Australian Government
Commonwealth Environmental Water Office

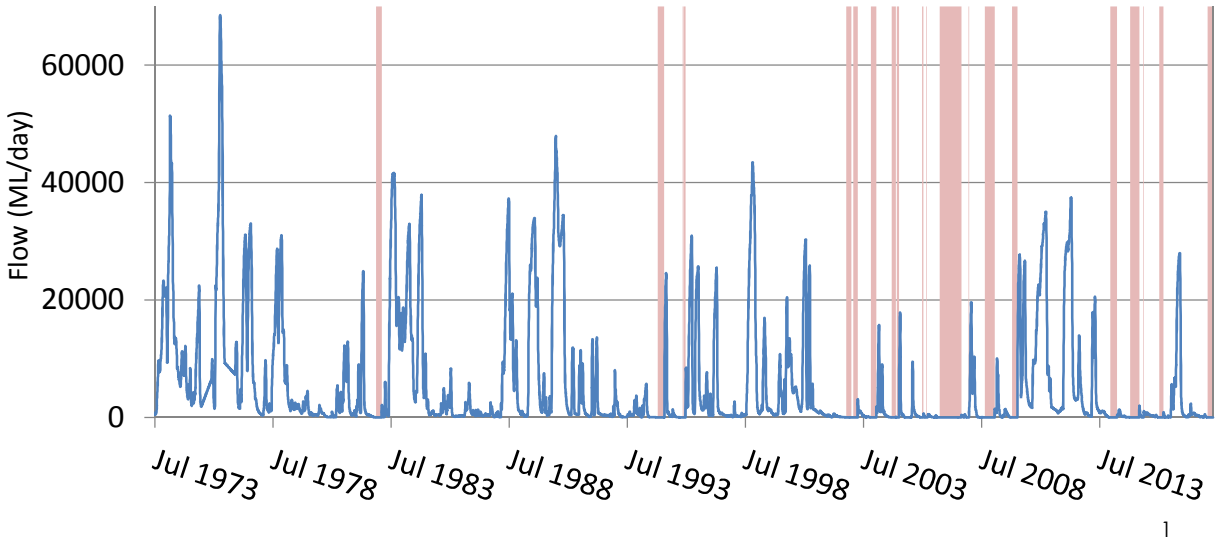
Northern connectivity event update 8

This is the eighth and final update on the northern connectivity event. This update provides: background to this flow event; a summary of flows, monitoring and community engagement during the event; and an initial evaluation of the event. A final evaluation report will be shared at the end of 2018 that will draw on reports and work from multiple agencies.

Background to the northern connectivity event

The northern Murray-Darling Basin includes the catchments of the Border Rivers, Gwydir, Namoi, Macquarie, and Intersecting Streams, which flow into the Barwon-Darling. The native fish community of the northern Basin is highly significant: it has five species that are listed as vulnerable or endangered; and the fish community overall is also listed as being endangered.

There is an increasing concern that recent flows in the Darling between Bourke and Wilcannia have stopped more often and for longer than previously in living memory. In addition to environmental implications, the river stopping is highly significant from a social and community health perspective. The pink vertical lines on the graph below highlight when the river ceased-to-flow at Wilcannia since 1972: with an increased frequency and duration of cease-to-flow periods in the last 17 years.



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The river 'stopping' more often and for longer is due to a number of factors including drought and upstream diversions, compounded by climate change.

From an environmental perspective, the northern Basin is being managed more as one system as implementation of the Basin Plan progresses. The annual environmental watering priorities released by the Murray-Darling Basin Authority include an increasing emphasis on connectivity between the northern rivers and the Barwon-Darling. This change in emphasis reflects an increasing awareness that native fish move opportunistically at a regional and, for some species, at a basin scale to find new habitat, disperse, spawn, recruit and link otherwise fragmented populations. In January 2018, whilst NSW northern tributaries of the Barwon-Darling with public dams were flowing well due to the delivery of water for irrigation, over 1,000 km of the Barwon-Darling River downstream of Brewarrina ceased-to-flow. As a result, the water quality deteriorated in stagnant waterholes. Blue-green algae alerts escalated to amber and red along the Barwon-Darling. Shires expressed concern on behalf of communities.

Photos of the Darling River downstream of Bourke: March to April 2

Some rainfall in Queensland in February and March 2018 resulted in flows into the Barwon-Darling. The NSW Minister protected this flow for social reasons including water supply. Some of this water partly replenished drought refuge waterholes and provided some short-term connectivity between waterholes.

In April 2018, Commonwealth and NSW water for the environment was made available for delivery in a northern (rivers flow) connectivity event after extensive discussions, and the NSW Minister agreeing to protect this flow from pumping for irrigation. This flow built on the previous unregulated flow and provided connectivity across multiple river systems to protect and support native fish. This created an innovative flow event in an unregulated river (the Barwon-Darling) using water from dams (regulated sources). The plan announced at the start of the event was to use between 25 and 30 GL of environmental water, subject to review, based on the progression of the unregulated flow event in the river and other environmental demands.

The purpose of the northern connectivity event was to benefit native fish along rivers in the northern Murray-Darling Basin by improving longitudinal connectivity, and therefore providing improved food sources, and opportunities to move and disperse to better habitats. The northern connectivity event provided a major opportunity for State and Commonwealth water agencies to coordinate their work in new ways,

with a greater emphasis on compliance. Coordinating an environmental flow and associated activities (including monitoring of flows and ecology, and engagement) was a complex task over 2,000 km of river and several months. This final update provides a summary of the northern connectivity event (including some of the more memorable images), and an evaluation of initial findings.

