectiveness (resolution) to meet management needs.

Managers are provided with annual inundation summaries to inform the following year's planning. Maps and tables provide information on the areas and the proportion of wetland vegetation communities watered. Figure 10 shows a series of contiguous inundation events in the Macquarie Marshes between 2009 and 2012.

Building an inundation frequency map allows managers to identify core wetland areas and to understand their water needs. Figure 11 provides an example of the inundation history from 1988–2008 for the Macquarie Marshes.

The area covered by the water and its timing, depth, duration and frequency determine ecological responses. Some examples of the outputs from inundation mapping for the Macquarie Marshes are provided below to highlight their use within the EWMP. Similar outputs are available for the Gwydir and Lowbidgee wetlands and are in preparation for the lower Lachlan wetlands.

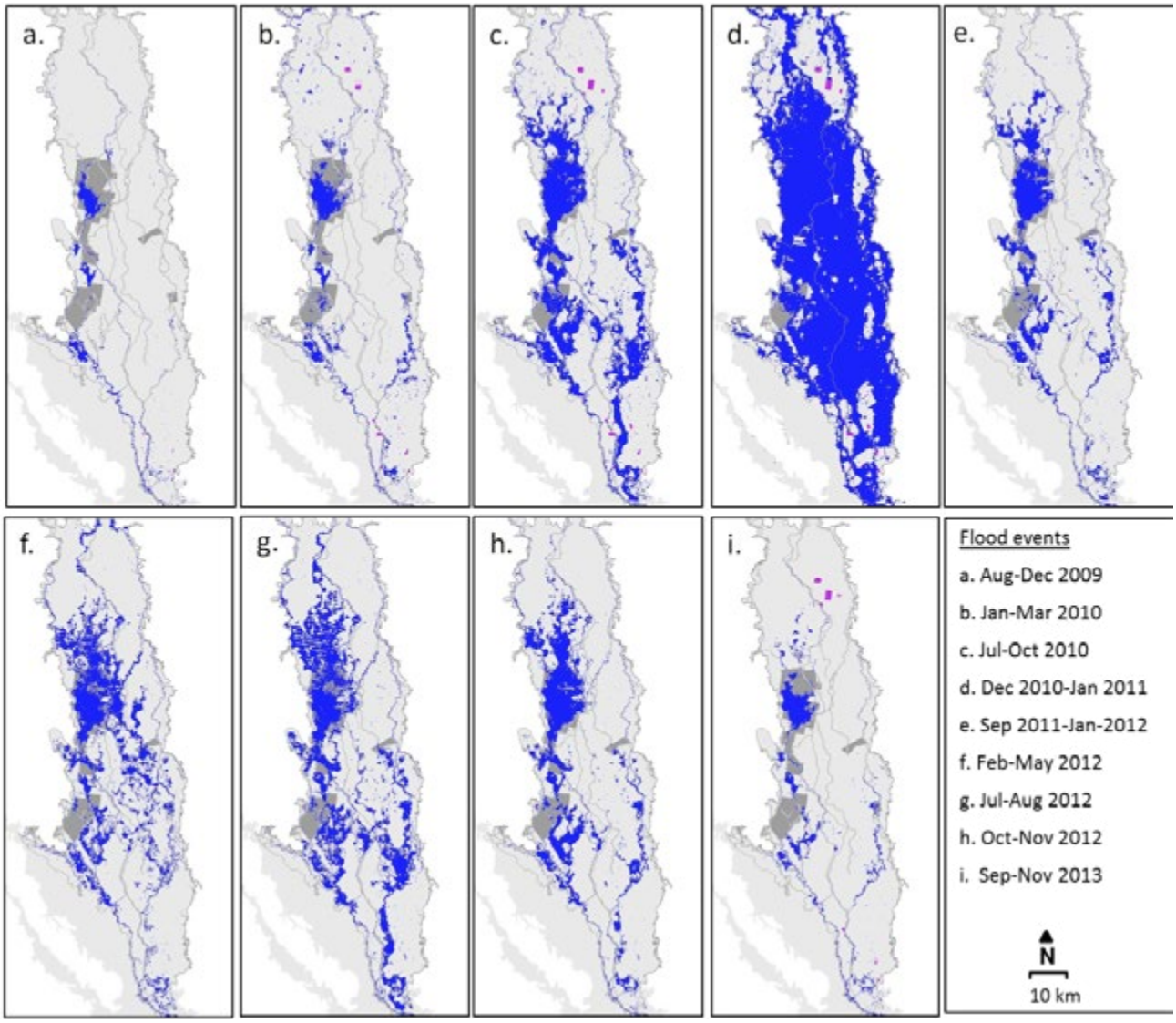


Figure 10: Distribution of total inundation (blue) in the Macquarie Marshes, as detected from Landsat satellite images of nine contiguous inundation events between 2009 and 2013. Individual inundation maps are composites of several satellite images.

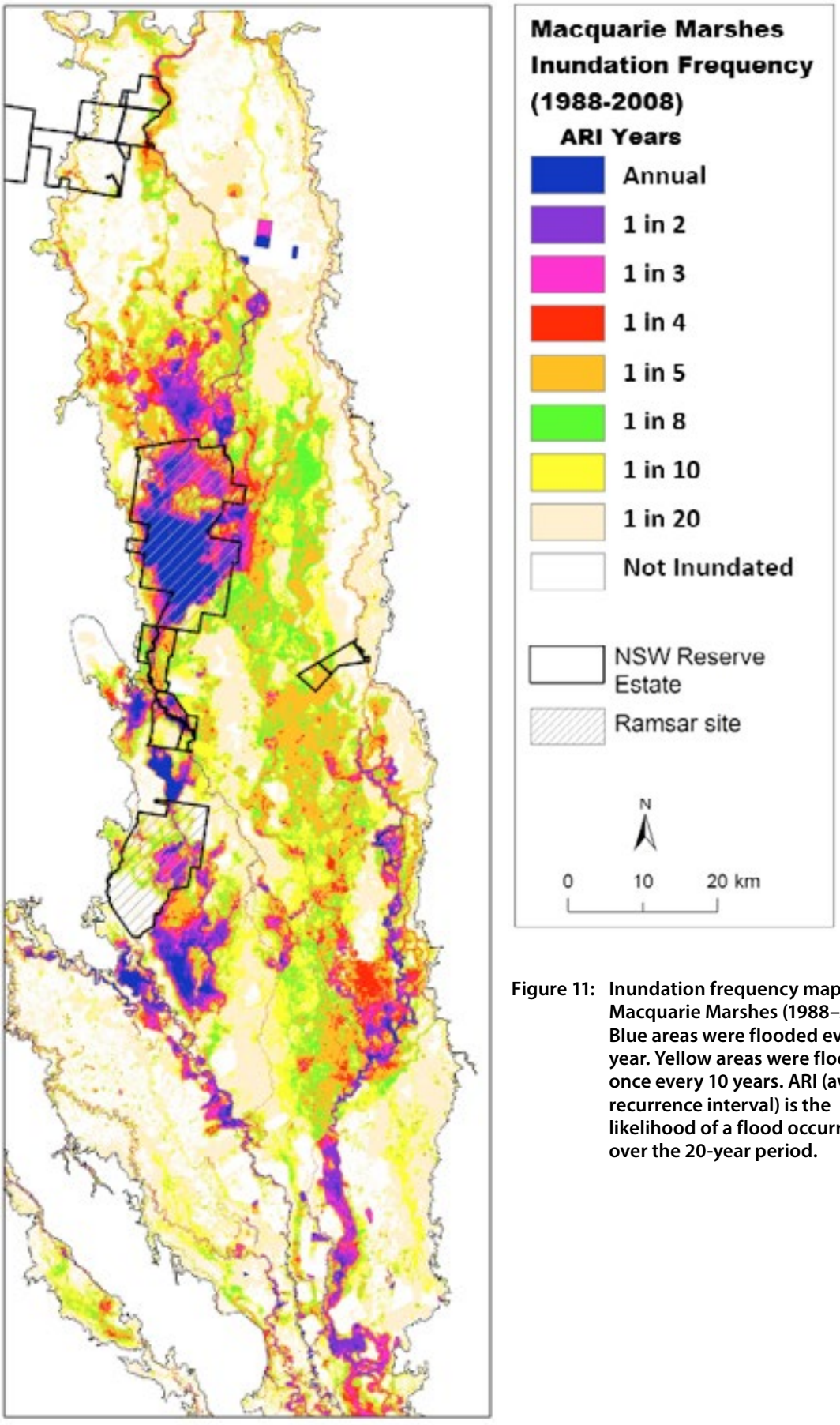


Figure 11: Inundation frequency map of the Macquarie Marshes (1988–2008). Blue areas were flooded every year. Yellow areas were flooded once every 10 years. ARI (average recurrence interval) is the likelihood of a flood occurring over the 20-year period.

Climatic variability characterises wetland environments through changes to water availability. Figure 12 highlights the variability in inundation frequency between 5-yearly intervals for the Macquarie Marshes. Figure 13 and Table 10 provide greater detail on the area inundated each year and the characteristics of the contributing flows.

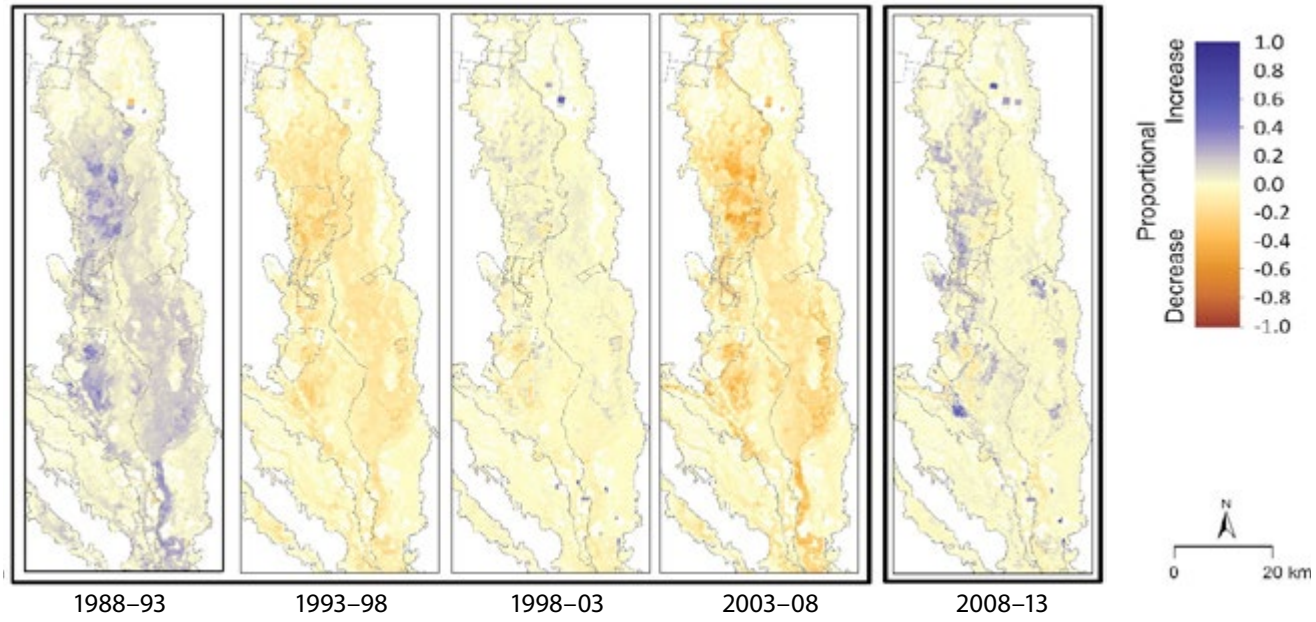


Figure 12: Proportional inundation frequency differences from the 20-year standardised flood frequency (1988–2008) for each of the 5-year intervals 1988–1993, 1993–1998, 1998–2003, 2003–2008 and 2008–2013 in the Macquarie Marshes (purple is a positive difference – increase; orange is a negative difference – decrease).

