HYDROLOGY | FOOD WEBS | VEGETATION | WATERBIRDS | FISH

Appendix A – Gwydir River Hydrology

1 Introduction

Hydrology, when, where and how water is delivered into a channel, floodplain or wetland, underpins the environmental and ecological processes in a river system.

Hydrological information is directly relevant to all other indicators measured in the Gwydir River system Selected Area (Gwydir Selected Area, Selected Area) namely: Food Webs (water quality, microinvertebrates, macroinvertebrates, metabolism); Vegetation; Waterbirds; and Fish.

The Hydrology indicator also provides information on the degree of hydrological connection maintained through the Selected Area during the 2019-20 water year and throughout the Commonwealth Environmental Water Office (CEWO) Long-term Intervention Monitoring (LTIM) project (2014-2019) and Monitoring Evaluation and Research (MER) project (2019-2022).

Several specific questions were addressed in relation to this indicator:

- What did Commonwealth environmental water contribute to hydrological connectivity of the Gwydir Selected Area channels?
- What did Commonwealth environmental water contribute to hydrological connectivity of the Gingham, Gwydir and Mallowa wetlands?
- What did Commonwealth environmental water contribute to sustainable ecosystem diversity?
- Were ecosystems to which Commonwealth environmental water was allocated sustained?
- Was Commonwealth environmental water delivered to a representative suite of ecosystem types?

It should be noted that environmental water in the Gwydir catchment is owned and managed by both the CEWO and the Department of Planning, Industry and Environment – Environment, Energy and Science (DPIE-EES). The CEWO and DPIE-EES generally work together to co-deliver water from both holdings for environmental benefit. Throughout this report the term environmental water is used to represent the combined deliveries from both government agencies. Where environmental water was delivered specifically by a single agency that usage is labelled as coming from that agency.

1.1 Weather conditions 2019-20

The region experienced some of the hottest and driest conditions on record in 2019 (BOM 2020). For the 2019 calendar year the weather station at the Moree airport recorded 125.4 mm of rainfall, the lowest on record. For the 2019-20 water year the period from July-December recorded only 49 mm compared to a long-term average of 274.8 mm (Figure 1). However, the period from January-June experienced above average rainfall with 380.2 mm.

The mean monthly maximum temperature was higher in 2019-20 than the long-term averages from July-January and generally lower from February-June (Figure 2).

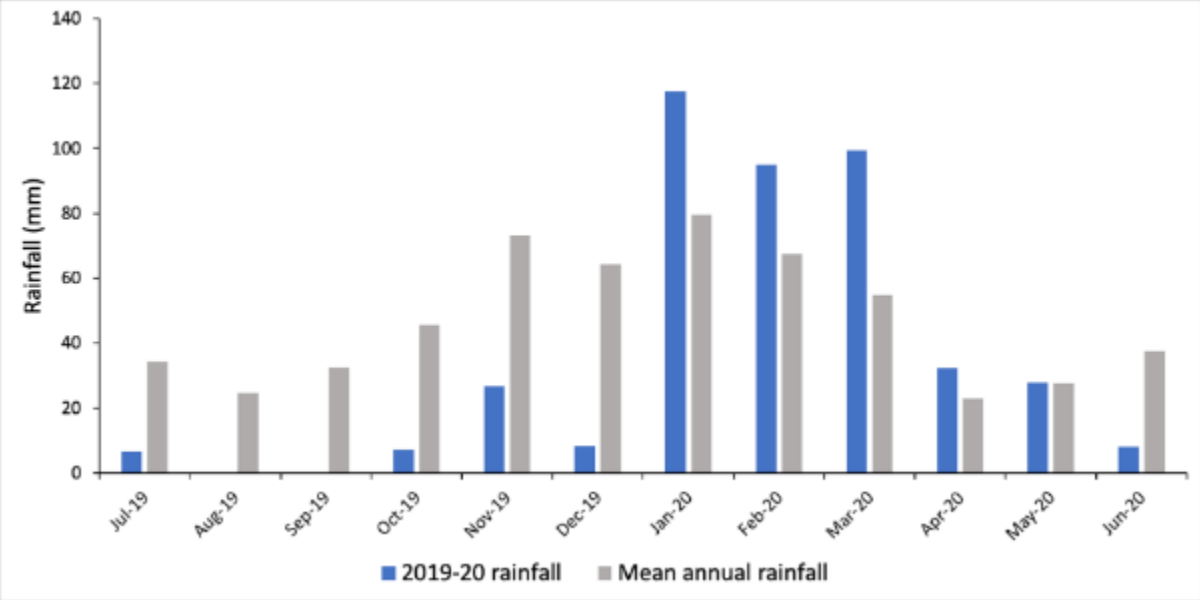

Figure 1 Moree (airport) rainfall for 2019-20 water year.

