



Long Term Intervention Monitoring Project Edward-Wakool River System Selected Area Project Progress Report #10

Reporting period: 1 October to 31 December 2016 (2016-17 Watering Year)

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Hypoxic blackwater in the Wakool River zone 4 site 1, November 2016 (Photo: R. Watts)

Further information:

Professor Robyn Watts (Edward-Wakool LTIM Project Leader)
School of Environmental Sciences, and Institute for Land, Water and Society
Charles Sturt University, PO Box 789, Albury NSW 2640
Ph:+61 2 6051 9807 Email: rwatts@csu.edu.au

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Summary of progress against monitoring and evaluation activities

This is the tenth progress report for the Edward-Wakool Long-Term Intervention Monitoring (LTIM) and Evaluation Project. This report contains a summary of work undertaken between October and December 2016 (Table 1). Other reports since the commencement of the project in July 2014 and September 2016 are available on the project website <http://www.csu.edu.au/research/ilws/research/sra-sustainable-water/edward-wakool-research-project>

Table 1. Summary of progress on the Edward-Wakool LTIM Project October to December 2016

Activities	Overview of progress from October to December 2016
Monitoring activities	
Hydraulic modelling	<ul style="list-style-type: none"> 2D hydraulic modelling reported in 2014-15 annual report. No modelling undertaken in 2016
River hydrology	<ul style="list-style-type: none"> Hydrological data from NSW Office of Water gauges regularly downloaded from the web Depth loggers at 7 sites were downloaded monthly The water levels on staff gauges were recorded once per month where possible
Stream metabolism	<ul style="list-style-type: none"> Dissolved oxygen loggers are downloaded monthly and probes are usually cleaned fortnightly. Some loggers could not be downloaded in Oct and Nov 2016 due to the flood Monitoring of nutrients and carbon undertaken monthly at sites where loggers installed
Carbon & water quality	<ul style="list-style-type: none"> Additional water monitoring was triggered by the hypoxic blackwater event. Water samples were collected upstream, downstream of four irrigation canal escapes plus within the canals
Riverbank and aquatic vegetation	<ul style="list-style-type: none"> Monitoring of aquatic and riverbank vegetation at fixed transects in four zones is usually undertaken monthly. No monitoring undertaken in October 2016 due to the flood
Fish larvae	<ul style="list-style-type: none"> Light trap sampling undertaken fortnightly. Some sites could not be monitored due to the flood Drift net sampling was undertaken over seven consecutive fortnights commencing 26 September 2016 and was completed on 23 December 2016
Fish recruitment	<ul style="list-style-type: none"> Sampling of young-of-year fish recruits with backpack electrofisher, set lines and angling will be undertaken in February and March 2017
Fish (river)	<ul style="list-style-type: none"> Fish community monitoring at Category 1 sites will be undertaken in May 2017 DPI Fisheries collected otoliths (ear bones) from fish that died as a result of hypoxia during late Oct/early Nov 2016. These will contribute to Basin-wide analysis undertaken by MDFRC
Fish movement	<ul style="list-style-type: none"> Receivers for the assessment of fish movement are usually downloaded four times per year. The download scheduled for Oct 2016 was delayed to Dec 2016 due to the flood
Evaluation activities	
Annual report	<ul style="list-style-type: none"> 2015-16 Edward-Wakool Monitoring and Evaluation synthesis report (Watts et al. 2016) was submitted in September 2016 and is under review by CEWO.
Progress reports	<ul style="list-style-type: none"> Progress reports submitted quarterly are available on the project website
Monitoring data	<ul style="list-style-type: none"> The 2015-16 monitoring data were uploaded into the CEWO Monitoring Data Management System from August through to October 2016
Communication and engagement	
Environmental Water Reference Group	<ul style="list-style-type: none"> The second meeting of the EWEWAG was held on 16th Nov at the Caldwell Hall followed by a walk at Thule Lagoon. Dr Julia Howitt presented an update on LTIM water quality monitoring
E-W Operational Advisory Group	<ul style="list-style-type: none"> The EWOAG met frequently between Oct and Dec 2016 during the flood event to coordinate delivery of Commonwealth environmental water through MIL escapes
Other stakeholder engagement	<ul style="list-style-type: none"> The Murray Dissolved Oxygen Group met regularly during the flood event CEWH media release October 24th to inform of refuge flows in the Edward-Wakool CSU media release 1st November on blackwater monitoring CSU published information sheet 20th Dec to answer FAQ about blackwater (see https://www.csu.edu.au/research/ilws/research/sra-sustainable-water/edward-wakool-research-project/Blackwater-event-in-the-Murray-in-2016.pdf) Prior to each monitoring trip landholders whose properties are accessed to undertake sampling are contacted