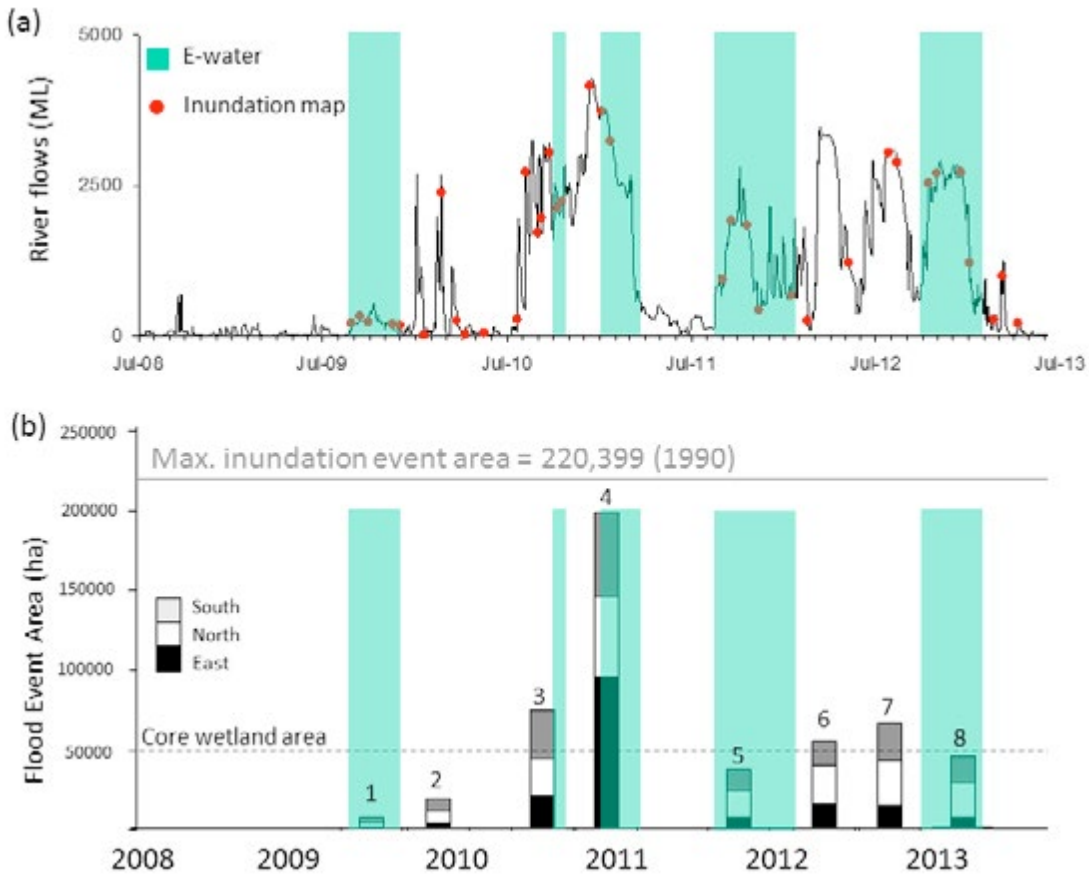


Figure 13: (a) River flows (Macquarie River at Marebone Weir), periods when environmental water (E-water) was released (green), and dates of inundation mapping. (b) Area (in hectares) watered during inundation events in the Macquarie Marshes and wetland regions (North, South and East). Numbered inundation events (1 to 8) correspond to those shown in Figure 10 as 'a' to 'h', respectively.

Table 10: **Summary of flow events and area inundated in the Macquarie Marshes within each 5-year period from July 1988 to June 2013. Events are categorised according to their volume (gigalitres) and flow duration, which together deliver known ecological requirements for specific components of biodiversity. 'Area inundated' is the cumulative total area of floodplain inundated over the event. 'Min' represents the smallest event area inundated and 'Max' is the largest during the period. '50,000' ha represents the core wetland area that requires watering at least 2 to 3 years in 5 to maintain vegetation persistence.**

Time period	No. of events	No. of times flow thresholds reached				Area inundated (ha)		
		>700 GL and >8 months	>400 GL and >6 months	>350 GL and >4 months	>250 GL and >3 months	Min	Max	No. (%) >50,000 ha
1988–93	6	2	2	2	3	24550	212903	3 (50%)
1993–98	6	0	0	0	0	8771	66139	1 (17%)
1998–03	6	1	2	2	2	9617	145024	2 (33%)
2003–08	6	0	0	0	0	3111	15947	0 (0%)
2008–13	8	0	1	1	2	3190	196448	3 (38%)

Wetland vegetation community extent

Vegetation communities (defined as functional vegetation groups) in the large wetland complexes are mapped every 5+ years from high-resolution vertical imagery to determine changes in their extent. For communities dominated by long-lived woody species (e.g. river red gum, black box), changes are expected to be slow. For communities dominated by herbaceous species (e.g. common reed, marsh club-rush, water couch) the changes can occur relatively quickly.

Wetland vegetation community condition

The condition of wetland vegetation communities is determined annually in the large wetland complexes from plot-based surveys using measures of individual plant health (canopy condition of dominant trees), structural diversity and species diversity. These are compared with reference conditions. Changes in condition are then compared between years and related to inundation patterns.

OEH contracted external research groups to provide additional information on the responses by wetland vegetation to watering patterns in some wetlands. This approach took advantage of specific opportunities to explore the role of environmental watering or to undertake one-off projects that otherwise were not possible using internal resources. Examples were a benchmark (2007) and repeat (2013) condition assessment of Murrumbidgil Swamp in the lower Lachlan, as well as the response by wetlands actively watered and those not watered to natural floods in the Murray.

Wetland-dependent fauna responses

Waterbirds and frogs are highly visible and audible occupants of wetland habitats. Fish are less obvious. All are valued, and most relevant monitoring programs attempt to include some assessment of their population status. However, as watering is only one of many factors determining population status, this status is not always considered a reliable indicator of responses to watering.

OEH's fauna monitoring focuses on waterbird population diversity and abundance, colonial waterbird breeding events, frog population diversity, and the abundance and the status of the endangered southern bell-frog population in the Lowbidgee and Murray wetlands. OEH has undertaken limited wetland fish monitoring (Lowbidgee and Gwydir wetlands) but has contracted work to fill specific knowledge gaps in the Lower Darling, Macquarie Marshes, lower Lachlan and Gwydir.

Waterbird ground counts are timed to coincide with the aerial waterbird survey conducted annually over eastern Australia since 1983. The aerial survey provides an appropriate scale at which to interpret ground observations at individual sites. Over time, changes in waterbird observations at individual sites can be assessed against changes in population status at the semi-continental scale.

Some waterbirds breed in colonies. These colonies can exceed 100,000 individual birds, often exceeding 10,000 and consisting of 10 or more species. There are limited sites in NSW that support these colonies. A large active colony is an unforgettable symbol of a well-functioning wetland. Large-scale breeding generally responds to large-scale natural flooding. Environmental water is managed to minimise fluctuations in water level and avoid nest desertion, as well as to extend the event to improve chances of breeding success.

Frog choruses symbolise wetland renewal. These and the presence of frogs generally are valued by local communities. OEH has supported surveys to document frog diversity and abundance in the large wetland complexes and at many smaller wetlands. The results of future surveys can then be compared with those of these reference surveys.

The population status of the threatened southern bell-frog depends directly on environmental water management. The distribution of this species has declined substantially in the last 10 to 20 years, with its stronghold now restricted to the Lowbidgee and some Murray wetlands. The Balranald community has adopted the frog as its emblem. OEH has partnered with Dr Skye Wassens of CSU and Riverina Local Land Services to monitor its status.

Use of models

Models are typically used when it is either impossible or impractical to create experimental conditions to measure outcomes directly. All models are simplified reflections of reality but are nevertheless extremely useful. Building and disputing models is fundamental to science, but support among managers for models is often equivocal.

OEH has invested in developing a range of first-generation models to support planning and evaluation activities. Some have been combined into decision-support systems for potential use by managers and community advisory groups. However, they largely remain in development and are generally not yet fit to be used for management purposes.

By connecting hydrologic, hydrodynamic and ecosystem-response models, it is possible to predict likely outcomes from a range of watering scenarios. In addition, models can be used to isolate the likely contribution by individual sources of water to a particular ecological outcome. There is potential to increase the use of models in the EWMP.

2.4 Answering the evaluation questions

The evaluation questions in Table 9 were developed for the purposes of this report, not when the EWMP started. The consequence is that there is not always a clear connection between program objectives and monitoring activities, compromising our ability to answer some evaluation questions clearly.

Have the ecosystem functions of wetlands and rivers improved?

OEH does not directly monitor ecosystem functions to determine the impacts of water management. However, it does undertake research to better understand the variability of some aspects in relation to season, watering patterns and land use. Ecosystem functions include those related to hydrological connectivity (e.g. dispersal opportunities for plants and animals; erosion and sedimentation) and those involving functional processes (e.g. primary productivity; decomposition; nutrient and carbon cycling).

Ecosystem functions of water-dependent habitats support the plant and animal populations that use them. Environmental water is generally delivered in response to natural cues; this assumes that functional processes are then supported. Therefore, the population status of selected plants and animals is used as a surrogate measure of ecosystem function. If plants and animals are responding as expected, it is assumed that the functions that support them are adequate.

Has the condition of water-dependent ecosystems improved?

The wetland vegetation community extent and condition indicators provide evidence to answer this question. Examples are given below.

Example 1: Changes in extent and condition—the Macquarie Marshes

Figure 14 shows the changes in extent of selected vegetation communities in the Macquarie Marshes from assessments in 1991, 2008 and 2013. The span of these assessments is the longest for any wetland targeted for watering in NSW. It includes extremes of drought and floods and provides insights into how communities respond to climatic patterns, including recovery. Importantly, the assessments in 1991 and 2013 followed large-scale flooding.

Of note are changes in semi-permanent wetland and derived chenopod shrubland extent. These communities are the most sensitive to short-term changes in water regime. Semi-permanent wetland requires annual watering if it is to persist. Derived chenopod shrubland expands when flooding frequency is significantly reduced.

Conversely, communities dominated by long-lived species such as river red gum did not change significantly in extent but showed significant changes in condition.

The proportions of each vegetation community in good, intermediate and poor condition are shown in Figure 14, with Figure 15 showing where the changes in condition have occurred. The results highlight the fact that a level of recovery occurred between 2008 and 2013, although the vegetation has not returned to the condition evident in 1991.