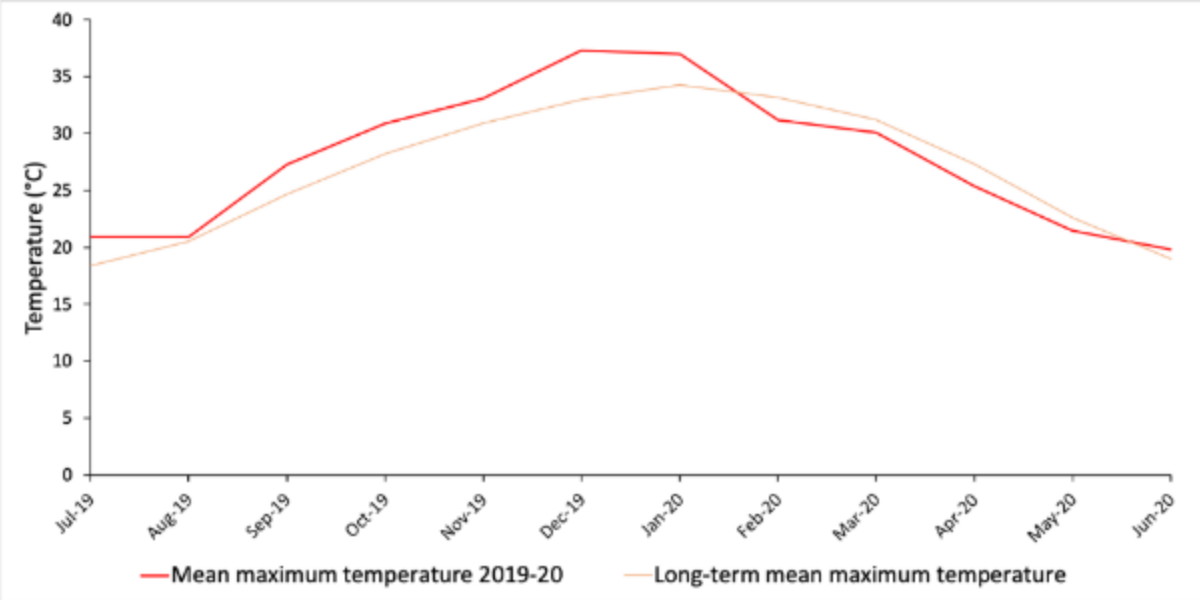

Figure 2 Moree (airport) mean maximum monthly temperature 2019-20 water year.

2 Methods

2.1 Environmental watering

Data on the environmental watering (dates and volumes) delivered into the system was accessed directly from the CEWO and DPIE-EES. These data are presented as tables and within hydrographs to describe the role of environmental water in the Selected Area in the 2019-20 water year (July 1 2019 to June 30 2020).

2.2 Hydrological connectivity

An assessment of the hydrological connectivity experienced throughout the channels and wetlands (including watercourses) in the Selected Area was undertaken via analysis of hydrographic data. Daily mean discharge data in megalitres per day (ML/d) were downloaded from the WaterNSW real time data website for the 2019-20 water year (realtimedata.waternsw.com.au) for all gauges in the Selected Area (Table 1, Figure 3). These data were plotted as annual hydrographs for descriptive analysis.

Hydrological connectivity was determined by comparing upstream and downstream flows. Flow thresholds measured at upstream gauging stations were identified that would ensure flow through the length of channel in each zone. These thresholds were estimated through an analysis of historical flow records (from 1990-2014) whereby corresponding peaks of small flow events were observed at both upstream and downstream gauging sites, suggesting connection throughout the length of the channel. These thresholds were then compared with known average stream losses provided by WaterNSW. Due to the off-river abstraction of flows in some channels, flows passing the downstream gauges were also quantified to confirm connectivity through the system. Here, discharge of 5 ML/d at the downstream gauge was used to indicate through flow connection.