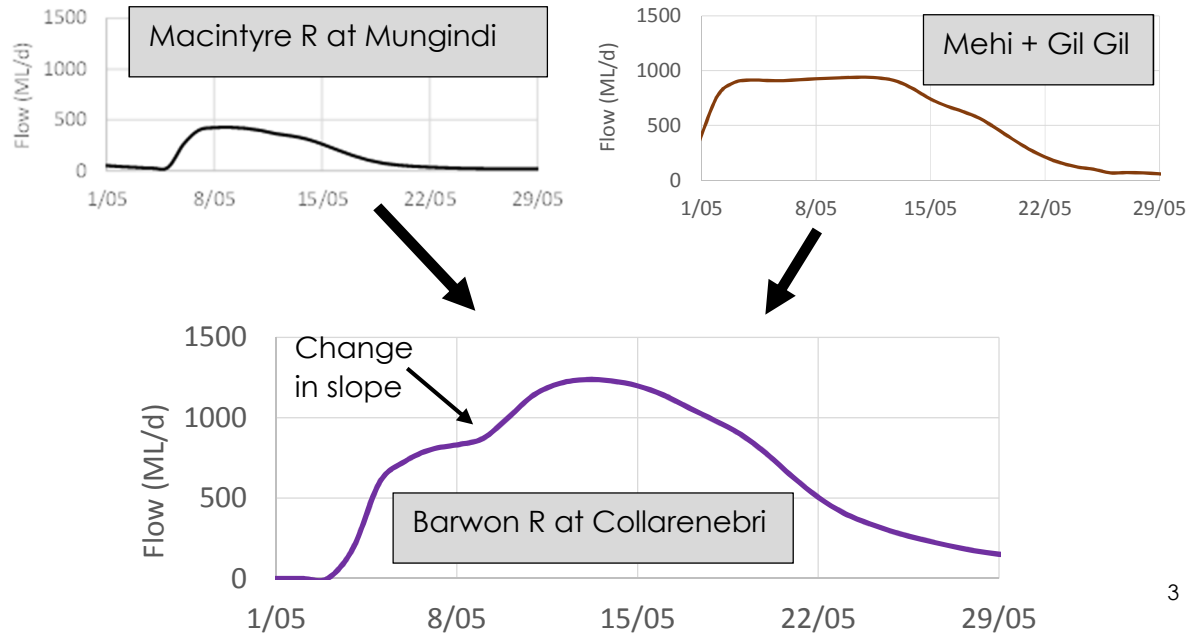
Flows

The orders placed by environmental water managers with the river operators were:

- near channel capacity for the Mehi and Carole / Gil Gil systems for around 20 days from both Commonwealth and NSW environmental water entitlements – to provide the body of the flow event; and
- 400 ML/day from water against Queensland entitlements held by the Commonwealth in the Border Rivers system, delivered to the Barwon River at Mungindi for 10 days – to add to the flow peak.

On 17 April, the river operators made the first releases of water from Glenlyon and Copeton dams, in the Border Rivers and Gwydir catchments respectively. In years before this water was recovered for the environment, the water used would have been diverted by irrigators further upstream: it would not have passed along the northern rivers and into the Barwon-Darling. This water subsequently created an additional flow event in the downstream end of the Macintyre and Mehi Rivers, and down the Barwon-Darling that would not have otherwise occurred.

Flows arrived at Collarenebri in the Barwon River on 3 May. The flow from the Macintyre arrived about 5 days after the flows from the Gwydir, as indicated by the change in slope on the rising limb of the hydrograph at Collarenebri below. The flows from the Macintyre clearly added to the peak in the Barwon as intended.



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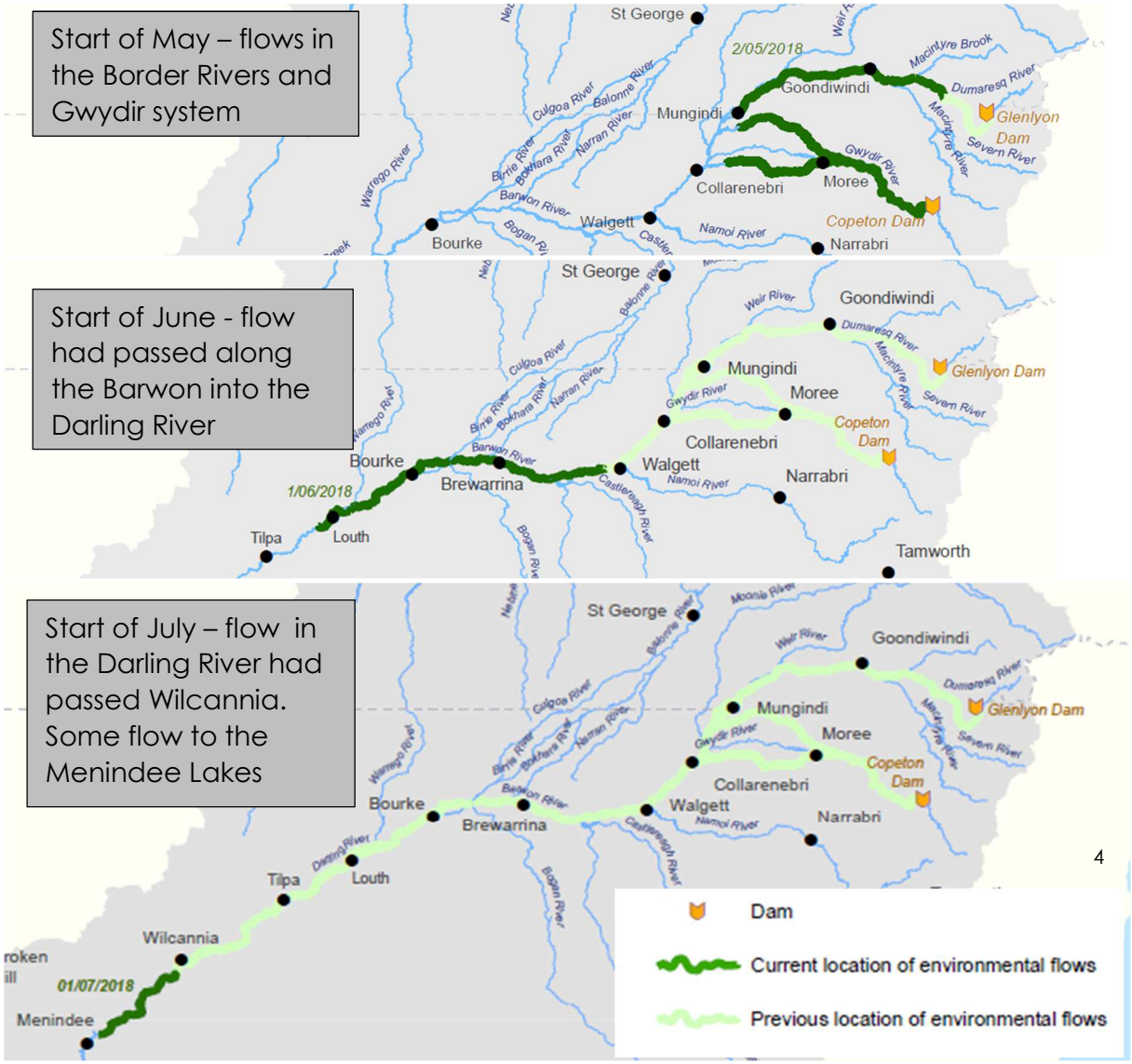
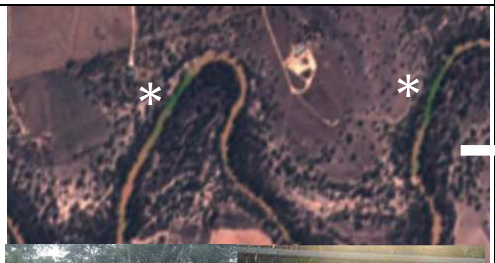
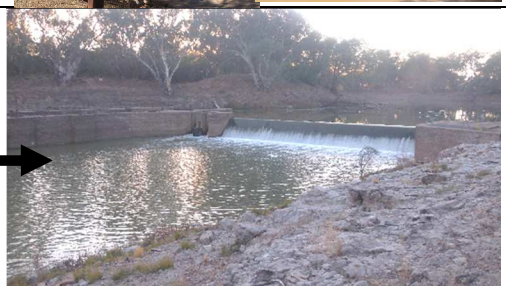
The below shows the progression of the northern connectivity event through the northern Basin at the start of each month.