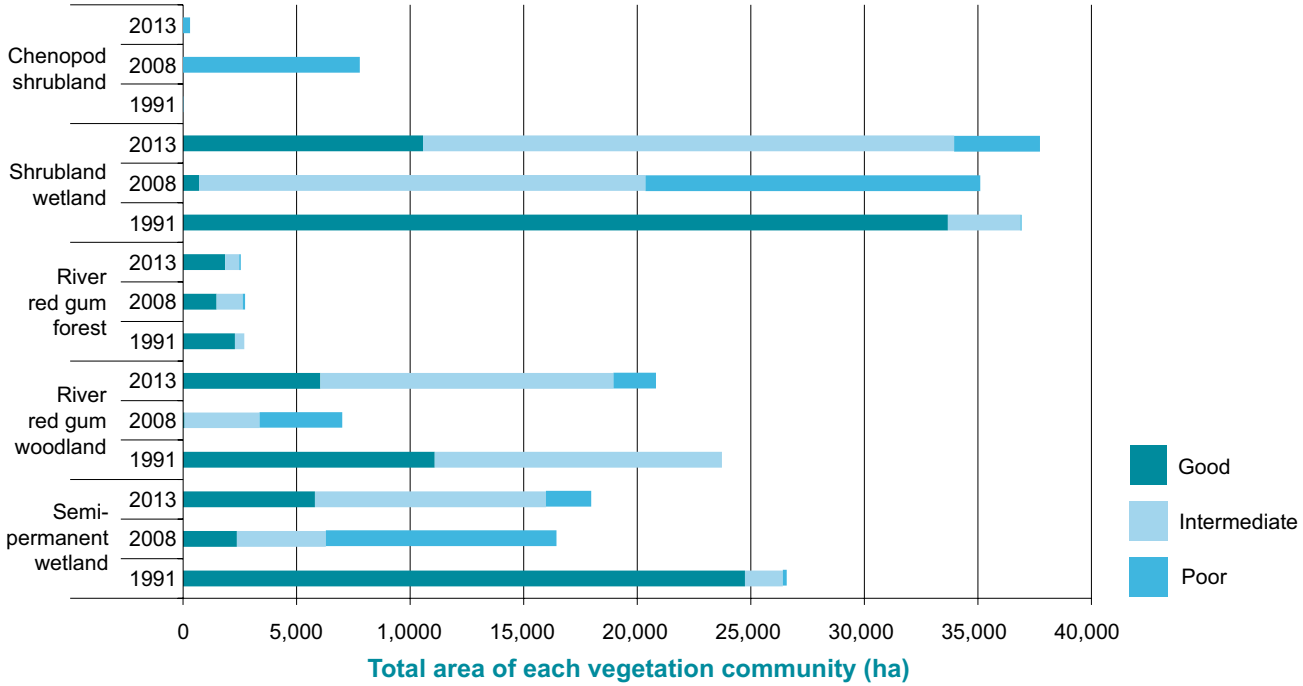


Figure 14: Total area (ha) and areas in good, intermediate and poor condition in selected vegetation communities of the Macquarie Marshes in 1991, 2008 and 2013. Note that chenopod shrubland was assigned 'poor', as it is not a wetland community. Its presence indicates poor wetland condition.

Example 2: Changes in condition—Murrumbidgil Swamp

Murrumbidgil Swamp is a relatively small (about 1 $km^{2)}$ wetland on a distributary creek of the lower Lachlan River. It is characterised by distinctive channel-mound topography and a vegetation community dominated by river red gum (Figure 16). In the 1970s and 1980s it was the location for foundational wetland science that clarified the role of water regimes in waterbird breeding specifically and wetland ecology more generally. It is listed in the Directory of Important Wetlands in Australia and was among the first watering targets identified under the NSW RiverBank Program.

OEH contracted Dr Jane Roberts to undertake a benchmarking study of the swamp's condition in 2007 and to repeat the assessment in 2013. Her 2013 report (Roberts and Robinson 2014) concluded that tree condition had greatly improved between assessments. Canopy cover had increased (although because of high variability the increase was not significant); the proportion of stressed trees was lower; and the proportion of vigorous trees higher. Population structure showed waves of recent recruitment, with all growth stages represented.

However, only three of the six ecological targets set in the 2007 assessment were met in 2013. This was interpreted to mean that, despite showing considerable improvement, Murrumbidgil Swamp had not yet recovered. Further analysis of the data led the author to propose a model of recovery processes for river red gums in relation to varying levels of stress (Figure 17). The report noted that all recovery pathways are under way in Murrumbidgil Swamp. It recommended that the original condition targets be modified to include a recovery target. It also highlighted—even for a relatively small wetland—the variability of responses.

River red gum is an iconic species, and its condition is a measure of the broader environmental condition throughout the Murray-Darling Basin. The proposed model is likely to influence targets set for river red gum recovery in other wetlands dominated by this species.

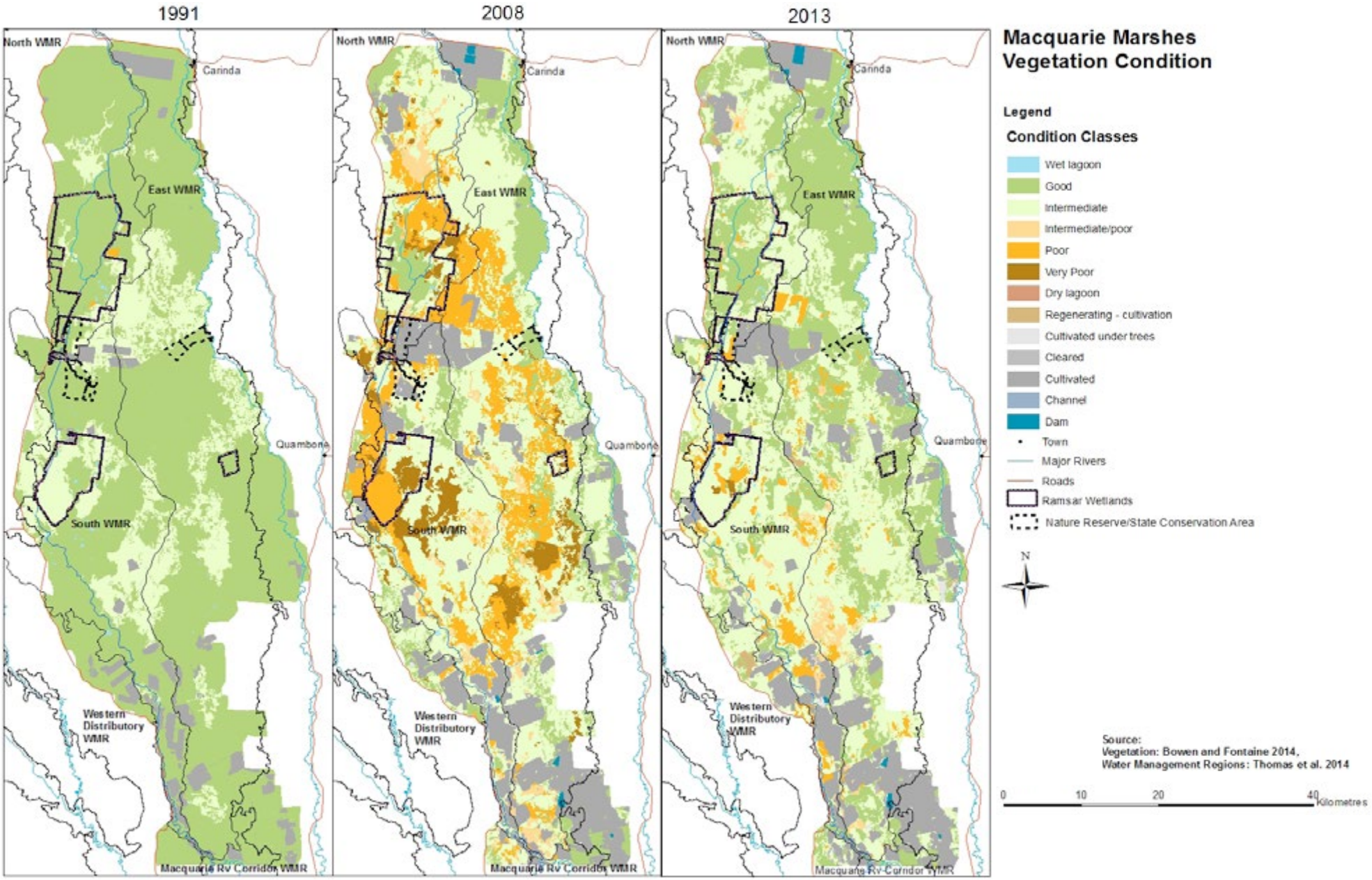


Figure 15: Condition classes of combined vegetation communities in the Macquarie Marshes in 1991, 2008 and 2013, as interpreted from aerial photography. Note that the methods differ between the 1991 interpretation and those in 2008 and 2013.

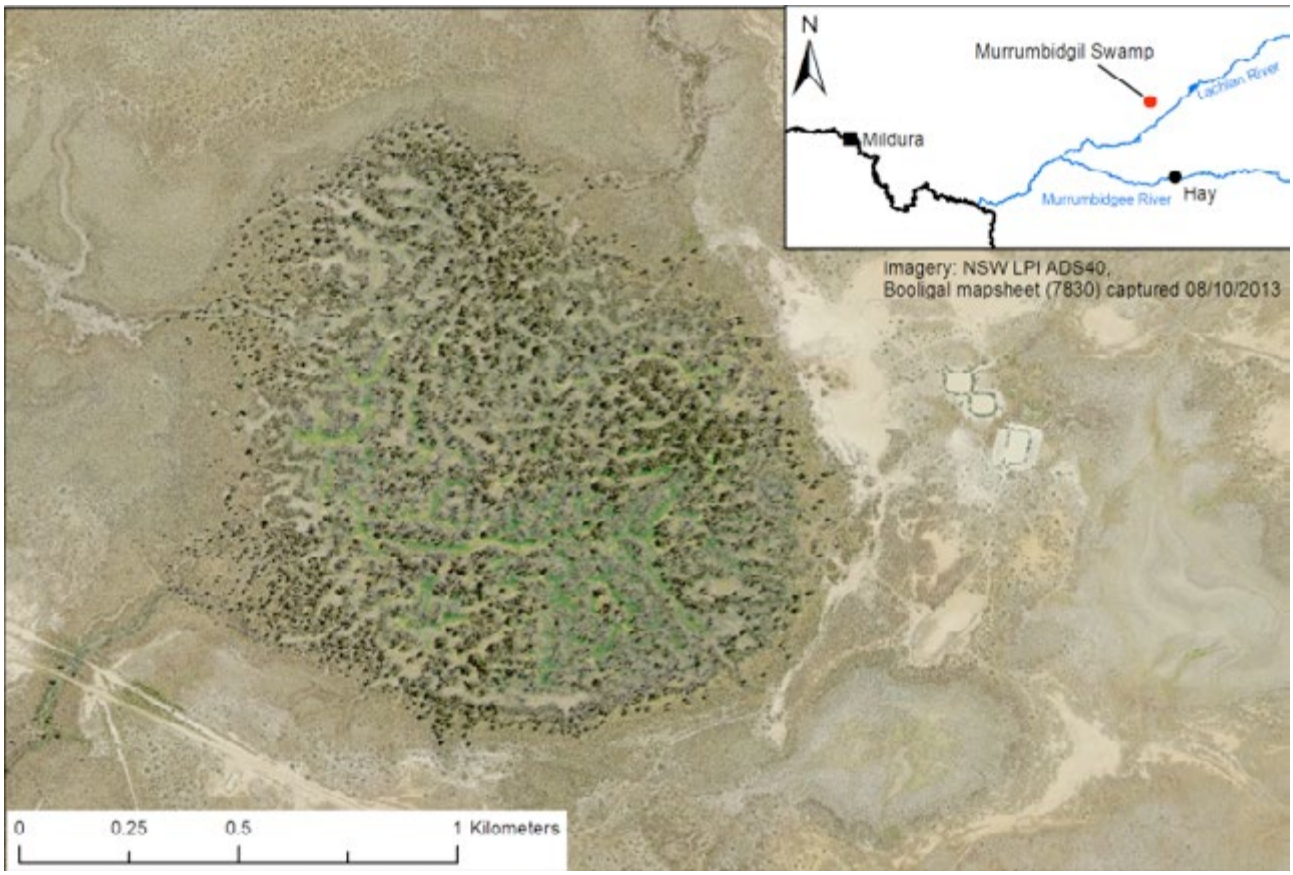


Figure 16: Murrumbidgil Swamp on 8 October 2013. River red gums mark mounds, which are interspersed with channels up to 2 metres deep. [source: Imagery taken by NSW Land and Property Information using Airborne Digital Sensory (ADS40)].