Once the thresholds were identified, spells analysis (Gordon *et al.* 1992) was undertaken to assess the total duration and frequency of flows passing each gauge. Results for downstream gauges were then subtracted from those at upstream gauges to provide an estimate of full longitudinal connectivity along channels throughout the 2019-20 season.

In the Mallowa Creek system no downstream gauge exists, making an assessment of hydrological connectivity impossible. To determine the duration of wet and dry spells a minimum value of 5 ML/d entering the system through the regulator was used to indicate a connection period.

Table 1 Gauging stations and connectivity thresholds used to determine hydrological connectivity in the Gwydir Selected Area.

Zone	Channel	Gauging station (upstream or downstream)	Gauging station number	Threshold for longitudinal connectivity
Gwydir River	Gwydir	Gwydir DS Copeton Dam (U/S)	418026	100 ML/d
		Gwydir River @ Pallamallawa (D/S)	418001	5 ML/d
Gingham-Gwydir	lower Gwydir	Gwydir (south arm) DS Tyreel regulator (U/S)	418063	40 ML/d
		Gwydir @ Millewa (D/S)	418066	5 ML/d
	Gingham	Gingham channel @ Teralba (U/S)	418074	50 ML/d
		Gingham channel @ Gingham bridge (D/S)	418079	5 ML/d
Mehi-Moomin	Mehi	Mehi River @ D/S Tareelaroi Regulator (U/S)	418044	300 ML/d
		Mehi River @ near Collarenebri (D/S)	418055	5 ML/d
	Moomin	Moomin @ Combadello Cutting (U/S)	418048	30 ML/d
		Moomin @ Moomin plains (D/S)	418070	5 ML/d
	Mallowa	Mallowa @ Mallowa Regulator (U/S)	418049	>5 ML/d