- **Appendix A** provides additional information about the project for the Edward-Wakool system
- **Appendix B** provides a map showing the location of hydrological zones that will be monitored
- **Appendix C** provides a summary of LTIM monitoring to be undertaken from 2014-2019.

Commonwealth environmental water use in the Edward-Wakool River system between October and December 2016

Widespread flooding in south-eastern Australia in 2016 resulted in a hypoxic (low dissolved oxygen, DO) blackwater (high dissolved organic carbon) event affecting a large area of the southern Murray-Darling Basin. There was concern that prolonged low DO would result in death of aquatic fauna, as a similar event in 2010 resulted in widespread fish deaths.

Australian federal and state governments and local stakeholders met to discuss the opportunities to create local refuge areas by releasing environmental flows with higher DO and lower DOC from irrigation canals via regulating structures (known as 'irrigation canal escapes') into rivers in the Edward-Wakool system after the flood peak had passed (Figure 1). The Murray Dissolved Oxygen Group, the Edward-Wakool Operations Advisory Group, and the Edward-Wakool Environmental Water Reference Group met frequently by teleconference during the event to share information, discuss options and plan watering actions and other activities to mitigate the negative impacts of the hypoxic blackwater. Landholders and the broader community were regularly consulted with respect to watering decisions.

In addition, a group of local community members installed borrowed and homemade improvised aerators (Figure 2) that introduce turbulence to the water surface or bubble air into the water column in an attempt to create small fish refuges by temporarily raising the DO.

Colligen-Niemur system

- Implementation of this watering action commenced 17/10/2016 and ended 16/12 2016. 3240 ML delivered
- Escape flows to provide hypoxic water refuge for fish and other aquatic biota. Up to 80ML/d from the Neimur syphon and some smaller flows to the Jimaringle Creek. Flows ceased by 16/12/2016 due to improvements in upstream DO

Edward River

- Implementation of this watering action commenced 24/10/2016 and ended 8/12/2016. 74,822 ML delivered
- Escape flows to provide hypoxic water refuge for fish and other aquatic biota. Staged approach up to 2,400 ML/d from Edward Escape. Flows decreased by 300ML/d from 2/12/2016-8/12/2016 due to increases in upstream DO.

Wakool River

- Implementation of this watering action commenced 31/10/2016 and ended 30/12 2016. 29,306 ML delivered
- Escape flows for hypoxic water refuge at the Thule, Wakool and other minor Wakool Escapes of up to 585 ML/d (40, 500 and 45 ML/d respectively). Flows through the Thule and other minor escapes were maintained until 16/12/2016 due to DO improvements upstream. The Wakool escape was operated at 500ML/d until 30/12/2016 to assist with maintaining good DO levels further downstream due to the influence of low DO outflows from Koondrook-Perricoota Forest.



Figure 1: Left: Water from the Wakool irrigation escape (cloudy, containing high dissolved oxygen and low dissolved carbon) mixing with water from the Wakool River (dark brown, containing low dissolved oxygen and high dissolved carbon) to create a local fish refuge (Photo: Robyn Watts 9/11/2016) Right: Commonwealth environmental water being delivered via the Thule escape to Thule Creek (Photo Robyn Watts)



Figure 2: Left: Small aeration system deployed in the Edward River upstream of Moulamein to create a local fish refuge (Photo: Roger Knight 1/11/2016). Right: Improved aeration system installed by local landholder

Field observations – October to December 2016

Observations from monitoring undertaken between October and December 2016 are provided in this report. Observations prior to October 2016 are in previous progress reports (see Edward-Wakool LTIM website <http://www.csu.edu.au/research/ilws/research/sra-sustainable-water/edward-wakool-research-project>).