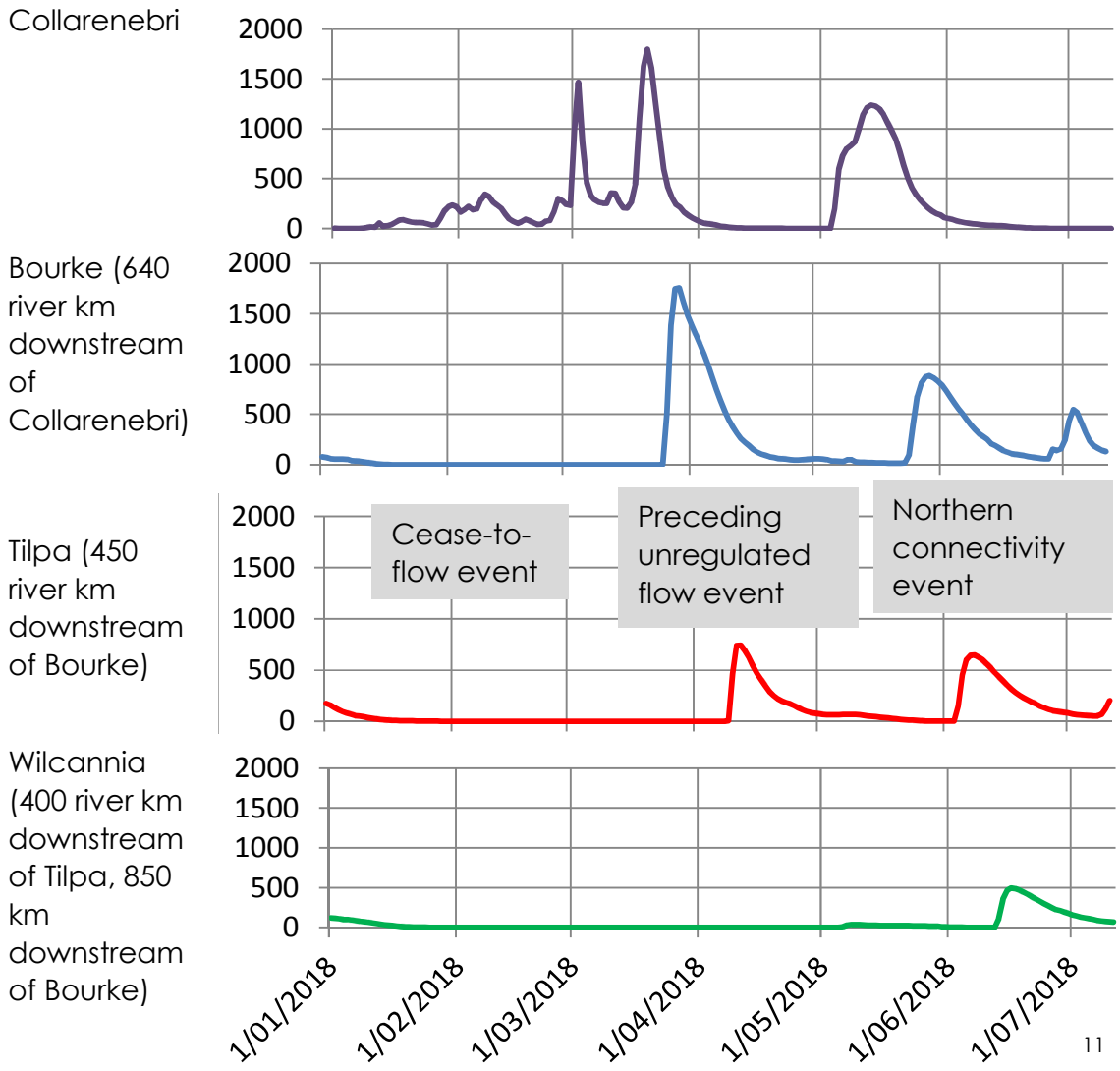


In total, 7.5 GL of water passed Wilcannia, which exceeded expectations. Some of this water is now located in Lake Wetherell (which is the upstream lake in the Menindee Lakes system and includes part of the Darling River channel). Lake Wetherell rose from mid-June to mid-July – this has plateaued.

Images before and during the northern connectivity event along the northern river systems are shown on the following page.

Location	Before the flow	During the flow
Macintyre at Goondi-wiindi late April 5		
Gwydir at Palla-Mallawa late April 6		
Barwon at Collar-enebri (asteriskes highlight algae before the flow) early May 7	  	  
Darling at Bourke mid-late May 8		
Darling at Tilpa After photo – mid June 9		
Darling at Wilcannia mid June 10		

The measured flows at Collarenebri, Bourke, Tilpa and Wilcannia since 1 January follow. Importantly, the northern connectivity event has been the only flow in the Barwon River at Collarenebri since early April.