How has the EWMP helped to protect and restore water-dependent ecosystems?

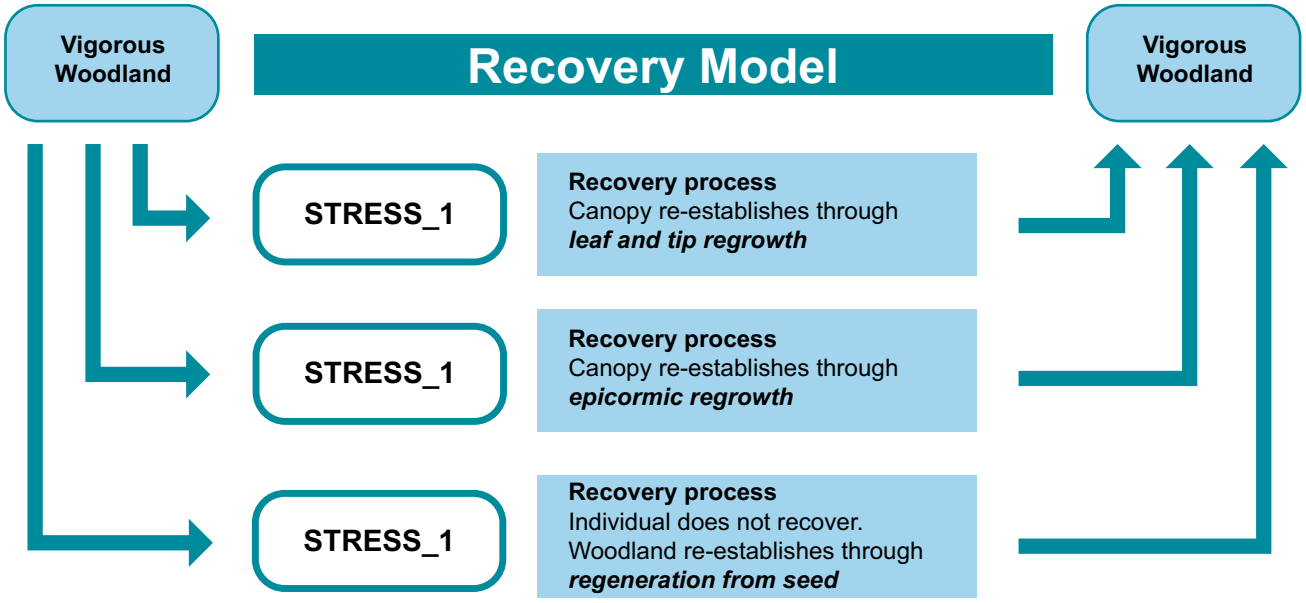


Figure 17: Recovery pathways for eucalypt trees and woodland following prolonged water stress. There are three recovery pathways for eucalypt trees and woodlands, depending on the level of stress: Stress_1 to Stress_3 indicate a gradient of increasing severity related to persistence of stress. (source: Roberts and Robinson 2014)

The wetland vegetation community condition indicator provides evidence to answer this question. Additional supporting evidence is provided by outputs from models.

Example 1: The Murray Wetlands

The then Murray Wetland Working Group (http://www.murraydarlingwetlands.com.au/) watered a number of wetlands along the Murray River before and during the Millennium drought. OEH subsequently continued the group's work. When floods returned in 2010, these wetlands provided an opportunity to explore the benefits of active watering. OEH worked with the Murray-Darling Freshwater Research Centre to assess and compare the responses after flooding by vegetation in wetlands actively watered and not watered during the drought (Campbell et al. 2013).

The experimental design is shown in Figure 18. The conclusions demonstrate that wetlands watered during the drought supported denser and more diverse populations of plants after flooding. Some species were observed only in wetlands watered during the drought.

The reasons for the observed differences are related to seed viability. Watering during drought years enables seeds to germinate and allows plants to complete their life-cycles and reintroduce viable seed to the seed bank. Seed viability decreases over time, although responses vary among species. The extended drought exceeded the viability of some species.

The report also highlighted natural variability and listed some potential contributing factors. It recommended that watering events be varied in terms of season, volume and duration to maximise landscape-scale biodiversity.

Example 2: Murrumbidgil Swamp

Improvements in the condition of Murrumbidgil Swamp are described above under the question 'Has the condition of water-dependent ecosystems improved?' The swamp is watered via Merrimajeel Creek. Since the benchmarking assessment in 2007, Murrumbidgil Swamp has been watered by intense local rainfall, uncontrolled flooding, replenishment flows provided for stock and domestic purposes and managed environmental flows.

Because of the swamp's ecological significance and declining condition, attempts were made from 2007 onward to deliver managed flows to it. Most were unsuccessful when attempted in isolation owing to the characteristics of the contributing creek. A successful flow was delivered to extend uncontrolled flooding in 2011. Uncontrolled flooding will remain the primary means of supplying Murrumbidgil Swamp's water requirements, but managed flows in combination with water from other sources can help to maintain its ecological character.

Example 3: Using models to predict change in Yanga National Park

Yanga National Park is part of the Lowbidgee floodplain system. The decision-support system developed for Yanga under the NSW Rivers Environment Restoration Program allows a comparison of habitat conditions provided with and without environmental water. It predicts the habitat suitability within 34 water management areas for 17 plant and animal species of conservation interest on the basis of their known hydrological and ecological requirements. These species include river red gum, black box, lignum, ibis, egrets, un-specked hardyhead (a small native fish) and southern bell-frog.

Figure 19 shows the predicted change in habitat condition (principally hydrological conditions) of river red gums in Yanga National Park in response to the addition of environmental water. Without environmental water, 17 of the 25 areas in which river red gum occurs are expected to remain highly stressed.

Resource limitations have prevented the collection of field data to verify modelled outputs at Yanga to date. This is a necessary step to ensure that models are continually improving their capacity to capture observed responses and, thus, improve their relevance to managers.

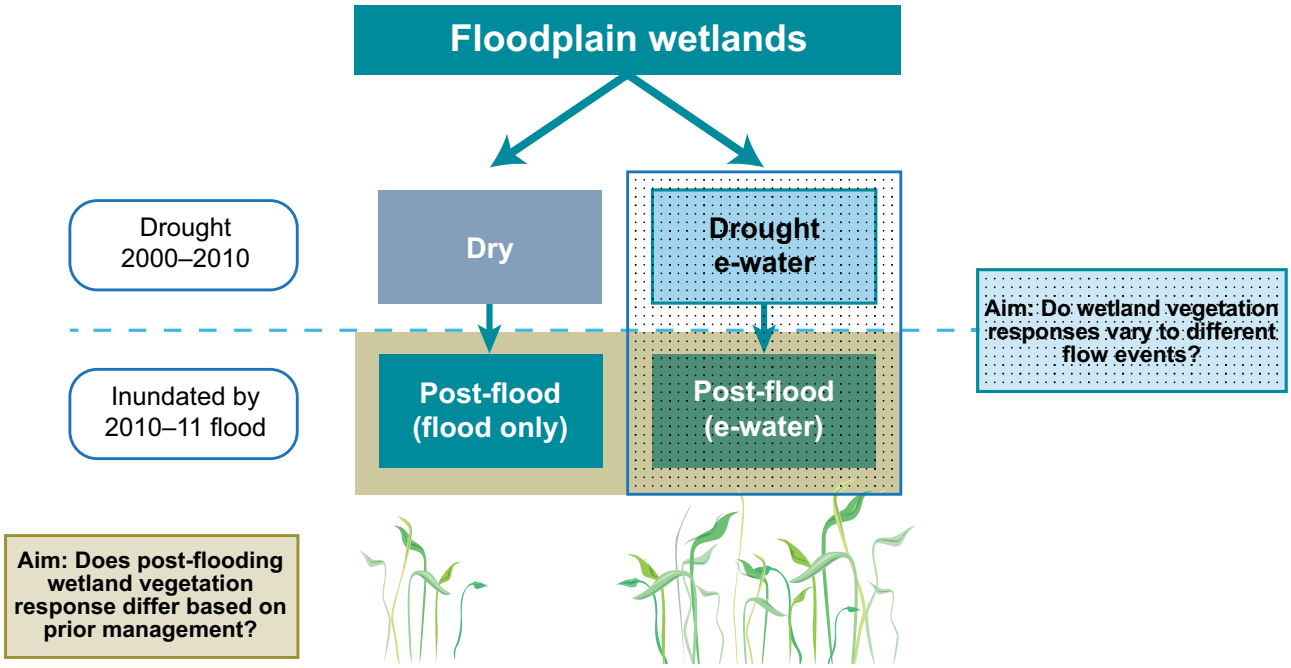


Figure 18: Experimental design to explore the responses of wetland vegetation to different watering regimes in wetlands of the Murray Valley (source: Campbell et al. 2013).

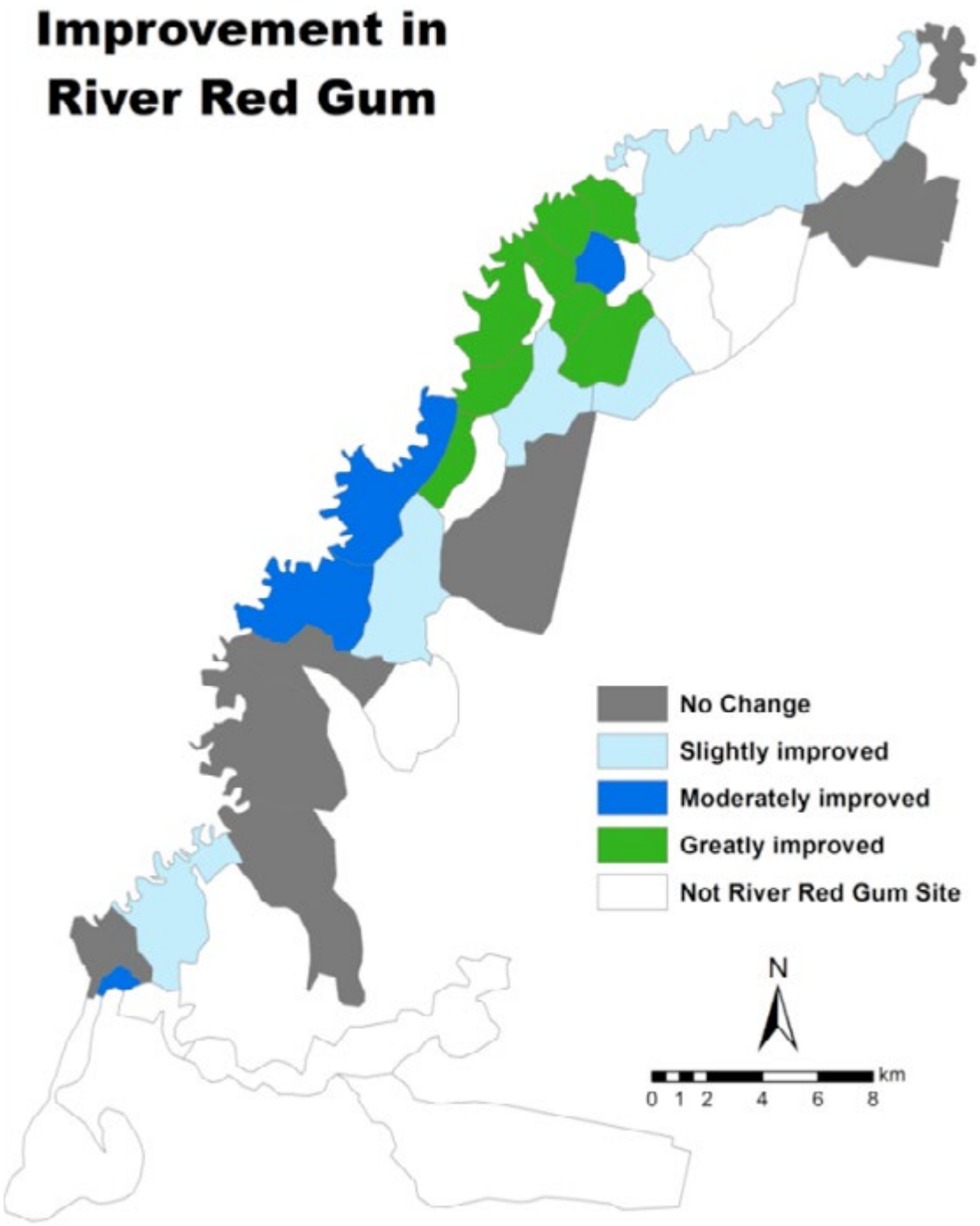


Figure 19: Predicted change in river red gum habitat condition in Yanga National Park resulting from the delivery of environmental water, 2007–2012.