1. Water quality

Water quality sampling was undertaken from October to December 2016, however water samples could not be collected from some sites due to the flood. Sampling was also undertaken at additional sites associated with the irrigation escapes. For more information on the water quality during the 2016 hypoxic blackwater event see <https://www.csu.edu.au/research/ilws/research/sra-sustainable-water/edward-wakool-research-project/Blackwater-event-in-the-Murray-in-2016.pdf>

Figure 3b shows the dissolved oxygen (DO) concentrations in the Edward River at Deniliquin and the Wakool River at Gee Gee Bridge from 1 June to 19 December 2016. Between October and December 2016 the DO concentrations were less than 4 mg/L, when fish are known to become stressed, and there were also many weeks when the DO was less than 2 mg/L, when fish deaths are expected to occur.

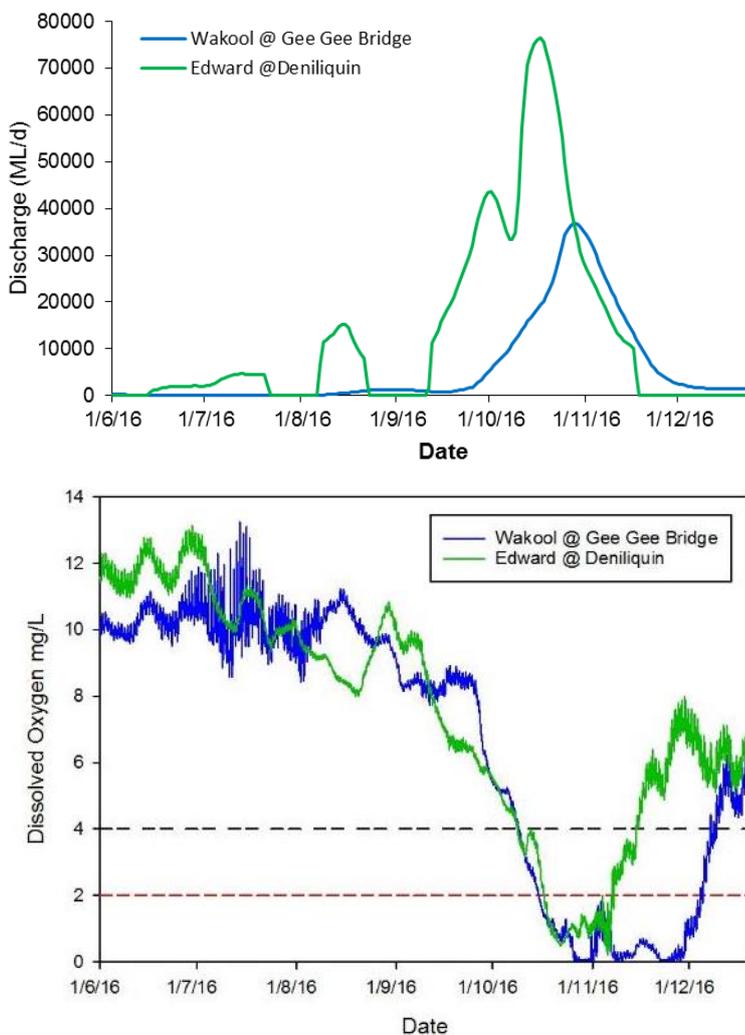


Figure 3: a) Discharge in the Wakool River at gee gee bridge and in the Edward River at Deniliquin, from June to December 2016 and b) Dissolved oxygen concentrations in the Edward and Wakool Rivers from June to December 2016. The dotted lines represent concentrations at which fish are known to become stressed (4 mg/L) and when fish deaths can occur (2 mg/L).