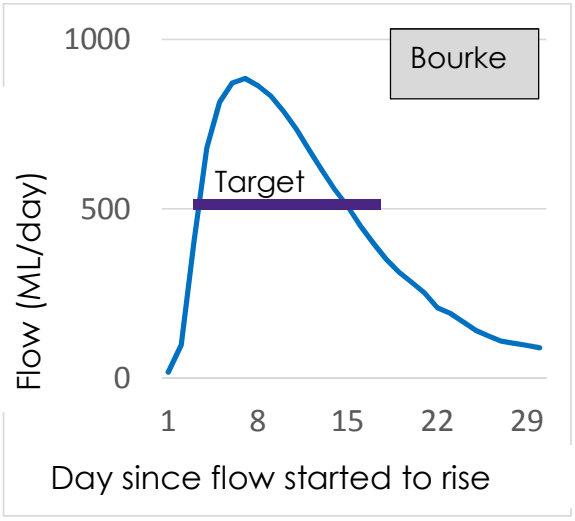
The preceding charts show: the cease-to-flow period at each gauge; the flows in unregulated flow from the rain in Queensland in late February and early March; and the northern connectivity event. The data can be used to improve the understanding of the progression of flow events through the Barwon-Darling when there is not significant pumping. Initial key points are:

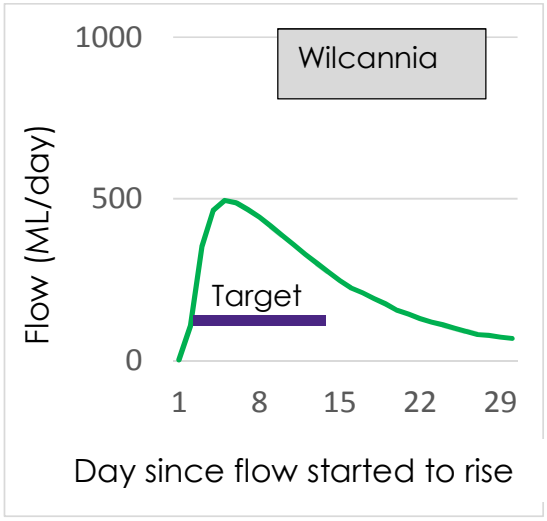
- **Peak flow**: the reduction of the peak from Bourke to Wilcannia was 1,700 ML/day in the unregulated event (when there was disconnection between waterholes) compared to 390 ML/day when the waterholes were connected. Some of the water in the first event was used to replenish waterholes between these towns.
- **Volume**: the volume that passed Wilcannia was 19.5 GL less than that which passed Bourke in the preceding unregulated event, and 5.5 GL less than that which passed Bourke in the northern connectivity event. This gives an indication of the amount of water used to replenish waterholes, and for seepage and evaporation under a range of antecedent conditions; and

- **Travel time**: the head of the flow in the northern connectivity event took about 21 days to move from Bourke to Wilcannia, compared to 41 days for the unregulated event. Travel times can be significantly longer when the river channel is dry and the flow is low because each waterhole needs to be filled up before the flow can move onto the next waterhole.

On 17 June, the flows started to enter Lake Wetherell in Menindee Lakes after traveling for over 60 days and over 2,000 km of river channel. (That is about the distance to drive from Toowoomba to the Murray mouth – roads are straighter than rivers!).

For longitudinal connectivity, the aim was to achieve flow targets of: over 500 ML/day for a duration of 14 days at Bourke; and over 150 ML/day for 10 days at Wilcannia. The observed flows at Bourke and Wilcannia from the northern connectivity event are shown below (these are the average daily flows at each gauge).





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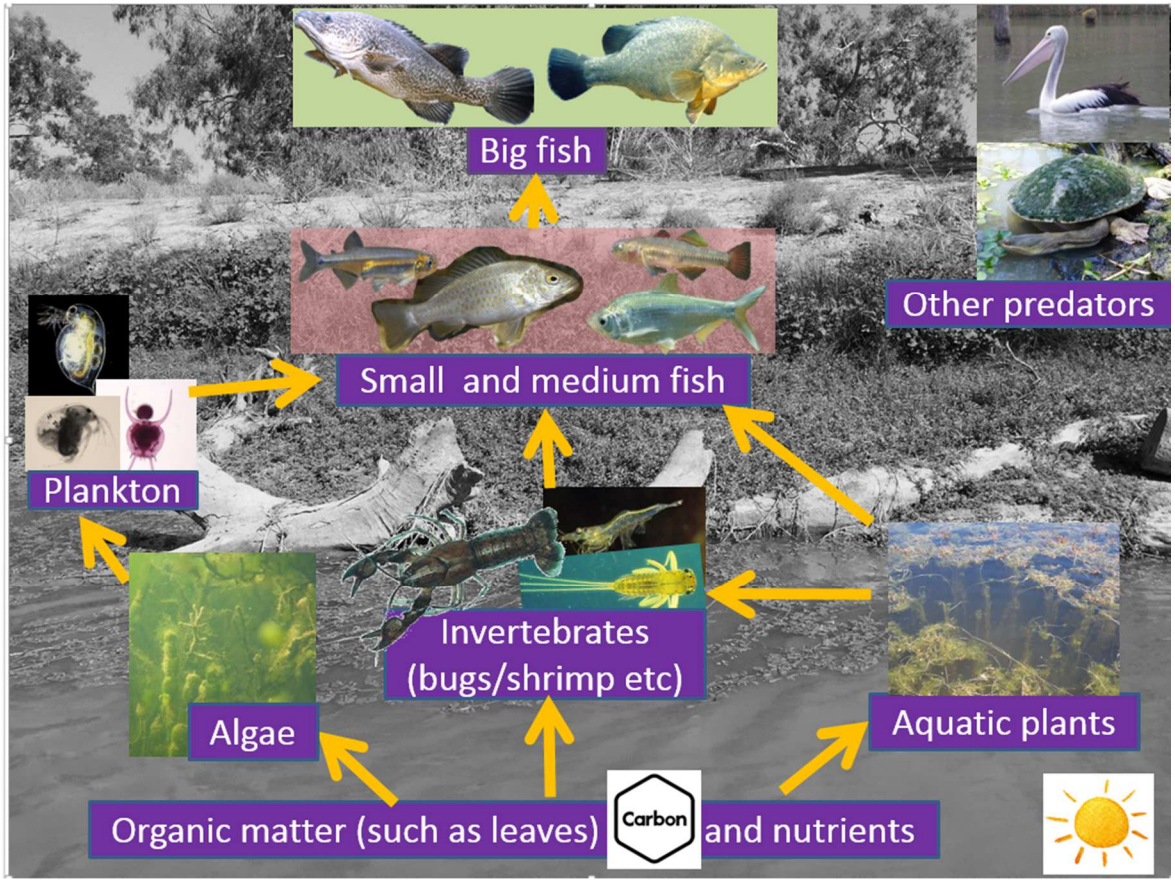
At Bourke, the flow peaked at 900 ML/day, considerably more than expected. The total volume above 500 ML/d was significantly larger than anticipated. The average daily flow at Bourke was above 500 ML/day for 12 days from 25 May, whilst the peak flow exceeded 500 ML/day during parts of 13 days. In short, the peak flow was considerable higher than targeted, and the duration was a little less. Although the duration was less than the target, the higher peak of the event and the gradual recession provided adequate time for native fish movement opportunities and connectivity along the Barwon-Darling. The duration is less critical at times of year when water temperatures are too low for spawning. The flow target at Bourke was effectively met.

