Edward/Kolety-Wakool system Environmental Flows Newsletter

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Edward/Kolety-Wakool Monitoring, Evaluation and Research Program

Environmental water flowing from the Edward Escape into the Edward/Kolety River to create fish refuge (Photo: Sam Lewis).

What's in issue 14

Unregulated flows continue in the mid-Murray River

Environmental water delivered to rivers via irrigation escapes provide fish refuge from hypoxic blackwater water

Report on Werai Forest published

GIS Training for the Kolety Werkul River Rangers

Welcome to issue 14 of the Edward/Kolety-Wakool Environmental Flows Newsletter - a quarterly newsletter that provides an update on our progress as we monitor and undertake research on the ecosystem outcomes of Commonwealth environmental watering actions in the Edward/Kolety-Wakool system.

The Edward/Kolety-Wakool MER Program is a collaboration between universities, state government agencies, consultants, and local community organisations. More information on the program can be found at: https://flow-mer.org.au/selected-area-edward-kolety-wakool/

FLOW Monitoring Evaluation Research

Australian Government Commonwealth Environmental Water Office | Charles Sturt University | NSW Department of Primary Industries | NSW Planning, Industry & Environment | streamology | La Trobe University | Yarkuwa Indigenous Knowledge Centre | EWAA Edward-Wakool Anglers Association

Unregulated flows continue in the mid-Murray River

The La Niña event continued through to the end of 2022 resulting in heavy rainfall and significant flooding across eastern Australia. Across the Murray-Darling Basin, rainfall in the 2022 calendar year was in the top decile for almost all catchments (Figure 1).

Throughout the second half of 2022 flows in the rivers and creeks in the Edward/Kolety system were influenced by rainfall and spills from Dartmouth Dam and Hume Dam. Unregulated flows in the Edward/Kolety system continued through to the end of 2022. Water that had flooded Millewa Forest and Koondrook-Perricoota Forest flowed into the Edward/Kolety-Wakool system, resulting in high tributary flows (e.g., Wakool, Yallakool, and Colligen-Niemur) and re-connected ephemeral creeks and runners at levels which had not been seen since the unregulated flood in 2016. Flows downstream of Stevens Weir were very high through to the end of 2022, remaining above the level required to inundate Werai Forest (Figure 2).