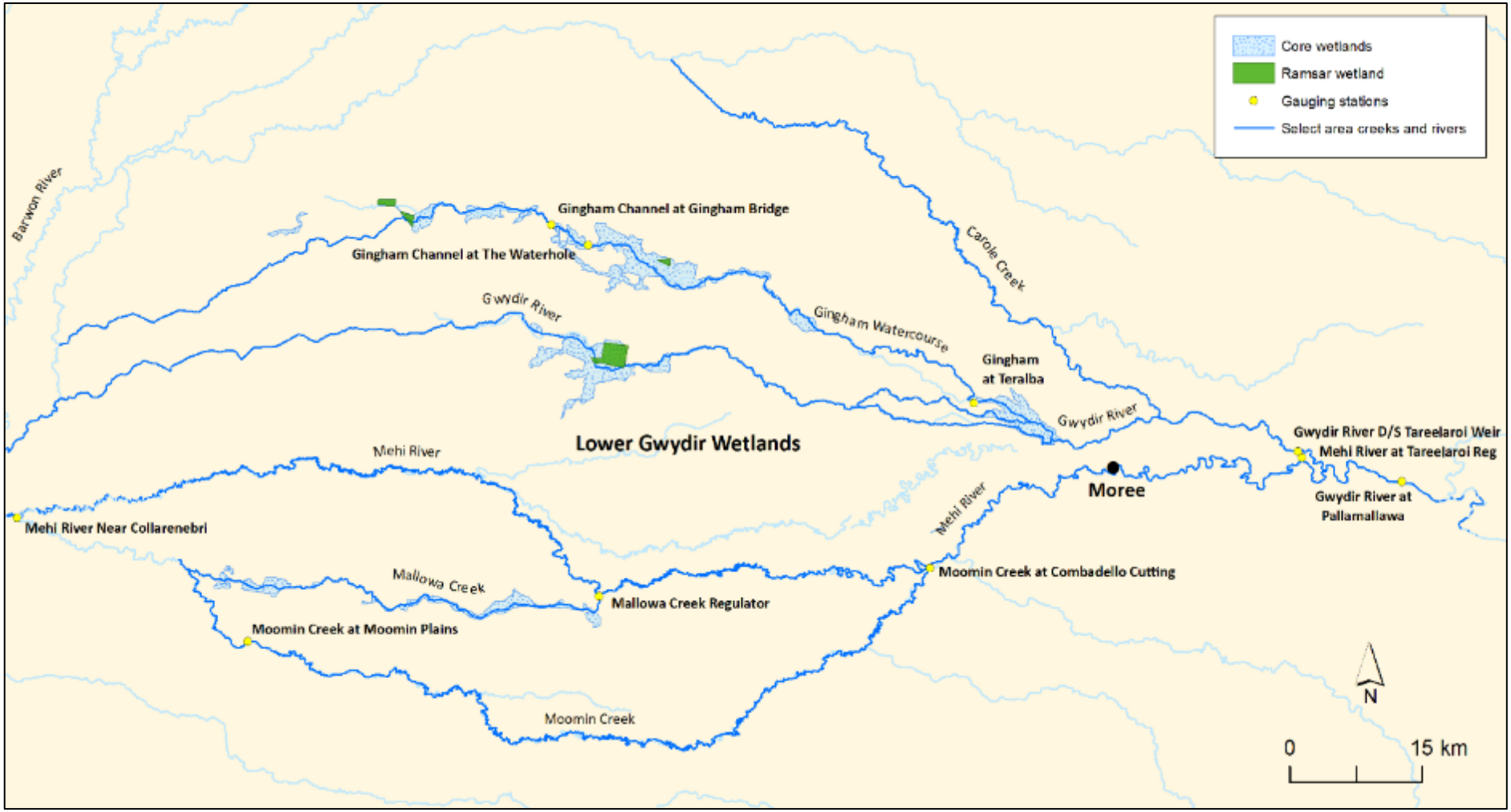

Figure 3 Gauging stations within the Gwydir River Selected Area.

2.3 Inundation mapping

2.3.1 Sentinel image analysis

Three data sources were used to build a model of inundation extent and volume in the Gwydir, Gingham and Mallowa systems. These included:

- Sentinel imagery
- Existing vegetation mapping
- Water level observations throughout the LTIM and MER project period

These data sources were examined together to produce relationships with inflow, inundation extent and volume. Existing vegetation mapping was used to determine the area and volume of inundation associated with each vegetation community in all three wetland systems.

All available Sentinel 2 images captured during the 2019-20 water year were provided by the Murray-Darling Basin Authority (MDBA) via the MDBsat system. Those with minimal cloud cover and no other problems were chosen for further analysis. A total of 37 images were selected for analysis (Table 2).

The MDBA also provided the data processed into Modified Normalised Difference Water Indices (MNDWI, Xu 2006). For each date the MNDWI was analysed to determine the water threshold value that was used to classify water and non-water pixels to define the inundation extent. Threshold values were found to lie between -0.12 and -0.17 (Table 2). A maximum wetland extent layer was then used to exclude waterbodies such as irrigation storages and farm dams outside of the target wetland area. Rainfall records were used to exclude image dates within 5 days of heavy rainfall to help reduce mapping error introduced by local rainfall derived wetting.

The mapped inundation extent for each capture date was used to quantify the inundation extent across each wetland area.

Table 2 Sentinel image dates analysed to map wetland inundation extent.

Image date	MNDWI Threshold	Image date	MNDWI Threshold
12-Jul-19	-0.17	14-Dec-19	-0.15
17-Jul-19	-0.17	19-Dec-19	-0.14
27-Jul-19	-0.17	29-Dec-19	-0.14
6-Aug-19	-0.17	2-Feb-20	-0.15
16-Aug-19	-0.16	17-Feb-20	-0.14
21-Aug-19	-0.13	27-Feb-20*	-0.14
26-Aug-19	-0.16	13-Mar-20*	-0.14
31-Aug-19	-0.15	18-Mar-20	-0.14
5-Sep-19	-0.15	23-Mar-20	-0.14
10-Sep-19	-0.15	12-Apr-20	-0.14
15-Sep-19	-0.16	22-Apr-20	-0.14
15-Oct-19	-0.14	2-May-20	-0.12
20-Oct-19	-0.15	12-May-20	-0.12
25-Oct-19	-0.15	17-May-20	-0.13
9-Nov-19	-0.14	6-Jun-20	-0.13
14-Nov-19	-0.15	11-Jun-20	-0.13
19-Nov-19	-0.14	16-Jun-20	-0.13
4-Dec-19	-0.14	26-Jun-20	-0.13
9-Dec-19	-0.14		