At Wilcannia, the average daily flow rate was above 150 ML/day for 18 days from 13 June, including above 350 ML/day for 7 days. The flow target was clearly met.

These flow results are discussed in the initial evaluation of the event, later in this update.

Initial results from monitoring

The monitoring program for the northern connectivity event will improve the understanding of the ecological, physical, and chemical effects of small in-channel flow pulses through the northern Basin, including following a cease-to-flow event. Monitoring is underway at multiple levels of the food web, and also of habitat and water quality, as discussed below.



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Fish

Monitoring by electrofishing and bait trapping in the Border Rivers, Gwydir and Barwon-Darling has been undertaken in both the northern connectivity event, and other existing programs. This monitoring has been undertaken by NSW DPI Fisheries and the Queensland Department of Agriculture and Fisheries. Some key initial findings have included that:

- monitoring in the Darling in April 2018 indicates a high diversity of fish species but low numbers;
- fish sampled in April 2018 were stressed where the Darling had ceased-to-flow. The proportion of fish with health conditions was highest at the two sites immediately downstream of Wilcannia where the river had ceased-to-flow for longest, and algae levels were high. Around a third of the fish sampled at one site downstream of Wilcannia had a health condition such as raised or discoloured scales, and the presence of parasites such as anchor worm.
- sampling in the Border Rivers in May 2018 has found many Murray cod and freshwater catfish recruits, as well as a number of olive perchlet;

- monitoring in the Gil Gil creek in late May 2018 sampled bony bream and young of year spangled perch; and
- data from one receiver in the acoustic array in the Darling between Tilpa and Louth has shown that a third of the 48 golden perch (yellowbelly) tagged for the northern connectivity event were detected moving along the river past the receiver, despite the water temperature being lower than when movement usually occurs. This finding suggests that golden perch may have been more opportunistic during the flow event. A fuller picture will emerge following download and analysis of the 21 receivers / loggers.

Electrofishing on the Darling

Murray cod with parasitic anchor worm

Golden perch with acoustic tag

Golden perch, Murray cod and freshwater catfish sampled in the northern Basin in 2017 and 2018 [14]

These initial results support that flow events are important to maintain drought refuges and connect habitats so that there is a greater prospect of survival supporting recruitment and improved health.

Invertebrates

Sampling of both microinvertebrates and macroinvertebrates is underway for the northern connectivity event. This work is being undertaken by Eco Logical Australia.

Assessing the numbers and variety of invertebrates in the river before, during and after the northern connectivity event will provide important insights into the ecological response to the flow and of the overall health of the river. Preliminary analysis of samples of macroinvertebrates collected before the northern connectivity event indicate that most found are tolerant of low water quality. For example, the

pink coloured macroinvertebrates in the image on the right are fly larvae (chironomids) collected before the northern connectivity event (the colouring is dye, which assists with identification). These larvae are tolerant of poor water quality. It will be interesting to see if species more sensitive to poor water quality are sampled after the event as the water quality has improved. Initial observations from the field suggest that the number of macroinvertebrates sampled after the flow are much higher than numbers prior to the event.

Sampling bugs near Brewarrina

Fly larvae sampled

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In-stream habitat

The flow inundated habitat features along the river bed and up the banks in the Macintyre, Mehi and Gil Gil systems, and across the river bed in the Barwon-Darling.

Mehi River at Moree

Gil Gil Creek at Wemalah

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River bed inundation downstream of Brewarrina Weir is shown for a flow of 1,000 ML/day.

Inundated habitat, including shrubs →

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The northern connectivity event inundated a range of instream habitat features along 2,000 km of river channel. These features include rootballs, bank overhangs, benches, bars and large woody habitat (snags) providing access to habitat.

Inundated instream bench

Bank overhangs

Rootball

Snags

Some habitat features inundated by the northern connectivity event in the Dumaresq in the Border Rivers, were over: 100 benches; 150 sites with bank overhangs; 270 rootballs; and 2,700 snags.

These results were for a small part of the 2,000 km of river channel that benefited from the event. The flows in the event are estimated to enhance native fish access to more than 8,000 snags between Walgett and Wilcannia[18]. Further analysis of the extent and benefits of habitat inundation are underway.

Water quality (including algae)

Water quality data originating from the existing NSW network and measurements were also taken at a number of waterholes as part of the northern connectivity event. Water quality monitoring is continuing to improve our understanding of the frequency, magnitude and duration of in-channel pulses that are required to maintain the condition of waterhole refuges. For example, oxygen is being monitored, as oxygen levels can be low when waterholes disconnect.

Deploying water quality loggers: Darling River

Water samples

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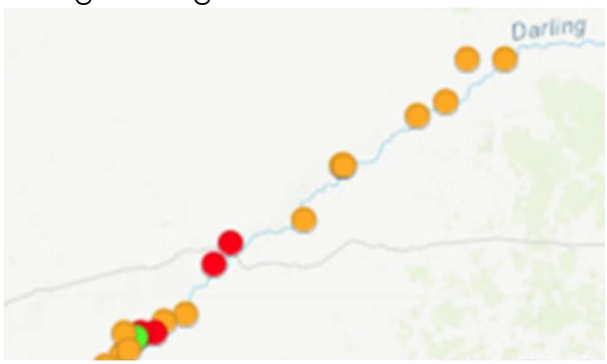
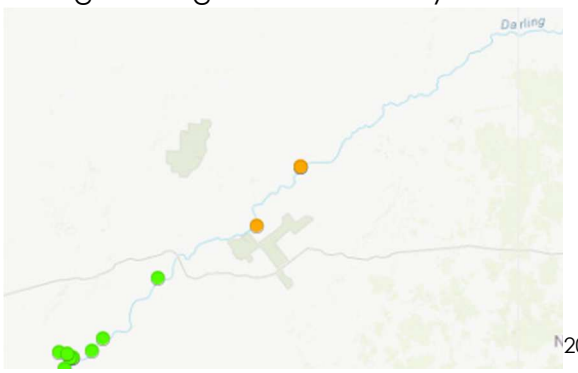
Regarding the reduction of algal concentrations, the improvement in water quality is likely to be greatest in upstream reaches (e.g. Collarenebri) and less downstream (e.g. Wilcannia). As the flow moved further downstream, the amount of waterholes diluted by the flows has increased, and the volume of water remaining in the event (due to evaporation and seepage) has decreased. Therefore, the potential of the event to significantly improve water quality is greater upstream.