There was a small peak in dissolved organic carbon (DOC) concentrations in the upper part of the study area during mid- August followed by the main peak in mid-October and then a period where DOC concentrations gradually declined from early November onwards (Figure 4). During October and December 2016 the concentrations of DOC were very high at some sites, particularly in the Wakool River at Gee Gee Bridge (Figures 4 and 5) that was affected by pulses of DOC moving down the Wakool River from upstream as well as inputs from Koondrook-Perricoota Forest via Thule and Barber Creek inflows. The carbon concentration in the Mulwala canal was considerably lower (Figure 4), making it a useful source of water for the delivery of refuge flows. In the Edward River at Deniliquin, DOC declined from 12 mg/L to 5.5 mg/L between the end of October and mid-December, and it was only slightly above normal for that time of year. By mid-December DOC had started to decrease in Thule Creek but high DOC (around 26 mg/L) persisted in Barber Creek. The Wakool River at Gee Gee Bridge (downstream of these sites) had DOC at 8 mg/L, reflecting improved water quality from upstream and reduced inputs from Koondrook.

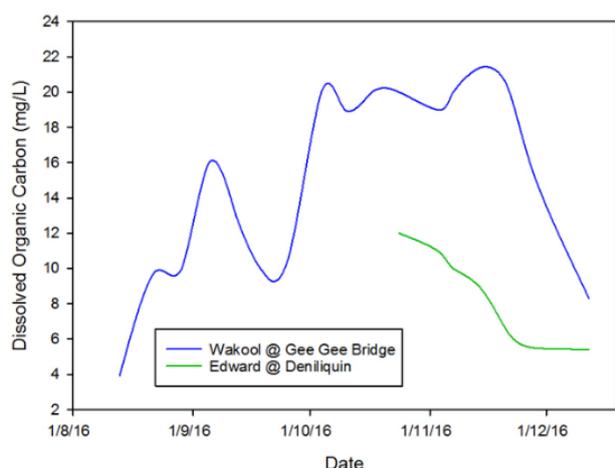


Figure 4: Dissolved organic carbon (DOC) concentrations in the Edward and Wakool Rivers from August to December 2016.

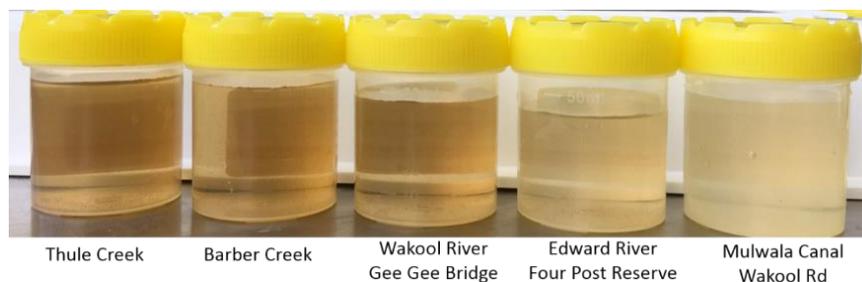


Figure 5: Water samples collected from sites in the Edward-Wakool system collected on 23 November 2016. The darker coloured water has highest dissolved organic carbon concentration

2. Fish community monitoring

In October and early November 2016 there were fish deaths reported throughout the Edward-Wakool system in association with the hypoxic blackwater. As the hypoxic blackwater was in response to a very large flood event, it was not possible for Commonwealth environmental water to fully mitigate the impacts of this hypoxic blackwater event. However, considerable effort was undertaken by communities, individuals and water management agencies to provide local refuges for native fish and other freshwater animals through the release of environmental flows with higher DO and lower DOC from irrigation canals (Figure 1) and the installation of aerators (Figure 2) that introduce turbulence to the water surface or bubble air into the water column in an attempt to create local fish refuges by temporarily raising the DO.