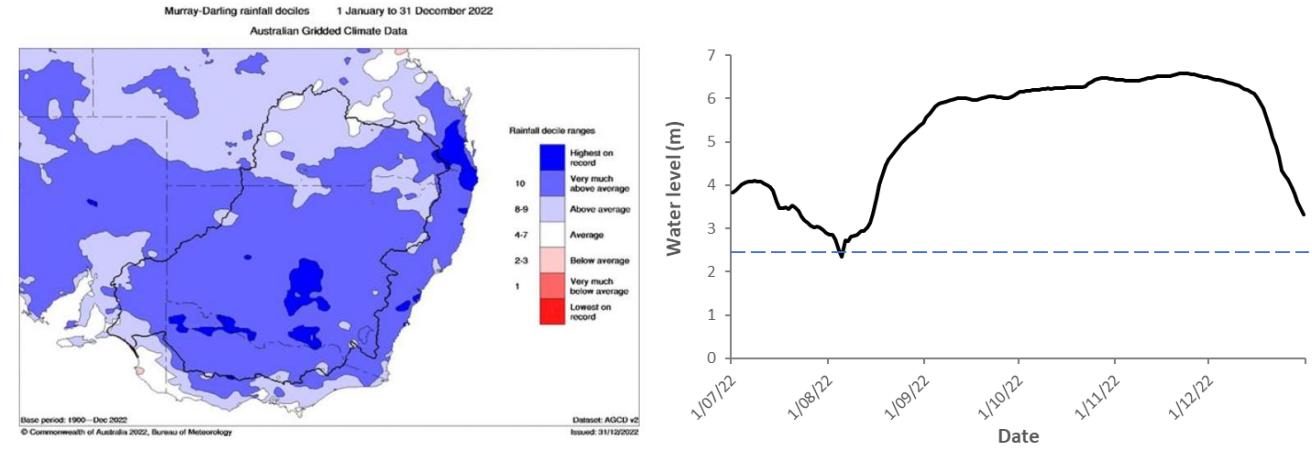

Figure 1 *Left: Rainfall deciles in eastern Australia for 2022 (Source: Bureau of Meteorology). Right: Water level (m) in the Edward/Kolety River at the gauge Downstream of Stevens Weir from 1 July to 31 December 2022. The blue dotted line indicates the level at which water in the Edward/Kolety River commences to flow into Werai Forest via Tumudgery Creek.*

Figure 2 *Werai Forest in flood, 8 Dec 2022 (Photo J Dyer)*

Environmental water delivered to rivers via irrigation escapes provide fish refuge from hypoxic blackwater water

Following widespread flooding in the second half of 2022, hypoxic blackwater conditions developed throughout the Murray River system resulting in fish kills in some areas. Unfortunately, the risk of hypoxic blackwater is likely to continue for some time as water temperatures increase over summer.

'Blackwater' is a term used when high levels of organic material and tannins discolour the water making it appear black. The blackwater can become hypoxic (low concentration of oxygen) when the material is broken down by microorganisms, reducing the concentration of oxygen in the water. Concentrations less than 2 mg/L can cause fish and other animals to die.

In an effort to save some of the fish in the Edward/Kolety-Wakool River system, CEWO, in collaboration with the NSW Department of Planning and Environment, Murray Irrigation Limited (MIL), and the Edward/Kolety-Wakool Environmental Water Reference Group, delivered small amounts of environmental water through MIL irrigation escapes to the Wakool, Edward/Kolety and Niemur rivers and Thule, Murrain-Yarrein and Cockrans-Jimaringal creeks to create small 'refuge patches' that have higher concentrations of dissolved oxygen. Native fish and other aquatic species take refuge in these patches to survive the declining water quality.

Managers have learned from experience during the 2016 floods, that it is important to start delivering environmental water early to create refuges and attract fish into them before the oxygen levels in the water in the rivers crash. Accordingly, in October 2022 (prior to the flood peak) water managers commenced the delivery of environmental water via a number of irrigation escapes to create fish refuges in the creeks and rivers in the Edward/Kolety system.

During large floods the water in the irrigation canal network generally has higher concentrations of dissolved oxygen than flooding rivers and creeks because the water in the canals is sourced from the Murray River at Yarrawonga, upstream of the floodplains and forests that are the main source of carbon inputs during floods.

Monitoring the outcomes of environmental water

To provide rapid feedback to water managers and increase knowledge about the effectiveness of using environmental water to create refuges, scientists from Charles Sturt University and La Trobe University, in collaboration with local citizen scientists (Figure 3), are monitoring water quality and fish responses to environmental fish refuge flows from the Edward Escape and Niemur Escape.

Collaborating with local people provides an opportunity for everyone to share knowledge and help protect the river ecosystem during the hypoxic blackwater event. One of the local people involved in this project is Anthony (Ant) Jones, from Deniliquin, who is assisting with water quality measurements.

> *"There's a lot worse jobs than being in a boat on the river all day," says Ant Jones from Deniliquin. "I think it is good that locals can be involved …. It gives you a better idea and understanding of what is actually happening in the rivers... we can also share that knowledge with other community members".*

***Figure 3**. Left: Ant Jones from Deniliquin checks the water quality near the Edward Escape from the Mulwala canal (Photo Alec Buckley). Right: Alec Buckley from Deniliquin has been helping monitor the water quality in the Edward Kolety River (Photo Ant Jones).*

The project team is collecting different types of data to help answer the following four questions about the delivery of environmental water from the irrigation escapes:

1. How far downstream of the escape is the refuge created under different flows?

Charles Sturt University scientists and local citizen scientists are taking spot measurements of water quality along the river upstream and downstream of the Edward Escape. These data will help us describe how far downstream the refuge extends under different flows, so we know how large the fish refuges are.