Regarding blue green algae, all the algal alerts between Bourke and the Menindee Lakes (below) were amber or red in March: they are mainly green now. This is because of both the increased flows and the lower water temperatures over winter.

Blue-green algal alerts – 9 March



Blue-green algal alerts – 19 July



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Final results of the monitoring will be provided later in the year, in reports by NSW DPI Fisheries and Eco Logical Australia.

Community engagement

Sharing the northern connectivity event with the community has been a priority. Water for the environment is a valuable public asset, and there is a lot of appetite in the community to understand more about fish and rivers when the information is presented in an accessible and timely way.

As the long, hot and dry summer of 2017-18 persisted in the northern Basin, the Barwon-Darling ceased-to-flow and the water quality deteriorated. From early in 2018, four Shire Councils that span from Walgett to Wilcannia along the Barwon-Darling requested water to improve the river's condition. The mood of riverside communities was being affected by the deteriorating condition of the river.

When announcing the northern connectivity event, Jody Swirepik, the Commonwealth Environmental Water Holder acknowledged this mood: "Although our purpose is to improve river health, we do hope it will also relieve some of the pressure the community has been feeling." In late May, the positive community response to the northern connectivity event was gratefully acknowledged by the four Shire Councils. Late in the flow event, the Chief Regulatory Officer of the NSW Natural Resource Access Regulator Grant Barnes said "I visited various locations along the river to witness the environmental flows and to see the impact on local communities and the environment first-hand. There is a real sense of excitement..."

A summary of face-to-face engagement activities and other information sharing follows. To share the event, five face-to-face functions were held with riverside communities as the flow moved along the system. People along the northern rivers and more broadly have been able to experience the flow event to some extent through these series of updates.

Face-to-face activities

From mid-May to early June, engagement functions were held at Mungindi, Collarenebri, Walgett, Brewarrina, and Bourke. These were organised by the CEWO's enthusiastic and knowledgeable Local Engagement Officers, Neal Foster and Jason Wilson. In total, around 150 community members attended these functions, including school groups. NSW representatives also attended. Functions will be held in Moree and Goondiwindi in the near future to share monitoring results and the importance of connectivity in the northern Basin for native fish populations.

In addition to these functions organised by the CEWO, a community celebration of the flows was organised by the Wilcannia community, and included music, dancing and art.

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Function at Bourke on 31 May 23

Brewarrina: 24 May

Key themes of the community feedback were: strong support for the northern connectivity event and amazement at its spatial scale; a suggestion that the northern connectivity event should be a more regular flow event; concerns about compliance generally and interest in the recent changes (such as the recent on-ground presence of the Natural Resource Access Regulator); and discussion of what is being and can be achieved under the Basin Plan.

Sharing of written information

A series of 8 updates were prepared during the event (including this one). In these updates, initial results were shared in a timely and qualified way. More thorough analysis will follow.

Originally, the updates were distributed through existing networks. Newspapers (including the Western Herald) drew on some of the content. When a high level of community interest was confirmed, the updates were put on the CEWO website. These updates have precedent – the NSW Office of Environment and Heritage has provided similar updates and watercourse reports in the past around environmental watering events. Twitter was used when the flow reached milestone locations.

Whilst water for the environment is used to protect and restore environmental values, the updates provided an opportunity to acknowledge important social dimensions associated with the flow: such as the relationship of Aboriginal communities with the river, river navigation and transport, and some of the poetry of Henry Lawson.

Feedback on these updates has been very positive.

Initial evaluation of the northern connectivity event

This is an initial evaluation of the northern connectivity event. Key points are:

- flows along the northern system met or exceeded expectations and targets;
- the inter-agency compliance effort was considerable, and identified no significant issues;
- the protection of environmental flows was effective;
- the community response was very positive;
- there was strong co-ordination between government agencies;
- risks were managed effectively; and
- managing expectations regarding future events like the northern connectivity event will be very important.

Further detail from the initial evaluation follows.

A more thorough evaluation of the northern connectivity event will occur in coming months, so as to learn as much as possible to inform future water management. This final evaluation will draw on analysis and reports of several aspects of the event. The ecological response will be evaluated drawing on final post event monitoring results of fish and habitat condition, prepared by NSW DPI Fisheries and Eco Logical Australia. The NSW Water Reform Action Plan process will draw on this pilot event when considering options to better manage environmental water across NSW, including what systems are needed to practically support this. A report on the use of remote sensing to test compliance is currently being prepared by the Murray-Darling Basin Authority (with the associated imagery to be made available). Social analysis of the flow event is also being considered.

Flows

Water orders were placed at the start of the northern connectivity event. Following review, it was decided to order 23 GL of environmental water sourced from the Border Rivers and Gwydir. This volume of orders was determined considering that the preceding unregulated flow event was persisting in the Darling and replenishing many waterholes, and thereby slightly reducing the amount of water needed to provide longitudinal connectivity in the northern connectivity event.

Observed flows in the Border and Gwydir systems, and subsequently in the Barwon-Darling, were close to those expected and estimated by WaterNSW. This was an achievement given that the shape of flow curves (hydrographs) changes along rivers, and a lot can happen (such as hot weather) in the months between releases at an upstream point and its arrival at a downstream point. In particular, the flows at Wilcannia exceeded expectations, which was a great result.

There was a lot learned on flow from the events in early 2018 that can be used into the future, such as:

- whilst there are challenges in meeting downstream flow orders when there is little other flow in the river and when it is desirable to reduce the flows quickly to conserve water in storage, the flows through the Mehi and Gil Gil systems were close to channel capacity as intended, and WaterNSW did a particularly good job in this regard;
- the water needed to replenish waterholes and for seepage is much greater if a river has ceased-to-flow and there are dry antecedent conditions than if it is still flowing;
- the duration of releases should reflect the duration of flow targets – in this instance it would have made more sense from a Barwon-Darling (Bourke) perspective for the order at Mungindi to be 285 ML/day for the duration of the flow target (14 days) rather than 400 ML/day for 10 days, however the higher flow in the Border Rivers accessed more habitat there, and this was an important consideration too;
- within catchment needs need to be balanced with broader system needs when scarce environmental water is allocated. Drawing on Commonwealth environmental water from the Namoi was considered for this event. The northern connectivity event did not include water from the Namoi as the Commonwealth currently holds low allocations there, and there are strong upcoming environmental demands (e.g. sustaining a population of endangered silver perch). Ordering water from the Macquarie in early 2018 would have been inefficient given that little of the water would have reached the Barwon, and there was an event targeting the connectivity between the Macquarie and Barwon rivers in the autumn of 2017 during wetter times.