Figure 6: dead fish in the Wakool River, 4th November 2016 (Photo: Luke Pearce)

DPI Fisheries undertook collection of otoliths (ear bones) from fish that died as a result of hypoxia during late October/early November 2016. Otoliths were collected from 135 Murray cod, 13 golden perch and three silver perch in both the Edward-Wakool and Billabong systems during this period (Figure 7). Otoliths will be sectioned in 2017 to provide information on the individual ages of fish by counting the number of annual growth rings on each otolith. Length-age data will be used by the LTIM team to support the basin-scale evaluation of Commonwealth environmental watering (this project being undertaken by Murray-Darling Freshwater Research Centre). Age data will also be used to support other existing projects including matching growth histories to previous environmental conditions for long-lived species such as Murray cod. Particular thanks are extended to landholders that were proactive during this unfortunate event, including those that granted property access and notified us of the locations and extent of fish kills.

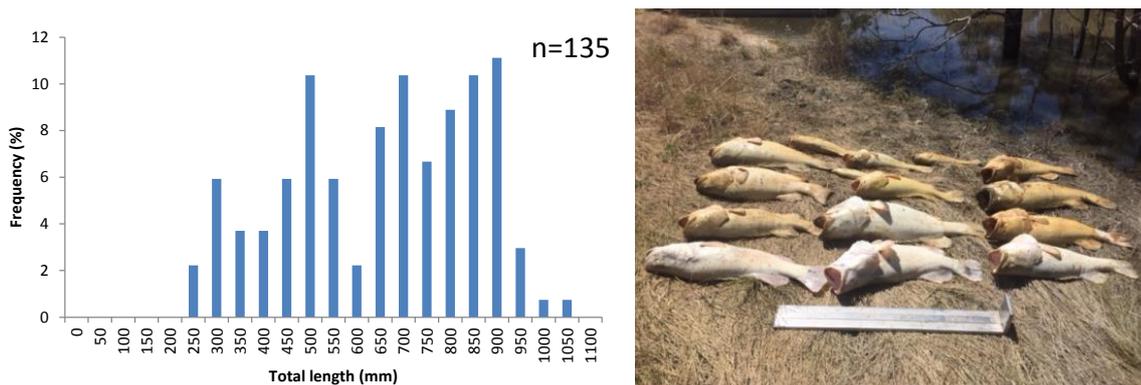


Figure 7. Length-frequency plot of Murray cod (left) collected during the recent hypoxic event, and a number of dead Murray cod (right) about to be measured prior to otolith removal.

3. Fish movement monitoring

A download of acoustic receivers (that monitor fish movement within the Edward-Wakool system) was completed on 15th December 2016. The acoustic receiver array monitors fine-scale movements of golden perch and silver perch in Yallakool Creek and the mid-upper reaches of the Wakool River. This is supplemented by a number of receivers funded by Murray LLS that enable us to monitor where tagged fish go (and when) throughout the broader Edward-Wakool system, including into the Murray River.

A total of 51 golden perch and 11 silver perch have been fitted with acoustic tags during the LTIM project. In the past 6 months 44 golden perch and six silver perch have been detected by the receiver array. High flows in September/October 2016 facilitated the movement of a number of fish out into the wider system, with detections of both species in the Edward River at Stevens Weir, near the Billabong Creek junction and at Kyalite. Tagged individuals of both species were also detected at the Murray-Wakool junction. Further analysis of the data will be undertaken. The effect of hypoxic water on the tagged fish is currently unknown.

4. Riverbank and aquatic vegetation

Surveys of the percent cover and diversity of riverbank and aquatic vegetation are usually undertaken once per month at sites in zones 1 to 4, however due to the flooding no monitoring was undertaken in October 2016 as sites were inaccessible. Some sites were unable to be accessed in November and December.

All of the riverbank transects were underwater during October. In November some transects remained inundated and transects higher up the bank were now exposed and were bare of vegetation (Figure 8). Areas of the floodplain that had been inundated showed strong vegetation response, with nardoo (*Marselia drummondii*), spike rush (*Eleocharis spp*) and water ribbons (*Triglochin spp*) flourishing (Figure 8). Male and female lignum plants were in flower and many were displaying leaf growth in response to the rain and flooding.