2. What is the effect of environmental water delivery from irrigation escapes on the water quality in the river system?

Water samples are being collected in the river upstream and downstream of escapes and analysed by scientist Dr Sha sha Liu (CSU) to document the levels of carbon and nutrients in the water.

3. Are fish using the refuges created by the delivery of water from the irrigation escapes?

Boat mounted sonar scans are being undertaken by scientists from La Trobe University and CSU to detect the presence and location of fish in the Edward/Kolety River in the vicinity of escapes (Figure 4). Sam Lewis, Research Officer from La Trobe University, says "the good news is that preliminary surveys have indicated a positive response by native fish associated with environmental releases from the escape."

4. How effective is satellite data for measuring water quality responses to environmental watering compared to field observations?

High resolution satellite imagery is being used to document outcomes of the delivery of environmental water from the Edward Escape to the river. Satellite imagery is often used to evaluate changes in turbidity in large open water bodies, for example where there are inflows to large lakes or the ocean. However, in our project remote sensing is being applied in a novel way because we are attempting to detect the impact of turbid, oxygen rich environmental water from the irrigation channel that is being released into dark, non-turbid blackwater in a narrow river. The results from the satellite imagery analysis will be compared with the field measured water quality data (see question 1 and 2 above) to help us to determine if changes in water quality can be evaluated using satellite imagery. This research is being undertaken by Deanna Duffy from CSU's Spatial Analysis Network (SPAN) and Professor Robyn Watts (Figure 4).

***Figure 4**. Left: John Trethewie (CSU) using boat mounted sonar scans to detect the presence and location of fish (Photo Sam Lewis). Right: Program Leader Professor Robyn Watts and Deanna Duffy (CSU SPAN) are using high resolution satellite imagery to measure changes in water quality following the delivery of environmental water to create fish refuges.*

The water quality data, fish sonar data and satellite imagery are being used by water managers to guide real time management of Commonwealth environmental watering actions. The monitoring results are shared with managers from multiple agencies who have been meeting weekly during the flood to discuss and plan their response to the flood. Agencies have been releasing fact sheets and updates to keep the community informed. The outcomes of this monitoring and research project will also contribute to future adaptive management of environmental watering.

Report on Werai Forest published

Werai Forest, located on the Edward/Kolety River downstream of Deniliquin, is one of three sub-sites in the NSW Central Murray Forests Ramsar Site that is listed as a wetland of international importance. The two other sites are the Millewa Forest and the Koondrook Forest, which depend on flows in the Murray River.

Local Traditional Owners have been working since 2009 towards having the Werai Forest become an Indigenous Protected Area (IPA) and have established the Werai Land and Water Aboriginal Corporation that will take over the ownership of the freehold title, which will be followed by the dedication of the Werai Indigenous Protected Area. While waiting for this transfer of ownership to be finalised, an informal Werai Forest Group has been established (see story in Newsletter #12 June 2022) to enable Wemba Wemba and Perrepa Perrepa Traditional Owners to identify key information that is needed to inform the future management of the forest and delivery of Commonwealth environmental water to the forest.

The Edward/Kolety-Wakool Environmental Flows Team has been able to address some of the information needs through research projects funded by the Commonwealth Environmental Water Office Flow-MER Program. In 2021-22 a collaborative research project was undertaken in Werai Forest with three components: 1) hydrology, 2) vegetation responses to inundation, and 3) primary productivity. The research has been completed and the results were recently published in a Werai Forest Research Report.