* 27 Feb 20 and 13 Mar 20 were rain affected and removed from further analysis

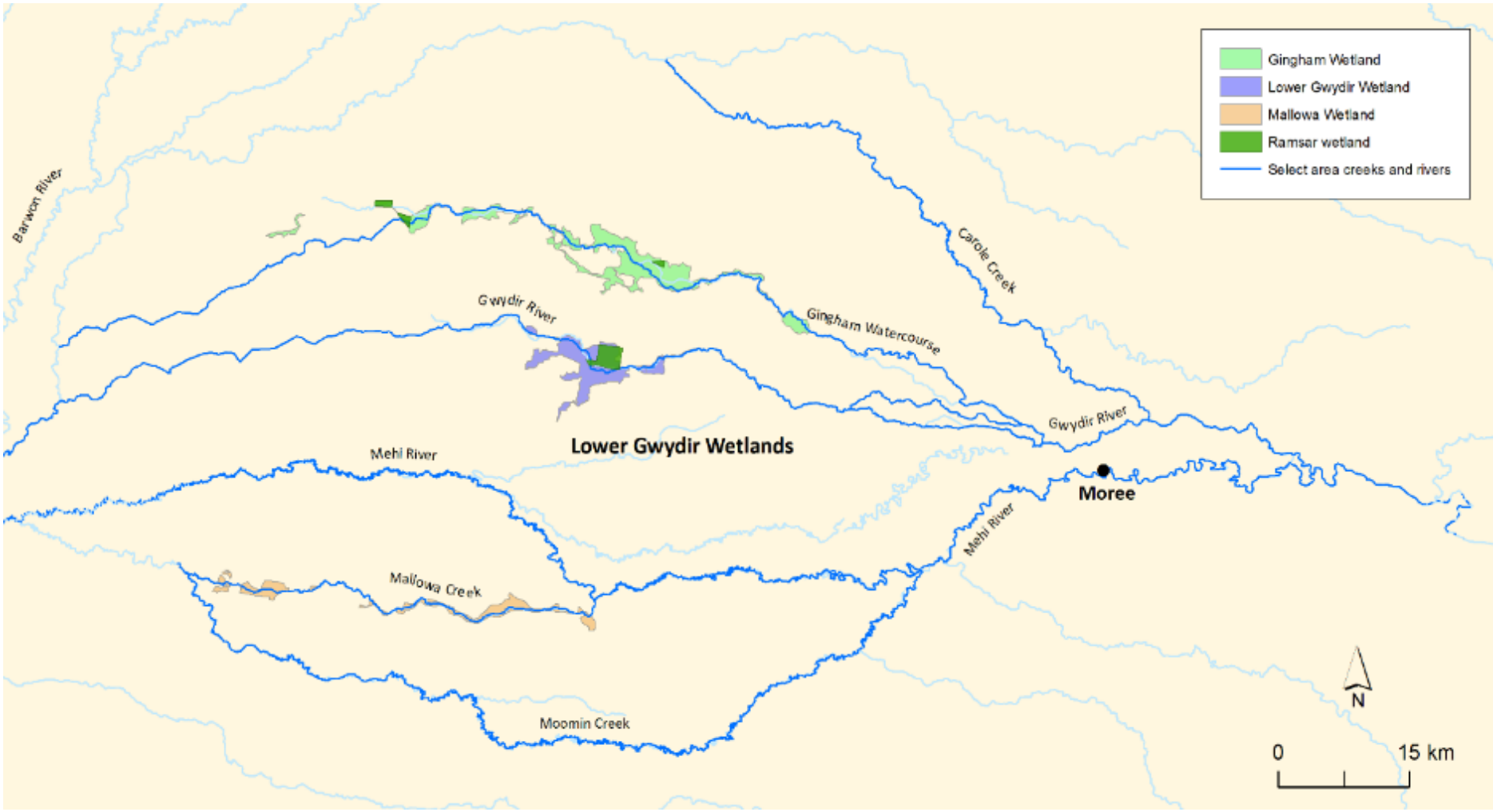

Figure 4 Wetland extent layer.

2.3.2 Inundation volume analysis

To calculate the volume of inundation associated with each image the mapped inundated extent was intersected with a Gwydir vegetation community layer to determine the extent of inundation within each vegetation community. The average depth of inundation within each community for large and small inundation events was determined via observations in the field and reconciliation against water level data (Table 3).