Achieving greater connectivity between the Barwon-Darling and its northern tributaries is expected to be reflected in annual priorities set by the MDBA, and an ongoing consideration in CEWO portfolio management plans.

The river operations were simpler in this case than they could have been because there was no unregulated flow event that occurred concurrently with the 'regulated' flow. If there had have been an unregulated event, then the finalisation and

implementation of an operational protocol to allow irrigators some access would have been required. The operational protocol and systems should be practical and give confidence. There is the likelihood of improvements to metering and hydrometric systems that would underpin the implementation of such an operational protocol, which increases confidence.

In summary, the flow events in early 2018 provided good information on flows and significant learnings that will be important in the future.

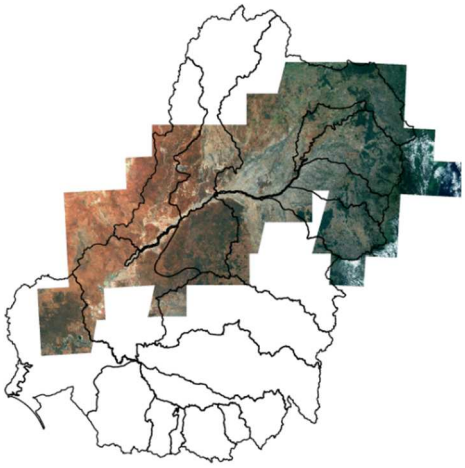
On compliance

The northern connectivity event provided an excellent opportunity for regulators to have 'boots on the ground' and to trial remote sensing technologies for ongoing compliance work. These regulators are the NSW Natural Resource Access Regulator, and the Murray-Darling Basin Authority.

There was no significant pumping for irrigation reported from the northern connectivity event. All signals to date are that the compliance effort was effective and that irrigators complied with the temporary restriction.

For remote sensing with satellite imagery, a large amount of information was gained for the northern connectivity event. More generally, this information is available for any particular flow event anywhere in the Basin, given: the number of satellite systems available that provide free and open data (including Landsat, Sentinel); the resolution of the imagery (down to 10m for Sentinel); and the frequency that the satellites pass overhead (every few days). The imagery informs where more detailed investigation may be required. Additionally, NSW agencies have access to data from other satellite systems, such as Planet. Further, radar images could also be used to provide some information when there is cloud cover, and is being considered by the MDBA for future use alongside the Landsat and Sentinel data.

For example, for the northern connectivity event, a total of 92 images were available as taken by both Sentinel and Landsat, covering the time period of the event and the spatial extent of the flow. The spatial extent covered by the satellite images along the Border Rivers / Gwydir / Barwon-Darling that were collected are shown on this map. These images will be made available over the coming months along with a MDBA report detailing methods and analysis used to track the flow.



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On the 'the temporary restriction' to pumping for irrigation

The northern connectivity event was the first time that NSW had put a temporary restriction (using the 'public interest' test under section 324 of the NSW Water Management Act) on pumping in the Barwon-Darling for environmental purposes. Irrigation groups accepted this under the circumstances, although there was some concern about the precedent.

The temporary restriction was announced by the NSW Government Gazette, media releases, and the WaterNSW website. As these restrictions reflect exceptional circumstances and are unusual, some irrigators expressed the preference that they were informed more directly.

The northern connectivity event flows in the Barwon-Darling were above commence-to-pump thresholds in some zones. Without the temporary restriction in place, the current rules in the Barwon-Darling Water Sharing Plan would have allowed irrigators to divert. If they had chosen to divert, and given 'losses' along the river system, this is likely to have resulted in the northern connectivity event not reaching Wilcannia. Hence, protection in some form was important.

The temporary restriction did allow diversion for town water supply, and stock and domestic access licences. There was some take for stock and domestic purposes during the event, and some community members enquired as to whether the volume taken was reasonable. Finalisation of 'reasonable use' guidelines by NSW is important to ensure clarity and transparency of access under these circumstances.

Co-ordination of government agencies

The event involved extensive co-ordination of water policy agencies, environmental water holders, natural resource regulators and river operators from NSW, the Commonwealth, and Queensland. Agencies worked together very well, as was demonstrated by the number of agencies represented at the

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community forum at Bourke Wharf. Opportunities to use the northern connectivity event to inform some actions under NSW's Water Reform Action Plan were taken. An operational advisory group, a higher level co-ordination and oversight group to facilitate co-ordination. With support of the CEWO, NSW appointed an independent reviewer to provide feedback on co-ordination.

Such co-ordination may be a precursor to establishing future arrangements for active management of environmental flow events.

Co-ordination of the event was also underpinned by strong support from irrigators, local governments and communities – which was very important and appreciated.

Community engagement

There was strong community interest in the northern connectivity event. Feedback on the engagement has been overwhelmingly positive. There were significant efforts to share the northern connectivity event with the community. Engagement functions moved downstream along the Barwon-Darling with the flows. Focussing engagement on a flow that is happening along rivers is more engaging for the community than discussing flows that have happened in the past or may happen in the future. Providing opportunities for the community to experience a flow event (either on the ground or remotely through information that is timely, relevant, visual and interesting) is important.

At least one group felt that they could have been consulted earlier. Not all groups in the community were engaged as early or as fully as they could have been. Establishing a northern system-scale coordinating group may assist with sharing of information, and could be considered. Any co-ordinating group could work together annually during planning, and when a flow event is being actively managed for environmental outcomes: joint efforts could be episodic like the flows in the north.

Ideas for future engagement include: greater use of the media (including social media) to advertise functions; running river trips (buses) or short cruises (the paddle steamer Jandra at Bourke) to allow more people to see the event; providing access to data in real-time perhaps by including links to relevant websites; providing more opportunity for commentary from the community; providing activities for

landholders/students to experience something meaningful to them, e.g. water quality sampling/riparian assessment/discussing cultural perspectives/art; and collating community footage (possibly video snap shots, drone footage, media grabs, i.e. sound bites) from the top of the catchment, and sharing with communities as the flow progresses downstream.

Managing risks

The primary risk considered prior to the event was the risk that stratified waterholes may become rapidly de-stratified when the flow arrived which could have resulted deoxygenation through the water profile, and in fish kills.