Aquatic plants (e.g. milfoil, water primrose and pondweed) that had been observed at most sites in zones 3 and 4 in the previous two years were not present after the flood (Figure 9).



Figure 8: Left - Typical transect after flooding with no emerging veg and exposed banks and litter. Right - newly inundated floodplain December 2016 (Photo Sascha Healy)



Figure 9: Open water at sites formerly prolific with aquatic plants e.g. Zone 3 site 1 (top: Feb 2016/ bottom: Nov 2016)(Photos Sascha Healy)

5. Larval fish monitoring using drift nets and light traps

Light trap and drift net sampling was undertaken each fortnight through October and December 2016. No golden perch or silver perch eggs or larvae were detected over this period, but high numbers of small carp were captured. Only a very small number of Murray cod larvae were collected in the light traps when compared to previous years. By mid-December when the water quality was improving we captured carp gudgeon, flathead gudgeon, rainbowfish, shrimp larvae and a small number of Murray cod larvae in the light traps, as well as small juveniles and adults smelt and gudgeons.

It was amazing to see the abundance of tadpoles and invertebrates that were captured in the nets that would not normally be seen in the river during within bank flows. The flood triggered a huge increase in biomass of aquatic invertebrates mostly Chironomids (non-biting fly larvae), and the microcrustacea order Cladocera (Figure 10). These invertebrates are an important source of food for native fish and other animals. The abundance at some sites on the peak of the flood was many times higher than we have previously observed during regulated flows – at one site sample jars had a combined wet weight of about 1.5 kg of invertebrates, and came from the one drift net.



Figure 10: Invertebrates collected in the drift nets during the flood in the Wakool River (Photo: Nicole McCasker)

Planned activities – January to June 2017

Between January and June 2017 the LTIM Monitoring and Evaluation Team will complete monitoring for the 2016-17 water year. Water quality monitoring will be undertaken monthly until May. The second year of fish recruitment monitoring will be undertaken in February and March. Otoliths from a sub-sample of juveniles will be extracted to determine the age of fish, identify the hatch year, estimate the growth rate and determine the strength of recruitment across years. A basin-wide standardised approach for monitoring the fish community consisting of electrofishing and netting will be undertaken at ten sites within the Wakool River (Wakool Reserve to Bookit Island) in May 2017. This approach utilises fine-mesh fyke nets to maximise catches of small bodied native fish including carp gudgeon, Murray River rainbowfish and un-specked hardyhead and compliments boat electro-fishing. Aquatic and riverbank vegetation will be monitored once per month. Acoustic data to assess fish movement will be downloaded from loggers every three months. During this period the LTIM team will complete laboratory processing of larval fish samples and water quality parameters (carbon, nutrients and chlorophyll-a). The team will also commence analysis of data for the 2016-17 annual report.

Acknowledgements

We respectfully acknowledge the Traditional Owners, their Elders past and present, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual and economic connection to their lands and waters. We extend our thanks to the Wakool River Association, the Edward-Wakool Anglers Association and landholders in the Edward-Wakool river system for allowing access to their properties and for their keen interest in this project. This project was funded by the Commonwealth Environmental Water Office and is a collaboration between Charles Sturt University, Murray Local Land Services, NSW Department of Primary Industries, Monash University, NSW Office of Environment and Heritage and Griffith University. Members of the Edward-Wakool Long-term Intervention Monitoring project team are listed on the Edward-Wakool LTIM website <http://www.csu.edu.au/research/ilws/research/sra-sustainable-water/edward-wakool-research-project>.

Appendix A: The Long-Term Intervention Monitoring Project for the Edward-Wakool system and its context in terms of ecological monitoring and evaluation within the Murray-Darling Basin.