Table 3 Relationship between inundation depth and wetland vegetation community for the Lower Gwydir and Gingham wetlands. No inundation depth data for the Mallowa was available for this analysis.

Wetland	Vegetation community	Depths (cm)	
		Small flood	Large flood
		<500 ha	>500 ha
Gingham	Belah woodland	5	10
	Cleared land	5	10
	Coolabah - River Coobah - Lignum woodland wetland	5	10
	Coolibah open grassy/chenopod grassy woodland	5	10
	Cultivated land	5	10
	Cumbungi rushland	20	30
	Farm Dam*	80	100
	Marsh Club-Rush very tall sedgeland	10	20
	Natural / ephemeral water body	40	60
	Poplar Box shrubby woodland on sandy loam soils	5	10
	River Cooba swamp/Lignum shrubland	10	20
	River Red Gum woodland	5	10
	Shallow freshwater wetland sedgeland	10	20
	Water Couch marsh grassland	10	20
		<200 ha	>200 ha
Lower Gwydir	Channel	40	60
	Common Reed	10	20
	Coolabah - River Coobah - Lignum woodland wetland	5	10
	Cultivated land	5	10
	Cumbungi rushland	20	30
	Cumbungi/Marsh Club-Rush very tall sedgeland	20	30
	Farm Dam*	80	100
	Marsh Club-Rush very tall sedgeland	10	20
	Marsh Club-Rush very tall sedgeland/Common Reed tall grassland	10	20
	Natural / ephemeral water body	40	60
	River Cooba swamp/Lignum shrubland	10	20
	River Red Gum woodland	5	10
	Shallow freshwater wetland sedgeland	10	20
	Shallow freshwater wetland sedgeland/Cumbungi rushland	10	20
	Water Couch marsh grassland	10	20
	Water Couch marsh grassland/Shallow freshwater sedgeland	10	20
	Water storage*	80	100

2.3.3 Ecosystem type assessment

The Australian National Aquatic Ecosystem (ANAE) classification for each sampling site in the Selected Area was mapped using a process of desktop identification and field verification (Commonwealth of Australia 2014). Existing ANAE GIS layers (Brooks et al. 2013) were used to assign an ecosystem type to each monitoring site, and this was then verified in the field. Sites where existing ANAE mapping did not provide coverage were assigned an ANAE classification using available desktop information and then verified in the field. Field based verification was undertaken following a dichotomous key (Brooks et al. 2013).

The ANAE layer was intersected with the maximum mapped extent of inundation to determine the extent of ANAE classes inundated in the water year.

3 Results

3.1 Environmental water deliveries

Available Commonwealth environmental water holdings totalled 18,917 ML in the Gwydir River system for the 2019-20 water year. This was complemented by DPIE-EES General Security water entitlements and the NSW Environmental Contingency Allowance (ECA) of 29,700 ML. Of this, a total of 7,659 ML of Commonwealth environmental water and 4,467 ML of NSW ECA and General Security water was delivered in the 2019-20 water year via several watering actions in multiple channels (Table 4).

During 2019-20, environmental water was delivered to in-channel assets in the Gwydir River system (Table 4), primarily for dry river protection given the very low inflows experienced in the early parts of the year. In late October/November, 5,000 ML of both Commonwealth and state environmental water was released from Copeton Dam to connect multiple channels in the lower Gwydir. This flow was accounted at the Copeton Dam wall, hence only 3,800 ML of environmental water flowed into the Gwydir, Gingham, Mehi and Carole Creek channels below Tareelaroi weir. Due to deteriorating water quality in the Mehi River associated with this flow release, 100 ML was abstracted into storage downstream of Combadello weir, and an additional 128 ML was diverted down the Mallowa Creek system to improve water quality and minimise ecological impacts in the Mehi River. As dry catchment conditions continued, two smaller flow pulses were delivered to the Gwydir, Gingham, Mehi and Carole channels to maintain refugial water holes. These flow pulses occurred in December (1,800 ML) and January (3,000 ML).

Table 4 Environmental water use during the 2019-20 water year.