How has the EWMP helped to meet international obligations for wetlands and migratory birds?

International obligations refer to wetlands listed under the Ramsar Convention; migratory species in general as listed under the Bonn Convention; and migratory birds specifically as listed under bilateral agreements between Australia and Japan, China and the Republic of Korea. See the Commonwealth Department of the Environment's site at http://www.environment.gov.au/cgi-bin/sprat/public/publicshowmigratory.pl for complete lists of migratory species.

Ramsar wetlands are primary targets for watering in NSW. The aim of watering is to maintain or improve the ecological character of Ramsar sites. Ecological character refers to the particular suite of values supported by the site and that satisfy one or more established criteria. (See http://www.environment.gov.au/water/wetlands/ramsar/criteria-identifying-wetlands.) Ramsar sites occur within the Gwydir wetlands, Macquarie Marshes, mid-Murrumbidgee wetlands (Fivebough and Tuckerbil Wetlands) and the mid-Murray (Central Murray Red Gum Forests). The Central Murray forests are targeted by The Living Murray.

All water deliveries by OEH to the Gwydir wetlands and Macquarie Marshes targeted their Ramsar sites and other associated important migratory waterbird habitat. The Fivebough and Tuckerbil wetlands received top-up flows in November 2011 and June 2013 to maintain their ecological character.

The habitat requirements of listed migratory species vary. Most are non-breeding migrants that require access to food sufficient to enable them to recover condition lost during post-breeding migration (spring to early summer) and to store condition for the return journey (late summer to autumn). Feeding habitat is mainly mud flats and the wet margins of drying wetlands. Some watering actions in the Macquarie Marshes, Fivebough Swamp and Lowbidgee specifically targeted feeding habitat outcomes for these species.

Those listed migratory species that do breed in Australian wetlands have requirements similar to those of indigenous waterbirds—namely, generally, continuous flooding during spring and summer in a range of wetland types.

In 2012–13, OEH (Spencer et al. 2014) started systematic ground surveys of waterbird species in significant floodplain wetlands across inland NSW to:

- assess the outcomes of environmental flows to support the adaptive management of environmental water
- complement annual aerial waterbird surveys of eastern Australia and key indicator sites in the Murray-Darling Basin
- assess waterbird use of Ramsar wetlands in inland NSW to help with Ramsar reporting.

During 2012–13, flooding in the surveyed sites resulted mainly from managed flows. In the previous 2 years, most surface water was due to natural flooding. Observations in 2012–13 therefore reflect the influence of watering. However, the direct contribution by the EWMP to observed waterbird populations cannot be clearly separated from other factors.

Key findings relating to the contribution by the EWMP to meeting international obligations included:

- 64 waterbird species recorded across 120 sites
- 59 waterbird species recorded on Ramsar sites
- 11 listed (Japan–Australia Migratory Bird Agreement [JAMBA]; China–Australia Migratory Bird Agreement [CAMBA]; Republic of Korea – Australia Migratory Bird Agreement [ROKAMBA]; Bonn Convention) migratory waterbird species recorded.

Figure 20 shows the results from the Fivebough and Tuckerbil wetlands. OEH contracted Mr Keith Hutton, a local ornithologist, to undertake these counts. He had identified and counted waterbirds on this site for many years before and after its listing as a Ramsar site. His observations provide a benchmark for assessing any change in ecological character and have informed the Fivebough-Tuckerbil Adaptive Environmental Management Plan (Price et al. 2014). They highlight the diversity of waterbirds supported by these relatively small wetlands, as well as the importance of the site for rare and endangered species and the seasonal habitat provided for migratory waders.

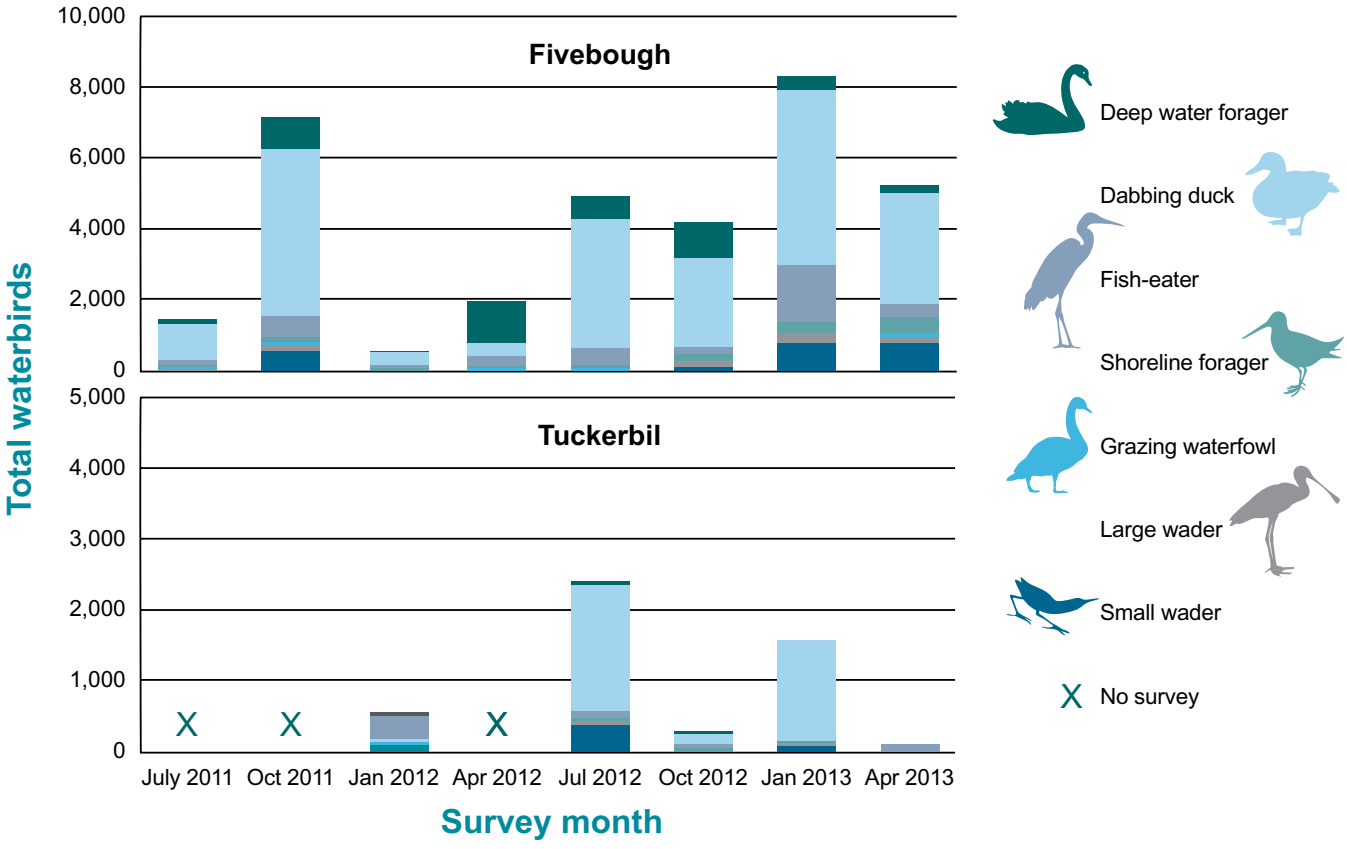


Figure 20: Total waterbird abundance observed during winter, spring, summer and autumn surveys of Fivebough and Tuckerbil wetlands Ramsar site in 2011–13. Waterbird species are grouped into seven feeding groups. Migratory species dominate the small wader group (source: Price et al. 2014).

How has the EWMP improved habitat for significant water-dependent plants and animals?

The indicators of colonial waterbird nesting success and southern bell-frog population status provide evidence to answer this question.

Example 1: Colonial waterbird breeding

Colonial waterbirds breed in a limited range of habitats. These habitats tend to occur in core wetland areas that support plants able to provide secure nest sites. Large colonies of ibis species use lignum, common reed beds and cumbungi. Egrets use live river red gums and casuarina. Cormorants and darters use live and dead trees. Herons and spoonbills use lignum and live trees. Maintenance of these habitats during non-breeding periods is critical to ensure they are in a condition capable of supporting large numbers of nests when unpredictable breeding conditions eventuate.

Figure 21 shows where waterbird breeding colonies became established during the 2006–13 period. Most of these were at sites known to support colonies historically.

Table 11 summarises the information available on the extent and success of colonial waterbird breeding activity in the Gwydir wetlands, Macquarie Marshes, lower Lachlan wetlands, mid-Murrumbidgee wetlands, Lowbidgee wetlands and mid-Murray wetlands. The total number of colonies is likely to be an underestimate, as small colonies are easily missed during widespread flooding.

Most breeding activity was initiated in response to uncontrolled flooding. Breeding responses tended to be early in the flooding cycle. The proportion of colonies requiring intervention increased as flooding decreased. Intervention primarily involved the delivery of environmental water to maintain appropriate levels to maximise the chance of chicks fledging successfully. In some cases, water was delivered to prevent sudden drops in levels at critical stages of the breeding cycle, when ibis in particular are prone to abandoning breeding attempts.

It is highly likely that management interventions increased the number of colonial waterbirds entering the population. However, it is extremely difficult to quantify the contribution to waterbird populations as a whole. Long-term annual aerial surveys provide some evidence, with increased numbers of birds in the year following a large flood event (Kingsford et al. 2013).

Table 11: Overview of colonial waterbird breeding* activity in the five valleys where managed environmental water was delivered between July 2006 and June 2013. (Managed events include those requiring delivery of environmental water and those using purpose-built infrastructure. Successful events are those where greater than 75% of hatched juveniles are estimated to have reached independence.)