The Long Term Intervention Monitoring (LTIM) Project for the Edward-Wakool river system Selected Area is funded by the Commonwealth Environmental Water Office. The project is being delivered by a consortium of service providers lead by Charles Sturt University (Institute for Land, Water and Society) and includes, NSW Department of Primary Industries (Fisheries), Monash University (Water Studies Centre), Griffith University, NSW Office of Environment and Heritage, and Murray Local Land Services.

The LTIM project is based on a clear and robust program logic, as detailed in the Long-Term Intervention Monitoring Project Logic and Rationale Document. That document sets out the scientific and technical foundations of long-term intervention monitoring and is being applied to areas where LTIM projects are being undertaken. It also provides links between Basin Plan objectives and targets to the monitoring of outcomes from Commonwealth environmental watering actions. For more information, see Monitoring and evaluation for the use of Commonwealth environmental water.

Many different agencies play a role in the reporting on environmental outcomes, consistent with the Basin Plan (see Figure A1 below). The Murray Darling Basin Authority is responsible for reporting on achievements against the environmental objectives of the Basin Plan at a basin-scale, which are broadly focussed on flows and water quality, fish, vegetation and birds across the whole of the Basin. State Governments are responsible for reporting on achievements against the environmental objectives of the Basin Plan at an asset-scale i.e. rivers, wetlands, floodplains. The Commonwealth Environmental Water Holder is responsible for reporting on the contribution of Commonwealth environmental water to the environmental objectives of the Basin Plan (at multiple-scales).

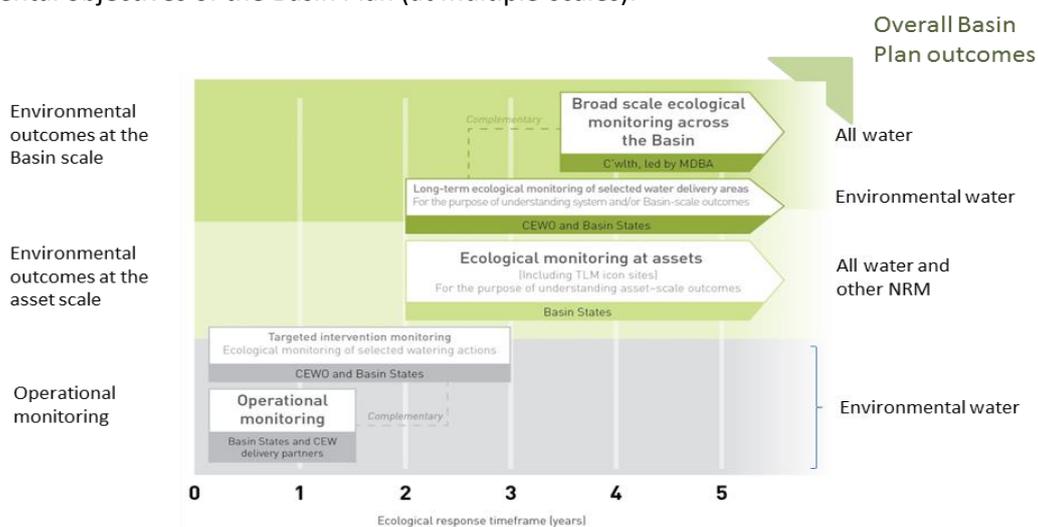


Figure A1. A summary of roles various agencies play in the reporting on environmental outcomes, consistent with the Basin Plan.

Appendix B: Map showing location of sample sites monitored in the Edward-Wakool Selected Area for the Long-Term Intervention Monitoring Project.

The monitoring for the Edward-Wakool LTIM Selected Area Evaluation is focussed on Yallakool Creek (zone 1), the upper Wakool River (zone 2) and mid reaches of the Wakool River (zones 3 and 4)(Figure B1). Fish population surveys are undertaken annually in the focal zone, and a further 20 sites throughout the Edward-Wakool system will be surveyed for fish populations in years 1 and 5. In addition to water quality sampling in the focal area, water quality is also monitored in Stevens Weir and the Mulwala canal as these sites are the potential source of Commonwealth environmental water in this system.