Key findings

1. Characterising the hydrology of Werai Forest using gauged hydrological data and Sentinel imagery

- Hydrological modelling undertaken by 2Rog Consulting examined the relationships between flows downstream of Stevens Weir and patterns of inundation in Werai Forest. Sentinel 2 imagery was used to map temporal water patterns and identify flow paths for six flow events between 2016 and 2022.
- Flows into Werai Forest via Tumudgery Creek commence when the discharge downstream of Stevens Weir is approximately 2,700 ML/d. Even small events (<3,500 ML/d downstream of Stevens Weir) can inundate approximately 200 ha of the forest.
- Return flows from the forest into the Edward/Kolety River (e.g., Figure 5) commenced when discharge downstream of Stevens Weir was between 3,152 and 3,237 ML/d. Return flows from Tumudgery Creek into Colligen Creek commenced when the discharge DS Stevens Weir was greater than 5,471 ML/d.
- For each of the six flow events that were analysed, the duration of inundation of the forest after flooding was short-lived, with a rapid decrease in inundation extent even following large floods.

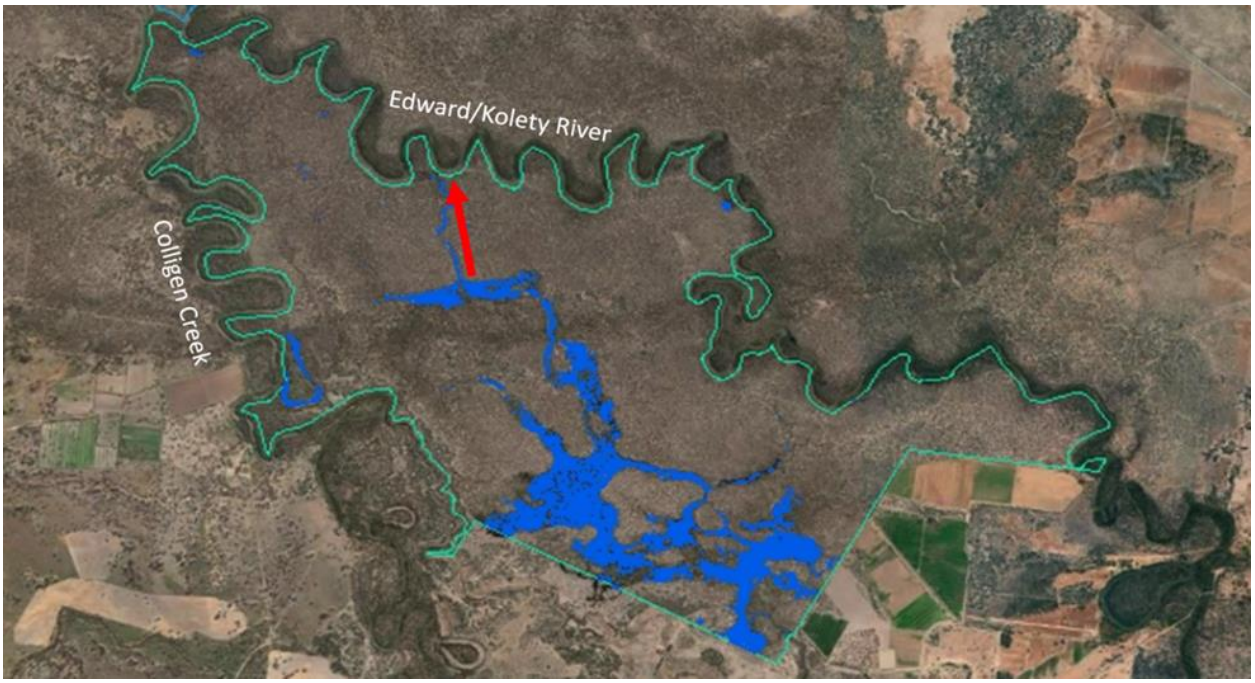

***Figure 5**. Image of the southern zone of Werai Forest. Red arrow indicates the connection of a flood runner with the Edward/Kolety River on 1/12/21 when discharge downstream of Stevens Weir was 3,257 ML/day.*

2. Evaluation of the effectiveness of drones for assessing the response of groundcover plants to inundation.

An innovative project evaluating effectiveness of drones for assessing the response of groundcover plants to inundation was undertaken by Streamology scientists in collaboration with the Kolety Werkul Rangers from Yarkuwa Indigenous Knowledge Centre, and researchers from Charles Sturt University and the Murray-Darling Wetlands Working Group. Three study areas within Werai Forest (Figure 6) were surveyed by drones and ground vegetation surveys in January, March and May 2022. Analysis of drone imagery was undertaken to remove the tree canopy from the data set, and the results from the drone survey were compared with ground survey data.