Channel	Commonwealth Environmental Water (CEW) delivered (ML)	NSW ECA/General Security /Supplementary environmental Water delivered (ML)	2019-20 total flow (ML)	Environmental Water % of total flow
Gwydir River*	4,589	4,339	121,796	7.33
Gingham watercourse	1,984 (inc. 1,410 supplementary water)	826	23,161	12.13
Lower Gwydir	2,714 (inc. 1,410 supplementary water)	946	19,718	18.56
Carole Creek	709	591	20,062	6.48
Mehi River<	2,002	1,976	35,426	11.23
Mallowa Creek	250 supplementary water	128	763	49.52
Total	**7,659 (inc. 3,070 supplementary water)**	**4,467**		

* All environmental water delivery (except supplementary) to the Gwydir system flowed through the Gwydir River in 2019-20. Therefore, volumes for this channel represent total volumes delivered downstream and as such are not included in the total.
< Also includes 100 ML NSW General Security water for delivery to Whittaker's Lagoon.

Increased catchment inflows in February and March triggered two periods of supplementary access. Two days of supplementary access were announced in mid-February where 2,820 ML were accounted for in the lower Gwydir and Gingham channels. This, along with some 3T water provided inflows to the downstream wetlands. A second period of supplementary access was announced in mid-March in response to inflows into the Mehi River from Tycanna and Washpool Creeks. During this time, 250 ML of Commonwealth supplementary water was delivered down the Mallowa Creek

3.2 Hydrological connectivity

In the 2019-20 water year hydrological connectivity was limited in all monitored channels within the Selected Area. Record low rainfall in 2019 meant that most channels had ceased-to-flow and were disconnected for long periods of time. The percentage of connected days out of the year ranged from 2.7-22.2%, and any connection events were of relatively short duration (Table 5).

Table 5 Hydrological connectivity within the Gwydir Selected Area 2019-2020 water year.

Monitoring Zone	Channel	Days connected (%)	No. of times connected	Average duration of connection events (days)	Longest wet (days)	Longest dry (days)
Gwydir River	Gwydir River	22.2	7	10	39	148
Lower Gwydir River and Gingham watercourse	Lower Gwydir River	18.1	8	8	16	210
	Gingham watercourse	12.6	4	12	19	244
Mehi River and Moomin Creek	Mehi River	3.8	4	4	8	75
	Moomin Creek	5.8	4	5	12	225
	Mallowa Creek	2.7	2	5	8	139

Connection in the Gwydir River channel occurred on 7 occasions, with the longest event being a 39-day period commencing in late October 2019 (Figure 5). Environmental water was released as 4 discrete events from September 2019 to early February 2020. Releases in late October-November, December and January helped to connect the channel and maintain connection for short durations. Rainfall in January and February led to an in-channel fresh from upstream tributaries that provided sustained flow below the confluence of the Gwydir and Horton Rivers. Releases from Copeton Dam were reduced during this runoff driven event and remained below the threshold used to signify connection along the entire reach.