The timing of the northern event was decided after a lot of thought. There was some risk that shallow flows in the heat of summer and early autumn could potentially mix layered pools and inundate organic matter from hot, dry river beds, resulting in very low dissolved oxygen levels. This can be magnified by hot daytime temperatures, which could lead to possible fish kills. Fish kills have occurred in the Darling River downstream of Menindee Lakes in the past (e.g. a very large kill between 1,000 to 5,000 mature Murray cod occurred along 160 km of the Lower Darling river in February 2004 as a result of low dissolved oxygen caused by a small replenishment flow that trickled into pools as it moved downstream – i.e. shallow flow over a very hot river bed).

To reduce this risk, the northern connectivity event was timed for the flows to reach the Darling by late May and early June when the temperature was less. No fish kills were recorded along the river, either from the unregulated flow event that preceded the northern connectivity event (when the risk was higher), or during the northern connectivity event.

Managing expectations

In addition to planned environmental water under water resource plans, regulated and unregulated entitlements provide water for the environment across the northern Basin by contributing in-channel flows. Regulated entitlements are in systems with public dams.

The northern connectivity event was unusual. There was an opportunity to use water stored in the wet spring of 2016 in public dams in tributaries to provide longitudinal connectivity in the very dry summer and autumn of 2017-18 in the Barwon-Darling. Occasionally, if there is sufficient water available, there may be an opportunity to use regulated entitlements held by the Commonwealth in the northern Basin tributary dams in a targeted way to improve water quality and aquatic habitats in the Barwon-Darling. Jody Swirepik, the Commonwealth Environmental Water Holder, gave an indication of the balance to be struck between in catchment environmental demand and system demands at a meeting in Bourke "we have certain other priorities for the water we hold including in the other rivers – like watering the Gwydir Wetlands and Macquarie Marshes that are internationally recognised wetlands. We also target fish health and habitat and are concerned to support endangered fish like the silver perch. We would like to orchestrate another flow like this one but would have to hold adequate water". Sometimes using regulated water in a catchment inevitably results in flows into the Barwon-Darling as

well. For example, watering of the Macquarie Marshes in coming months using NSW and Commonwealth environmental water is expected to result in an extended very low flow into the Barwon.

In addition to water from regulated entitlements, the Commonwealth's unregulated entitlements are left in-stream where they contribute to natural flow variability and improve the environmental outcomes of natural flow events. These unregulated entitlements in the Barwon-Darling comprise A, B and C class licences, which combined contribute to most unregulated flows. The capacity of these entitlements to enhance in-channel flow pulses is under consideration as part of the NSW Water Reform Action Plan process, as preserving enough flow events is critical for environmental health. The benefits of protecting this environmental water from extraction would be most pronounced in the Darling between Bourke and Wilcannia.

So other environmental demands, the volumes required and operational constraints will influence the capacity of regulated entitlements to meet environmental demands in the Barwon-Darling, particularly in downstream reaches. Unregulated entitlements will contribute additional water to most flow events, and regulated entitlements can also provide some water to some events. In short, held environmental water flows into the Barwon-Darling already occur several times per year. Creating a flow 'from scratch' in an unregulated system like the Barwon-Darling using water from regulated systems is unusual: it may occur once or twice per decade, for example.

Acknowledgements

Thank you to those who have shared the journey of the northern connectivity event: including those from the environmental, floodplain, irrigation, and local government sectors. In particular, thank you to those who have shared these updates with others.

Thank you also to the NSW, Queensland and Commonwealth agencies that have worked together with us at the CEWO to help make this flow event happen. This includes the NSW Office of Environment and Heritage (who also contributed NSW environmental water to the event and managed orders with the Gwydir); the NSW Department of Primary Industries, Fisheries; the NSW Department of Industry, Water; WaterNSW; the Murray-Darling Basin Authority; the NSW Natural Resources Access Regulator; SunWater; the Queensland Department of Agriculture and Fisheries; the Queensland Department of Natural Resources and Mines; and the Commonwealth Department of Energy and the Environment.

Bourke Shire Council were exceptional in jointly arranging community functions there in late May.

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Neal assisting NSW DPI Fisheries to stock silver perch in the Namoi River, for conservation purposes

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Jason discussing opportunities for sharing information on river health with Aaron Hinch at Collarenebri Central School

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Sources:

1 – Commonwealth Environmental Water Office, using NSW gauged data for the Darling River at Wilcannia
2 – Commonwealth Environmental Water Office (left and right) and NSW DPI Fisheries (middle)
3 – Commonwealth Environmental Water Office, using NSW gauged data
4 – Commonwealth Department of the Environment and Energy
5 – WaterNSW (left) and Commonwealth Environmental Water Office (right). The left photo was taken after the event, but at the same flow conditions that occurred prior to the event
6 – The Murray-Darling Basin Authority, using raw Sentinel 2 satellite images, which have a resolution of 10m^2 and cover the whole Basin every few days. The image is enhanced to highlight the presence of water.
7 – The satellite images to above were provided by the Murray-Darling Basin Authority, using Sentinel 2 satellite images, which have a resolution of 10m2. Source of photos: Commonwealth Environmental Water Office.
8 – Bourke Shire Council.
9 – Justin and Julie McClure.
10 – Central Darling Shire.
11 and 12 – Commonwealth Environmental Water Office, using NSW gauged data
13 – NSW DPI Fisheries and the Commonwealth Environmental Water Office
14 – NSW DPI Fisheries and Queensland Department of Agriculture and Fisheries
15 – Eco Logical Australia
16 – Commonwealth Environmental Water Office
17 – Drone image kindly provided by Paul Harman
18 – NSW DPI Fisheries
19 – Eco Logical Australia
20 – Images from WaterNSW website, https://maps.waternsw.com.au/AlgalAlerts/
21 – Commonwealth Environmental Water Office
22 – Wilcannia Drop-in Centre
23 – Commonwealth Environmental Water Office
24 – Murray-Darling Basin Authority
25 – Western Herald (photograph of Grant Barnes, Chief Regulatory Officer, Natural Resource Access Regulator and Jody Swirepik, the Commonwealth Environmental Water Holder)
26 – Representatives of multiple agencies: WaterNSW, the Murray-Darling Basin Authority, the NSW Office of Environment and Heritage, NSW DPI Fisheries, the Natural Resource Access Regulator, and the Commonwealth Environmental Water Office.
27 – Western Herald (photograph of Grant Barnes, Chief Regulatory Officer, Natural Resource Access Regulator and Jody Swirepik, the Commonwealth Environmental Water Holder)
28 and 29 - Commonwealth Environmental Water Office, using NSW gauged data

Other references:

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