- Sixty-five plant species were recorded at the three survey areas. Most of the survey quadrats contained a mix of several plant species, and many included of bare ground, leaves/stick/bark, and plants.
- A method was developed to analyse the drone derived data that enabled the canopy data to be removed from the dataset to facilitate the analysis of ground cover that is under the canopy.
- Drone derived multispectral data was effective in differentiating between uniform areas of ground vegetation. However, when cover was a mixture of both bare earth and vegetation the accuracy of detection was lower. The drone multispectral method could differentiate between different growth stages of some plant species in areas of uniform cover. Drone imagery was also used to detect changes in ground cover plant condition (greenness) in response to different inundation regimes (Figure 7).
- Drone technology can be captured over a larger area than is possible with traditional ground-based surveys. With continued refinement, these techniques could be applied to help inform future Commonwealth environmental watering actions and assist the management of Werai Forest.

***Figure 6**. Photo of Werai Forest taken by a drone (Photo: Streamology)*

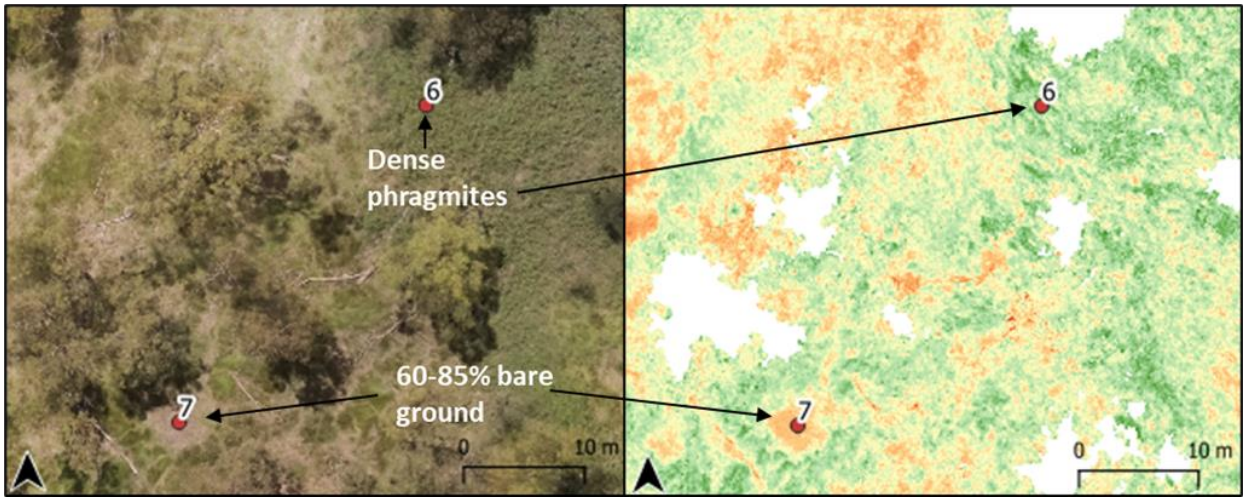

***Figure 7**. Left: Normal colour drone image showing the difference in appearance of different cover types. Right – Plot of calculated Vegetation Index results. In this figure the orange areas indicate bare ground, and the green areas indicate living vegetation cover.*

3. Field experiment to examine primary productivity in flooded areas of Werai Forest following an unregulated flow event in December 2021.

Results from a field experiment that measured metabolic rates across river and floodplain environments before, during and after an inundation event in Werai Forest were combined with results from automated loggers that recorded dissolved oxygen concentrations at paired locations upstream and downstream of potential outflow points from the inundated Werai Forest.