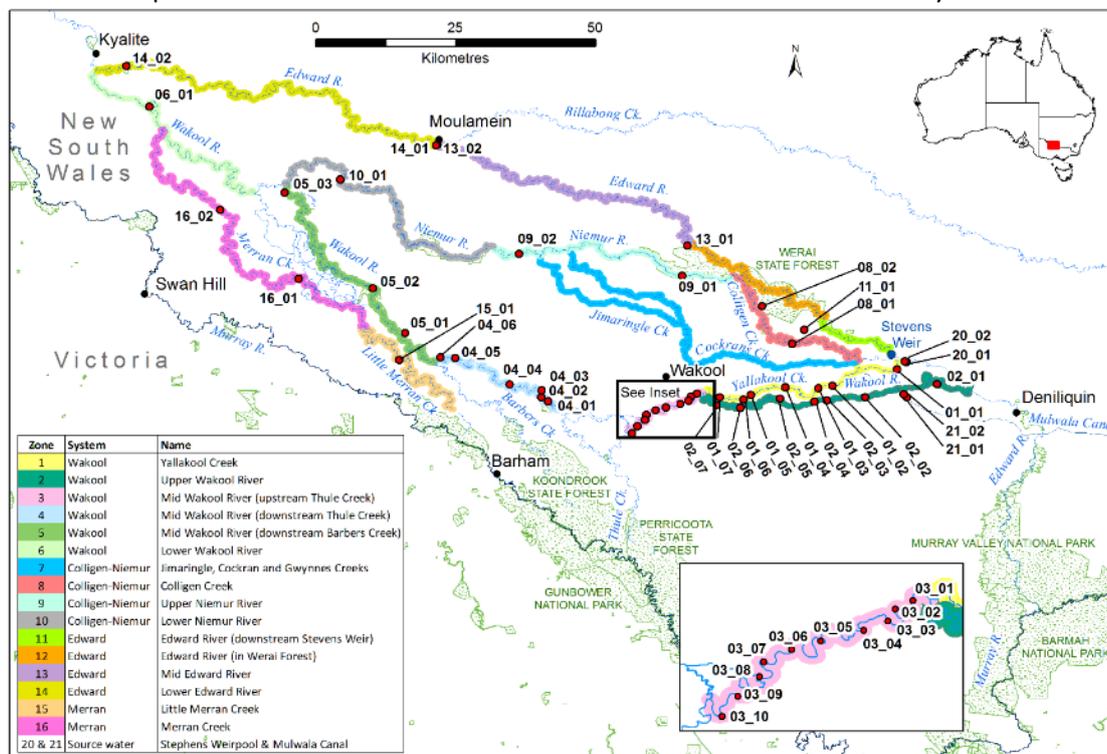


Figure B1. Monitoring sites for the Edward-Wakool Selected Area for the Long-Term Intervention Monitoring (LTIM) Project.

Appendix C: Summary of monitoring undertaken in the Edward-Wakool system for the Long Term Intervention Monitoring Project from 2014-2019.

Indicator	Cat	Zones	Schedule of activities											
			J	A	S	O	N	D	J	F	M	A	M	J
River hydrology	1	1,2,3,4	Continuous data from automated gauging stations											
Hydraulic modelling	3	1,2,3,4	Modelling undertaken in 2014-15											
Stream metabolism and primary productivity	1	1,2,3,4	Continuous data from loggers											
Nutrients and carbon	1	1,2,3,4	Monthly sampling											
Carbon characterisation	3	1,2,3,4	Monthly sampling											
Riverbank and aquatic vegetation	3	1,2,3,4	Monthly monitoring											
Fish reproduction (larvae)	1	3						Fortnightly						
Fish reproduction (larvae)	3	1,2,3,4	Fortnightly sampling											
Fish recruitment	3	1,2,3,4												
Fish (river)	1	3												
Fish community survey	3	20 sites	Undertaken in 2014-15 and 2018-19 only											
Fish movement	2	1,2,3,4 (plus sites funded Murray LLS)	Continuous data from acoustic receivers											