Year	Total no. of colonies	Colonies with >1000 nests	Total no. of species	Managed colonies (% of total)	Successful colonies (% of total)
2006–07	0	–	–	–	–
2007–08	1	1	9	100	100
2008–09	1	0	5	100	100
2009–10	6	1	8	33	100
2010–11	43	15	19	33	98
2011–12	30	11	14	53	97
2012–13	14	1	11	29	86

* Limited to ibis, egrets, spoonbills, herons and cormorants

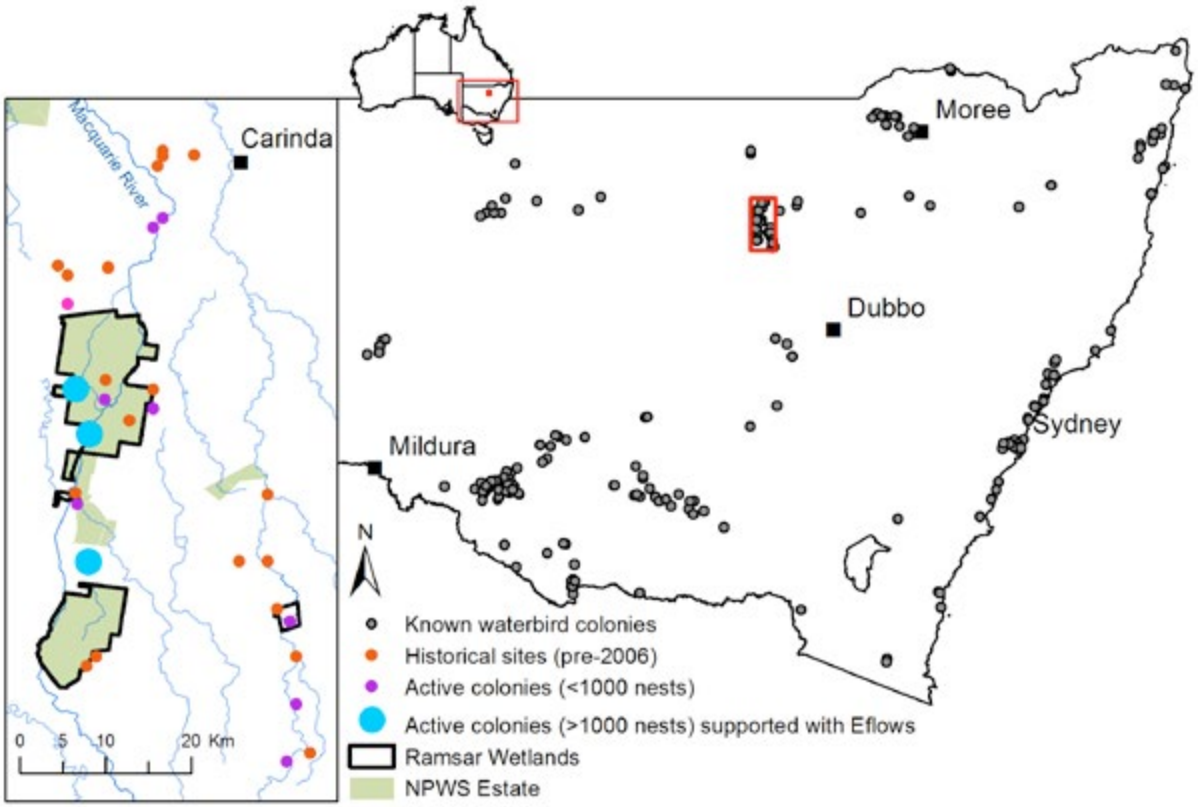


Figure 21: Locations of known colonial waterbird (egret, heron, ibis, tern and pelican) breeding sites across NSW and breeding activity in the Macquarie Marshes (inset) during 2006–13. Formation of large egret and ibis colonies in the Macquarie Marshes was triggered by natural flooding and maintained by managed environmental flows. Note that environmental flows were also delivered to small and large colony sites in the Macquarie Marshes to maintain the condition of nesting vegetation during drier periods.

Example 2: Southern bell-frog population status

From 2007 onwards, targeted environmental watering has supported remnant populations of, and promoted breeding opportunities for, the southern bell-frog in key wetlands of the Lowbidgee. Surveys in 2001 and 2004 found southern bell-frogs to be abundant and widespread in the Lowbidgee. However, surveys during 2007–10 found small numbers in only seven wetlands. Environmental water was delivered to these wetlands. Breeding was subsequently recorded in four of them.

Surveys since the drought ended in late 2010 have detected southern bell-frogs in 10 Lowbidgee wetlands and breeding in five. In two of the successful breeding sites, environmental water was delivered during summer and autumn to extend habitat availability.

Southern bell-frogs were also recorded during the 2010 floods at two mid-Murrumbidgee wetlands and at a single site in the lower Lachlan in late 2012. No breeding was recorded at these sites at the time and the species has not been recorded since, despite follow-up environmental watering.

Along the Murray, several populations of southern bell-frogs were recorded at sites targeted for watering (Wassens et al. 2010) in 2008. Flows delivered in 2009–2011 aimed to provide breeding opportunities but no tadpoles were recorded.

The outputs from the Yanga National Park decision-support system (see Example 3 in 'How has the EWMP helped to protect and restore water-dependent ecosystems?') predicted significant improvement in habitat suitability when environmental water was applied to all four locations known to historically support breeding populations of the southern bell-frog. Despite some evidence to support the contribution made by environmental watering in supporting the Lowbidgee southern bell-frog population, numbers remain critically low across the species' former range. It is thought that suitable breeding habitat (wetlands with diverse and dense aquatic plants) has not yet become re-established since the Millennium drought owing to depletion of seed banks.

Maintaining populations of southern bell-frog will require sustained active management to seasonally inundate breeding habitat for 4 or 5 months and to water core maintenance habitats annually. A management plan (Spencer et al. 2013) has been prepared to guide the species' recovery, and the frog has been identified as a site-managed species under the Saving our Species Program (http://www.environment.nsw.gov.au/savingourspecies/about.htm).

To what extent has the EWMP improved the ecological outcomes achieved by water-sharing plans?

NOW is responsible for the administration of water-sharing plans (in NSW. These plans are the statutory basis for sharing water between the environment and extractive uses. NOW reviewed the effectiveness of relevant plans in 2013, noting among other things that there was poor alignment among vision, objectives, strategies and performance indicators (see www.water.nsw.gov.au/Water-management/Water-sharing-plans/Plans-review). It recommended improvements to monitoring and evaluation.

The Integrated Monitoring of Environmental Flows program was established by NOW in 1997 to assess the ecological benefits of environmental flow rules within plans. The program is now discontinued, although many sites and methods have featured in subsequent monitoring efforts. (See the NSW Department of Primary Industries water site at http://www.water.nsw.gov.au/Water-Management/Monitoring/Regulated-rivers/Regulated-rivers/default.aspx for more details.) NOW is developing a Performance Assessment Strategy to merge previous approaches to monitoring.

Water-sharing plans allow water access licences to be conditioned for environmental use. All licences purchased under the EWMP have been conditioned in this way. The conditions are contained within adaptive environmental water use plans approved by NOW. Adaptive environmental water use plans specify the objectives, locations, delivery points and accounting arrangements for any use of environmental water. OEH has prepared and had approved adaptive environmental water use plans for the Gwydir, Macquarie-Cudgegong, Lachlan, Murrumbidgee and Murray – Lower Darling Water Management Areas.

The objectives of adaptive environmental water use plans must add value to those of the relevant water-sharing plan for approval to be given. Examples include the use of licensed water to extend benefits from rules-based water by:

- increasing the area watered
- extending the duration of watering
- providing appropriate rates of recession of flows to avoid sudden drops in water levels.

The volumes of water available under licences within the EWMP are substantially less than that available under water-sharing plan rules (see Figure 5). However, licenced water provides managers with greater flexibility to target specific and emerging outcomes than is the case with the fixed environmental rules of water-sharing plans.

Are there opportunities for Aboriginal perspectives on water management to be heard?

All EWAGs have potential Aboriginal membership and provide the primary means to include Aboriginal perspectives when planning for, and managing, the delivery of environmental water. Participation varies among EWAGs. Contributions depend on the representative individual's capacity to connect with a range of traditional owners and to identify the types of flows that support cultural values. These are called cultural flows. Aboriginal cultural values encompass spiritual, social, customary and economic values.

NOW has a dedicated program (the Aboriginal Water Initiative) to improve outcomes for Aboriginal people and their involvement in water planning and management within NSW. (See www.water.nsw.gov.au/water-management/water-sharing/aboriginal-communities.) The outputs from this program, which is to run until 2015, promise to empower Aboriginal people with the tools to include cultural needs in future water management decisions. These tools should help Aboriginal representatives in EWAGs to expand the scope of environmental watering to include appropriate cultural objectives.

The benefits to environmental watering from including a cultural perspective are potentially significant. Insights gained from the Aboriginal Water Initiative and similarly focused community-led activities can strengthen the basis for environmental flows by connecting them with a broader need. This potential is highlighted by the following principles listed by one such community initiative (Weir et al. 2013):

- country as a meaningful framework for water
- Indigenous nations as an essential part of cultural flows
- recognition of Indigenous ecological knowledge as science
- capacity-building as central to Indigenous nations' full and meaningful participation.

Have Aboriginal cultural values influenced water management decisions?

There are few examples of environmental water deliveries specifically to support cultural values. However, in some cases, water managers have assumed that the objectives of most environmental flows are likely to be consistent with certain cultural flow objectives. Such assumptions need to be confirmed both as a courtesy to Aboriginal people and to further emphasise that multiple objectives can be achieved by single deliveries.

Examples of culturally specific flows are:

- Organisers of an Aboriginal cultural event taking place in the Macquarie Marshes in September 2012 notified the Macquarie-Cudgegong Environmental Flows Reference Group and requested consideration of a cultural flow in the lead-up to the event. The Group agreed to the request and noted that the planned environmental watering would also meet the cultural requirement, which was to have water in the wetland.
- The Hay Aboriginal Community identified 30 Mile Gums wetland on a travelling stock reserve as a culturally significant site and requested environmental watering in 2010. Thirty megalitres was delivered to this site to maintain the condition of the dominant red gums. It remains a watering target.

3 Involving the community in the environmental water management program

3.1 Context

The NSW Government is committed to the cooperative management of environmental water (see Cooperative management of environmental water to improve river and wetland health in NSW; http://www.environment.nsw.gov.au/resources/environmentalwater/140308-env-water-management.pdf), including providing opportunities for community input to decision-making processes. The primary means for local participation in environmental water management is through catchment-based environmental water advisory groups (EWAGs), which are chaired by representatives of Local Land Services.

In NSW there are currently five EWAGs operating under various names:

- Gwydir Environmental Contingency Allowance Operations Advisory Committee
- Macquarie Cudgegong Environmental Flow Reference Group
- Lachlan Riverine Working Group
- Murrumbidgee Environmental Water Allowance Reference Group
- Murray – Lower Darling Environmental Water Advisory Group.

The names reflect the varying origins of each group and were generally chosen by the membership at the time the groups were formalised. All are convened and funded by OEH, with the exception of the Lachlan Riverine Working Group, which was an initiative of the then Lachlan Catchment Management Authority.

Given the important role of EWAGs, the Environmental Water Governance Team commissioned an independent evaluation by researchers from the Institute for Governance and Policy Analysis at the University of Canberra (Lukasiewicz and Dare 2014). This study was undertaken to establish the extent to which EWAGs constitute effective local participation in environmental water management, focusing on two core themes:

1. **EWAG processes.** How EWAGs fulfil stakeholder and government expectations of local participation, including how EWAGs function in terms of group process, resources and participant capacity, identifying best practices among the groups, and suggesting changes to improve group functionality.
2. **EWAG decision outcomes.** The effectiveness of EWAGs as vehicles for democratic participation and localism in environmental water management, identifying challenges of broader participation and communication within EWAG processes, including suggestions for how EWAGs can improve opportunities for broader community involvement.

EWAGs were previously reviewed in 2008 by OEH (Department of Environment and Climate Change 2008).

The summary and the recommendations of the independent evaluation follow. Also included are the proposed responses by OEH to the recommendations. These responses were developed by relevant Regional Operations staff and included consultation with EWAG Chairs

3.2 Conclusions and recommendations of the independent study of EWAGs

EWAGs serve multiple purposes, including acting as a sounding board for the implementation of environmental watering, providing community endorsement for watering actions and acting as a forum for information exchange. While EWAG structures (in terms of meeting formats and positions) are largely standardised, the decision-making processes and the perceived level of influence that EWAGs exercise over environmental water management differ between more established and relatively newer EWAGs. Communication with the broader community has been identified as an ongoing area of concern in most EWAGs and is currently being addressed by the EWAGs through the development of individual communication strategies.