- Primary production within the river channels followed a seasonal trend, increasing as temperatures increase through summer. Flooded off-channel areas within Werai Forest had higher rates of productivity than the river channels. Aquatic plants and attached algae in inundated floodplains and flood runners (Figure 8) had very high rates of productivity (up to 10 times that of algae in the water column), with productivity being highest at peak flows.
- Our findings suggest that while planktonic production can sometimes be higher in riverine environments, the productivity of aquatic macrophytes and attached algae on floodplains can be considerable during inundation events, and do not contribute to equivalent pulses of respiration.
- Floodplain productivity may provide a substantial boost to overall primary production across the Edward/Kolety River system, which is not currently captured by conventional stream metabolism monitoring techniques. This study emphasises the importance of multiple measurement approaches for characterising river-floodplain production during flow pulses.

Figure 8 *John Trethewie monitoring water quality in a flood runner in Werai Forest during one of the as part of the primary productivity research project (Photo: Andre Siebers).*

The Werai Forest project provided opportunities for participants to share understandings and knowledge and develop personal relationships. Personal reflections on the collaborative partnerships that developed over the course of the project are included in the report.

The findings will assist the future management of this Ramsar wetland and will inform the delivery of Commonwealth environmental water to the forest and other nearby rivers and wetlands in the Edward/Kolety system. The Werai Forest Research Report is available on the Commonwealth Environmental Water Office website.

GIS Training for the Kolety Werkul River Rangers

Over the past few years, the Edward/Kolety-Wakool Flow-MER Team have collaborated with Wemba Wemba and Perrepa Perrepa Traditional Owners on several projects in Werai Forest and nearby rivers and floodplains. The Traditional Owners identified that they would like to receive GIS (Geographic Information System) training to help them manage data they are collecting through field-based projects and data from Werai Forest that they have accessed from other sources and organisations.

> *A GIS is a computer system for capturing, storing, checking, and displaying data related to positions on the Earth's surface. A GIS may include maps, photos, imagery, or data in spreadsheets, and the GIS assists the integration of many different sources of data. For example, a GIS can be used to map species distribution, or landuse change over time.*

In October 2022 the Kolety Werkul River Rangers and Junior Rangers from Yarkuwa Indigenous Knowledge Centre attended a GIS workshop in Deniliquin facilitated by Deanna Duffy from Charles Sturt University (CSU) Spatial Data Analysis Network (SPAN) and Professor Robyn Watts (CSU). Following a general introduction to GIS, the Rangers explored the ArcGIS Field Maps App, that can be used to capture data, collect photos, take notes, and share information. A fun part of the workshop was going outside and walking around the Deni Lagoons to trial using the ArcGIS Field Maps App to collect data (Figure 9). Later in the workshop we reflected on what worked, what didn't work, and what aspects of using the App were easy or complicated.

A second GIS training workshop is planned for early 2023 to enable the Kolety Werkul River Rangers to consolidate their learnings and gain further skills in using the ArcGIS software and Field Maps App. The GIS skills that the River Rangers gain through these workshops will assist the management and future delivery of Commonwealth environmental water to Werai Forest.

Figure 9 *Left: The GIS workshop participants walked around the Deni Lagoons to trial using the ArcGIS Field Maps App to collect field data. Right: Participants in the GIS workshop sharing lunch in Deniliquin.*

More information

To join the newsletter mailing list please subscribe here or contact Professor Robyn Watts, Charles Sturt University, Albury NSW. rwatts@csu.edu.au

We respectfully acknowledge the Wamba Wamba or Wemba Wemba, and Perrepa Perrepa or Barapa Barapa peoples, traditional owners of the land on which the Edward/Kolety-Wakool program is focussed. We recognise their unique ability to care for Country and their deep spiritual connection to it. We honour Elders past, present and emerging whose knowledge and wisdom has ensured the continuation of culture and traditional practices. The Edward/Kolety-Wakool team would also like to acknowledge the local landholders with whom we work and thank them for their contribution to the monitoring and research.

Watts R.J. and Beemster M. (2022) Edward/Kolety-Wakool System Environmental Flows Newsletter, Issue 14. Charles Sturt University.