Representation of the community interests within the EWAG membership is important for the success of EWAGs. The processes for joining, participating and exiting EWAGs have been ad hoc and sporadic as EWAGs evolved and responded to internal and external pressures. Given the roles that EWAGs are fulfilling, they face challenges in achieving effective representation of broader interests (including Aboriginal, environmental and younger generation perspectives) and their efforts to expand direct representation need to be supplemented with effective communication methods and greater access to EWAGs by the wider community.

EWAGs are an important platform for communities to deal with existing and ongoing tensions and conflicts around environmental water, which include pre-existing conflicts regarding land management, public policy and perceived impacts on private property (both positive and negative). Due to ongoing reforms in environmental water management, EWAG responsibilities are expanding, prompting concerns over the ability of current Members to undertake further EWAG business, and the ability to replace Members. This makes capacity building of existing Members and succession planning for future Members critical for the future of EWAGs.

Overall EWAGs are a successful mechanism for public participation in environmental water management and reflect an effective localism approach, although with limitations. The opportunity for EWAGs to develop solutions for their local context is blurred in practice due to some exclusionary processes in developing draft environmental watering plans. The limited involvement of stakeholders in some EWAGs reduces the range of perspectives and experiences considered throughout plan development. Community members external to the EWAG membership have very little to no opportunity for input into decision-making, which if unmanaged can result in the reinforcement of existing power relations and the reduction in broader community capacity regarding environmental water management. Through improvements to the group processes, the accessibility of EWAG forums and communication with the broader community, EWAGs have the capacity to become an important example of localism for environmental water management in the Murray-Darling Basin.

The following recommendations for improving the process and participatory qualities of Environmental Water Advisory Groups have been developed from the results of the evaluation

Recommendation 1: Governance

Improved Environmental Water Advisory Group Governance

The governance of EWAGs must be clear, consistent over time and perceived to be fair and legitimate. Recommendations for improved governance of EWAGs include the following:

a. *Clarification of EWAG roles and responsibilities with respect to other government agencies (NSW and Commonwealth) and codification of these in appropriate policy and legislative documents to ensure that upcoming reforms do not dilute or distort the primary business of EWAGs.*

Proposed OEH response: Agree

Proposed implementation: Clarify roles through inter-agency forums. Acknowledge EWAGs in water-sharing plans and codify roles in updated terms of reference. Undertake business planning with each EWAG.

b. *Development of a formal and well documented decision-making framework that clearly identifies environmental watering priorities, criteria for decision-making and explicit decision points where EWAG Members can deliberate on proposed actions and solutions and agree or disagree with final derived actions.*

Proposed OEH response: Agree

Proposed implementation: Regional Operations to develop a framework for each EWAG to customise and integrate with its business plan. Include a section in the annual outcomes report on EWAG business performance.

c. *Development of appropriate grievance mechanisms to be incorporated into the Terms of Reference (or other appropriate document). The grievance mechanism will comply with government protocols and standards and will provide a process that enables EWAG Members and the broader community to discuss concerns with Member behaviour, including the behaviour and effectiveness of the Chair and Executive Officer.*

Proposed OEH response: Agree

Proposed implementation: Update terms of reference to be consistent with OEH grievance procedures.

d. *Clarifying the role of the Chair and ensuring Chairs have access to sufficient training. The impartial role of the Chair is fundamental to the proper conduct of meetings and hence the success of the EWAG. Necessary leadership, conflict resolution, group psychology and facilitation training should be provided to Chairs to ensure they are able to conduct this role effectively.*

Proposed OEH response: Agree

Proposed implementation: Hold annual meeting of Chairs and establish a supporting network. Develop a range of information/marketing products for Chairs and EWAG members. Consider possible future training costs for Chairs if a further need is identified.

Recommendation 2: Membership

Ensuring sustainable retention and participation of Environmental Water Advisory Group members

Engagement in EWAGs is a long-term investment for Members who need opportunities to enhance their capacity to participate. The following recommendations are designed to maximise Member participation in EWAG processes:

a. *The development and implementation of an induction program that includes basic information regarding the EWAG (history, membership and their interests); current operating protocols and EWAG roles and responsibilities; and an overview of water management in the Murray-Darling Basin, including environmental water management, water licensing and trading and other elements important for EWAG decision-making.*

Proposed OEH response: Agree

Proposed implementation: Develop an induction package for all environmental water, involving relevant NSW and Commonwealth agencies.

b. *The provision of mentors for new Members. Mentors from within the group membership can help new Members integrate with the group and reduce the feeling of alienation.*

Proposed OEH response: Agree

Proposed implementation: Outline a framework for mentors in terms of reference

c. *Alternatives should be encouraged to attend meetings, provided their participation is effectively managed. Through attending meeting Alternatives will enhance and maintain their understanding of group process and deliberations, and the broader environmental water management context.*

Proposed OEH response: Agree

Proposed implementation: Outline a framework for alternatives in terms of reference. Need to apply consistency across EWAGs.

d. *Sitting fees should be paid to EWAG community participants as recognition of their value and expertise to support Member retention and group functionality.*

Proposed OEH response: Agree

Proposed implementation: Update terms of reference once committee processes are agreed to by government.

Recommendation 3: Representation

Development of improved review and selection process for group Members

The effectiveness of EWAGs as a mechanism for community involvement relies on a good representation of community interests and perspectives. The development of a systematic Member selection process is required that includes:

a. *Clear and transparent selection criteria upon which new membership is based. Such criteria would be based on EWAG roles and core focus, and developed to ensure adequate representation of interests, expertise and demographics, and will identify prioritisation criteria where relevant (e.g. affected stakeholders, marginalised groups).*

Proposed OEH response: Agree

Proposed implementation: Update terms of reference and develop business plans for each EWAG to outline strategic direction and document selection processes to provide appropriate representation.

b. *EWAG membership protocols which establish minimum requirements for participation to emphasise the importance of attending EWAG meetings, and processes that effectively deal with Members leaving the group and Member succession.*

Proposed OEH response: Agree

Proposed implementation: Update terms of reference and develop business plans for each EWAG to maximise retention of knowledge.

Recommendation 4: Communication

Increasing the public profile of Environmental Water Advisory Groups through improved public access to process and outcomes

EWAGs are critical for ensuring public participation within environmental water planning. A greater public awareness of EWAGs and their role in the wider community is essential to their role. The following actions are recommended to improve broader community involvement in environmental water planning:

a. *Inviting community representatives as Observers to EWAG meetings and or/activities to enable external community representatives an opportunity to provide alternative perspectives and insights into EWAG deliberations.*

Proposed OEH response: Agree with qualification

Proposed implementation: Intention supported but needs to be balanced by potential to constrain decision-making capacity and introduce high transaction costs. Approach to be outlined in individual EWAG business plans. Update terms of reference to include guidance and induction of observers.

b. *The provision of publicly available minutes and/or summary documentation to provide the wider community with accessible information regarding the decision-making process and outcomes.*

Proposed OEH response: Agree with qualification

Proposed implementation: Preference for meeting communiqués that balance the need for broad communication with potentially sensitive discussions among members.

c. *The development of an effective and comprehensive communication strategy that promotes the role and activities of EWAGs, enables the inclusion of community representatives, and develops the broader community capacity regarding environmental water management.*

Proposed OEH response: Agree

Proposed implementation: Agency responsibility. Currently being developed with links to OEH environmental water communication strategy and including processes required to develop Long-term Watering Plans.

Recommendation 5: Regular monitoring

Develop an ongoing monitoring and evaluation strategy to promote group functionality and Member retention

EWAGs represent a considerable investment for the NSW Government and EWAG Members. It is therefore essential to develop a monitoring and evaluation strategy to ensure ongoing improvement in group functionality and outcomes. This strategy may include:

a. *A biennial self-evaluation to identify challenges and enablers to a) the EWAG as a whole, and; b) their participation within it.*

Proposed OEH response: Agree

Proposed implementation: Could be outsourced to provide both appropriate expertise in design and independence of process. Approach needs to be co-developed with operational staff. Utilise annual Chairs' forum to discuss.

b. *Provision of opportunities for learning across the groups. This could take the form of meetings between group Chairs and/or collaborative forums between interested Members from different EWAGs.*

Proposed OEH response: Agree

Proposed implementation: Inaugural Chairs meeting held October 2014, leading to ongoing commitment to hold further annual meetings. Revise the format of annual review workshops to focus on cross-group learning.

c. *Access to appropriate and regular monitoring and evaluation of environmental water outcomes to guide the development of future water management plans.*

Proposed OEH response: Agree

Proposed implementation: Subject to consolidating processes under way as part of Basin Plan implementation activities, OEH will co-ordinate an effective and efficient monitoring program for 5-year periods with ongoing commitments subject to performance evaluation.

4 Findings and recommendations

The EWMP operates in a complex and uncertain world. Like most conservation programs, the EWMP is embedded in a larger socio-ecological system and possesses many of the characteristics of what have become known as 'wicked problems'. Wicked problems generally lack clear solutions, because each problem is linked to other problems and the nature and identity of each cannot be isolated. They feature many interacting elements, constant change which is often irreversible, nonlinear interactions between elements and no clearly defined boundaries to the system.

Research (Game et al. 2013) into complexity across several disciplines provides insights to guide future directions for the EWMP. Commonly accepted notions of best practice, adaptive management and standardized planning approaches ignore the realities of complex systems. These realities are that there is no 'right' solution (rather, there are trade-offs that appear more or less acceptable depending on perspectives) and that measuring performance can be problematic.

Features of a program responding to the challenges of complexity include:

- nurturing of creativity: encourage a willingness to disrupt existing behaviours and respond openly to competing and creative options
- distributed leadership: decentralize strategic analysis and acknowledge the need for diverse inputs to decision-making
- clearly defined and shared objectives that leave space for flexibility in how tasks are achieved
- use of multiple scenarios to predict the likely impact and benefit of management strategies
- transparent and constructive communication about successes and failures.

The EWMP did not begin as a structured program with an established identity. It evolved to incorporate several NSW Government initiatives with similar objectives that could in part be met by management of allocated environmental water. These additional responsibilities were absorbed within the existing structure and resources of OEH.

The novelty of the EWMP meant that the initial priorities were to determine the scope of the new responsibilities and then identify the associated roles and allocate them across OEH. This approach relied on individuals across existing work teams developing a shared purpose—a typical bottom-up approach. Its strength was the practical focus brought early to developing effective practices. Its weakness was the lack of a clear identity at the corporate level. Over time, the organisational structure has recognised and consolidated the EWMP. It has matured into a credible and effective program, either incorporating or identifying the need for features consistent with managing complex systems.

As the EWMP blended several programs, it is only one of many contributors to the larger Murray-Darling Basin program, as defined by the Basin Plan. There are substantial efficiencies possible from developing institutional arrangements that encourage, rather than stymie, collaboration and creativity to deliver improved outcomes at the Basin scale. The leadership challenge is to recognise potential and foster flexibility.

4.1 Findings

Environmental outcomes

- The condition of wetland vegetation communities in wetlands targeted for environmental watering has improved since the EWMP started.
- Some of the improvement can be attributed directly to management of allocated environmental water, and some can be implied by modelling. Uncontrolled flooding from late 2010 until mid-2012 provided the major source of water to the environment.
- Allocated environmental water improved the diversity and abundance of aquatic plants and the recruitment success of colonial waterbirds by either increasing the frequency of watering or extending the duration of individual events. It also maintained critical refuge habitat for the endangered southern bell-frog at the end of the Millennium drought.
- The condition of wetland plant and animal communities has not generally returned to that observed before the Millennium drought. Recovery pathways are uncertain for many plant and animal species, given the extreme range of conditions experienced since 2006. Watering regimes required to restore condition are likely to differ from those needed to maintain condition.
- Models providing outputs with and without the addition of allocated environmental water predict improvements in habitat quality for most biodiversity for which we have a good knowledge of response to water regimes.
- The contribution of water available under licences held by the Minister for the Environment was modest. It averaged 10% of all environmental water actively delivered (including water under allowances in water-sharing plans and allocations under licences held by the Commonwealth Environmental Water Holder) and less than 5% of all water (including rules-based environmental water under water-sharing plans) delivered to watering targets. However, this contribution provides important flexibility when targeting specific environmental outcomes that cannot be met by the rules in water-sharing plans.
- Cooperative arrangements with the Commonwealth Environmental Water Holder ensure the integrated management of all available environmental water.

Program components

- There is no reason to make substantive changes to the EWMP. The main components are appropriate. All, except purchase of water entitlements, are likely to continue in the long term. Planning for, delivering and reporting on the use of allocated environmental water will in future be driven primarily by the requirements of the Murray-Darling Basin Plan.
- The major weaknesses of the EWMP are:
  - the lack of formal, long-term planning to communicate broadly the scope, intent and constraints for managing allocated environmental water in each water source
  - the need for a complementary monitoring program covering all valleys where allocated environmental water is managed, as the basis for assessing how well planning objectives are being met and improving the quality of those objectives (i.e. making them SMART).

The independent review found that EWAGs are an effective means of sourcing local community stakeholder input to decision-making; the input they provide is critical for the sustainability of the EWMP. There is scope to improve governance arrangements and strengthen connections between EWAG business and the broader community through better communication, ensuring that stakeholder representation adequately reflects the community of interest; there is also a need for more formal recognition by government of the role performed.

- Because of their effectiveness, EWAGs are likely to be called on to provide community views on other water planning and management processes. It is important to ensure that their contributions to the EWMP are not compromised by additional demands, and that they retain sufficient flexibility to determine effective operational cultures.
- There is scope to improve communication within the EWMP in order to:
  - define and share objectives
  - report on achievements in a timely way
  - highlight the trade-offs between possible management options
  - provide opportunities for broad and creative input.
- The potential for models to support planning and evaluation components is not yet realised. First-generation models were generally developed without strong input by managers, and the outputs did not match observations.
- Continual improvements to the EWMP are expected to occur within all components by the use of existing evaluation and review procedures under the coordination of the Environmental Water Governance Team.
- Five-yearly evaluations under the Murray-Darling Basin Plan (first due in 2019) will provide an external perspective on the EWMP to determine its effectiveness and drive required changes to components.
- Existing institutional arrangements do not always provide an operating environment that fosters the creativity and risk-taking needed to test the limits of current knowledge. Fear of failure and adverse reactions to it lead to introspection rather than an open co-learning environment.

Complementary activities

Activities primarily undertaken as part of the EWMP have also influenced or contributed to other activities and processes within OEH. Some examples are:

- Developing knowledge strategies to ensure that investments in science are relevant to organisational needs. Early work identifying knowledge gaps relevant to environmental water management strongly influenced the approach adopted more broadly across OEH; it also underpinned the resulting Water and Wetlands Knowledge Strategy.
- Developing mechanisms for cross-functional input to large-scale programs. The EWMP identified early on the need to formalise opportunities for input by all functional groups within OEH. Regional Operations has applied a similar model for the range of activities it undertakes.
- Infrastructure works on wetland reserves. The availability and active management of environmental water have highlighted opportunities to improve biodiversity outcomes on reserves and elsewhere through the addition of, or improvements to, infrastructure.
- Meeting international obligations for wetlands and wetland species. The likely change in ecological character of the Macquarie Marshes Ramsar site prompted a formal notification to the Ramsar Secretariat by the Australian Government in 2010. Various actions under the EWMP were included in a response strategy prepared by OEH; these actions prevented a finding of adverse change in ecological character. (See http://www.environment.nsw.gov.au/wetlands/20130104mmrsart32.htm.)
- Contributing information to other floodplain or wetland planning projects, for example floodplain management plans prepared by the Healthy Floodplains Team in OEH (see Rural floodplain management at http://www.www.environment.nsw.gov.au/floodplains/ruralfloodmanagementplanning.htm) or the Nimmie-Caira System enhanced environmental water delivery project implemented by NOW (see http://www.water.nsw.gov.au/__data/assets/pdf_file/0006/548187/water-recovery-nimmie-caira-enhanced-environmental-water-delivery.pdf).
- Influencing related activities of Commonwealth partners. The experience gained under many components of the EWMP has informed a similar program implemented by the Commonwealth Environmental Water Office, as well as elements of Murray-Darling Basin Plan implementation. OEH's water managers and wetland scientists are considered leaders and receive many requests for advice and input to Basin-scale issues.
- Influencing Basin Plan implementation. The experience gained under the EWMP has allowed OEH to gather details of the activities and funding required to implement Basin-planning implementation requirements.

Progress since June 2013

The new organisational structure within Regional Operations clearly recognises the required roles and accountabilities to deliver the EWMP, and the Environmental Water and Floodplains Working Group provides an appropriate means to connect with other relevant work groups in OEH.

The EWMP is continually evolving. Initially, many activities were driven by accountability requirements as the program established legitimacy. Importantly, improvements now are generally driven by an identified management need and adopted when there is an appropriate capacity to do so. Capacity is determined by a mix of available resources and current management skills. This shift recognises a generally improved understanding and acceptance of environmental water management and a changing focus on outcomes rather than process. The involvement of the community via EWAGs is critical for this acceptance.

4.2 Recommendations

1. Formally recognise the EWMP and identify it as a priority initiative within OEH. The EWMP involves management of a valuable public asset, with similarities to management of land for biodiversity and cultural outcomes. Formal recognition should strengthen the current whole-of-organisation input, identify adequate levels of resourcing over realistic time frames and encourage good governance for the management of a valuable public asset.
2. Refine the EWM Program logic and develop a formal, long-term evaluation strategy for whole-of-program and individual program components. The experience gained since 2006 provides a practical foundation to improve the links between expected outcomes, evaluation questions and performance indicators.
3. Strengthen the contribution by EWAGs to the EWMP by implementing the coordinated responses to the recommendations of the independent review, as described in '3 Involving the community in the EWMP'.
4. Assess and plan resource needs on a 5-year cycle, aligning with the Basin Plan evaluation timetable and guided by an operational plan. Each evaluation should inform subsequent funding decisions.
5. Allocate funding to undertake monitoring activities and the analysis and reporting of information obtained. Monitoring and evaluation by OEH will increasingly integrate with Commonwealth Environmental Water Holder and Murray-Darling Basin Authority activity under the Basin Plan framework. The value of long-term information, shared among agencies and the community and covering a range of watering and climate scenarios, will increase.
6. Co-develop plans on the desired extent and condition of water-dependent ecosystems to encourage a diversity of voices and incorporate a broad view of expertise. Long-term watering plans to be developed under the Basin Plan and resourced by the Implementation Agreement between NSW and the Commonwealth provide the means to do this effectively.

7. Continually improve institutional arrangements to foster flexibility, creativity and distributed decision-making and encourage risk-taking to test knowledge boundaries. This acknowledges that the EWMP is one of several programs helping to achieve the objectives of the Basin Plan. Effective arrangements should operate at both valley and Basin scales and should recognise the role of EWAGs.
8. Continually update the OEH Water and Wetlands Knowledge Strategy to recognise the technical support required to improve the planning, operational and reporting components of the EWMP. The uncertainty from limited knowledge of recovery processes in stressed wetlands, together with the lack of clearly articulated environmental outcomes desired at local, regional and Basin scales, highlights the importance of an ongoing knowledge acquisition program to complement the EWMP.
9. Seek to establish a single source of communication where ever possible, in order to reinforce the fact that individual programs are contributing to a larger program objective, namely the Basin Plan. An obvious example is a dedicated website highlighting all watering targets in the Basin, with information on past, current and planned watering activities, asset condition and ecological responses.
10. Initiate a coordinated communication strategy among NSW and Commonwealth partners, with all partners contributing resources toward its implementation. OEH's environmental water management role and direct links to the community via EWAGs
11. Improve the use of models to inform planning and evaluation components of the EWMP. Models can provide significant efficiencies by predicting outcomes from multiple scenarios to support planning; discriminating the contributions of individual management actions or sources of water; and allowing the extrapolation of results to areas where there is no active monitoring. However, models must be co-developed with managers (users) to be credible.
12. Develop a succession plan to ensure an appropriately skilled workforce in the long term. The skill set required for effective environmental water management is based strongly on experience and the standing of individual officers within the local regional community. OEH has highly skilled operational staff who are valued by their local community. The current Regional Operations structure will foster the transfer of experience over time.

References

Campbell C, Healy S and D'Santos P (2013) *E-watering and wetland vegetation: Post-flooding response and comparison. Draft Report prepared in conjunction with NSW Office of Environment and Heritage by The Murray-Darling Freshwater Research Centre, MDFRC Publication 31/2013, June, 87* pp.

Department of Environment and Climate Change (2008) *Review of NSW Environmental Water Advisory Groups NSW. Report to the NSW Office of Environment and Heritage. Department of Environment and Climate Change*, Sydney.

Game ET, Meijard E, Sheil D and McDonald-Madden E (2013) Conservation in a wicked complex world; challenges and solutions. *Conservation Letters* 7(3):271–277. doi:10.1111/conl.12050

Kingsford RT, Blino G, Porter JL and Brandis K (2013) *Waterbird communities in the Murray-Darling Basin (1983–2012). Australian Wetlands, Rivers and Landscapes Centre, University of New South Wales. Report to Murray-Darling Basin Authority*, Canberra.

Lukasiewicz A and Dare L (2014) *Evaluation of NSW Environmental Water Advisory Groups. Report to the NSW Office of Environment and Heritage. Institute for Governance and Policy Analysis, University of Canberra*, Canberra.

Price C, White L and Haigh S (2014) *Fivebough-Tuckerbil Swamp Adaptive Environmental Management Plan. Compiled for NSW Trade and Investment – Crown Lands by WetlandCare Australia.*

*Roberts J and Robinson W (2014) River Red Gum Condition and Recovery at Murrumbidgil Swamp in the Lower Lachlan Alluvial Fan, October 2013. Report to NSW O*ffice of Environment and Heritage, Queanbeyan. Report JR 33/2014. Canberra, ACT 2602. August.

Spencer JA, Wassens S, Hunter D, Maguire J, Hardwick L, Webster R, Childs P and Maher M (2013) *Draft Management Plan for the Southern bell frog in the Murrumbidgee Catchment.* NSW *O*ffice of Environment and Heritage, Sydney.

Spencer J, Hosking T, Ewin P, Webster R, Hutton K, Allmann R, Thomas R, Humphries J, Berney P and Mulholland M (2014) *Waterbird Monitoring in Inland NSW: Summary Report 2012–13. NSW Office of Environment and Heritage, Sydney.*

Wassens S, Healy S and Watts R (2010) Optimising Frog Breeding Responses to Flooding in Managed Wetlands (ii) Frog Distributions through the Murray Floodplain. Final report to NSW DECCW, Institute for Land, Water and Society, Albury.

Weir, JK, Ross, SL, Crew, DRJ and Crew, JL (2013) *Cultural Water and the Edward/Kolety and Wakool River System, research report, Australian Institute of Aboriginal and Torres Strait Islander Studies Centre for Land and Water Research, Canberra.*

www.environment.nsw.gov.au