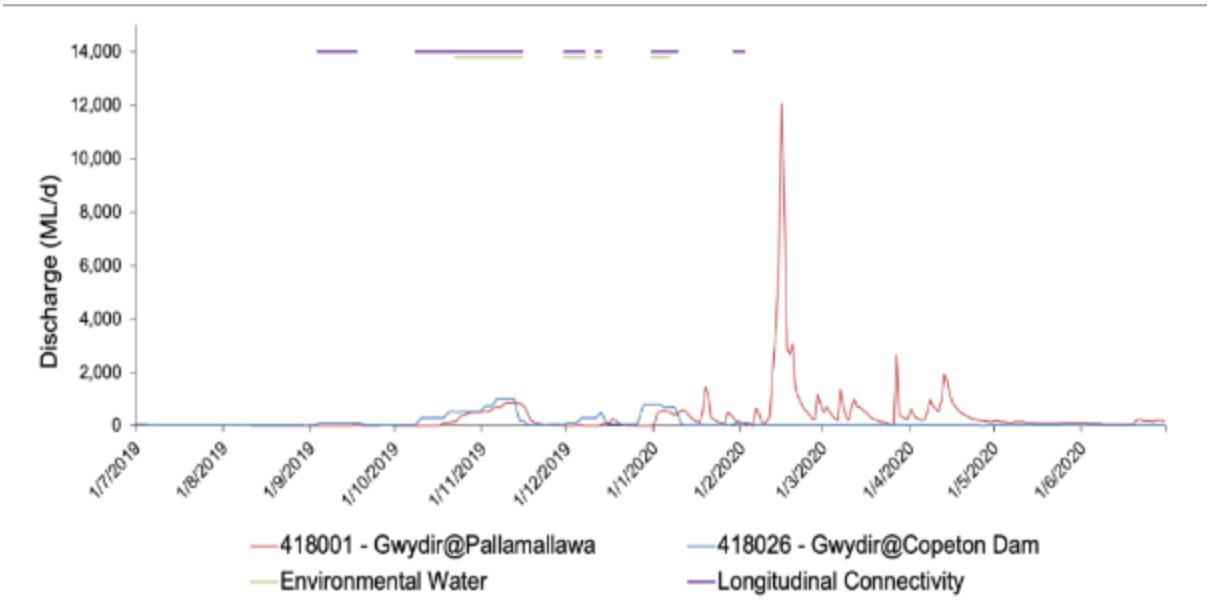

Figure 5 Gwydir channel hydrology and connectivity, Copeton Dam to Pallamallawa, 2019-20 water year.

Connectivity in the lower Gwydir River channel was also dominated by very restricted flows and low connectivity until the runoff driven flow events in February-April provided several longer connection events (Figure 6).

Environmental water was used to maintain refugial pool water quality in several releases from November to January. While these releases reached the target pools in the reach, they did not travel far enough downstream to provide full connectivity along this channel.

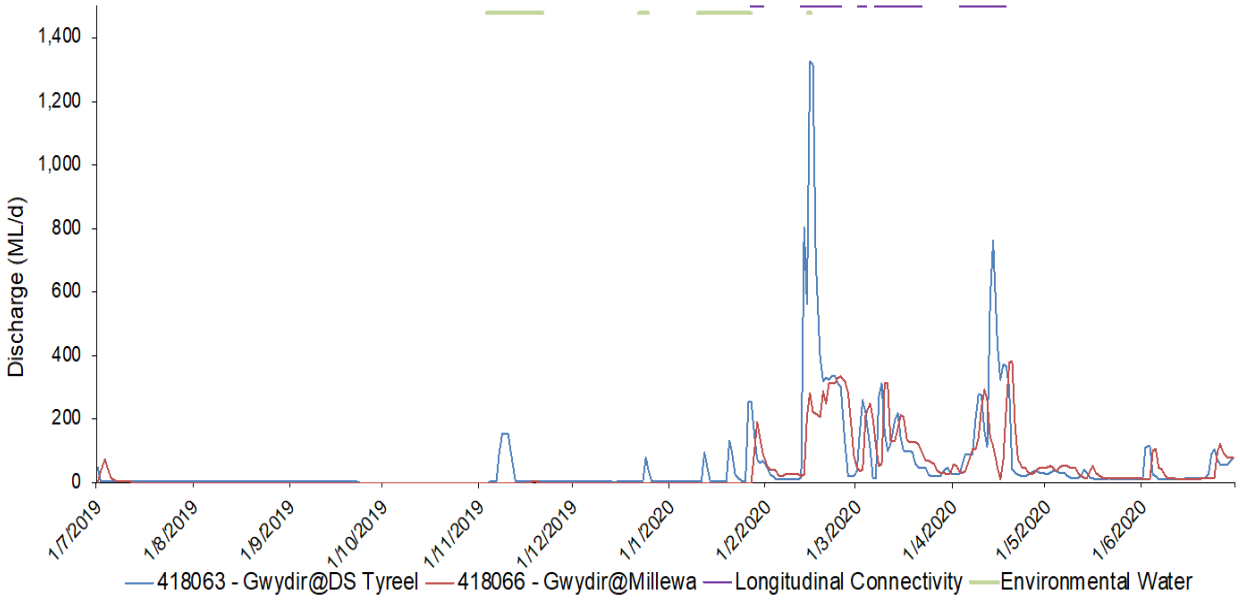

Figure 6 Lower Gwydir channel hydrology and connectivity, 2019-20 water year.

The Gingham watercourse was disconnected until early April when discharge from January to March rainfall made its way to the Gingham Bridge (Figure 7). Two pulses of environmental water were released down the channel, one in November and another in January but they did not connect all the way to the Gingham Bridge.

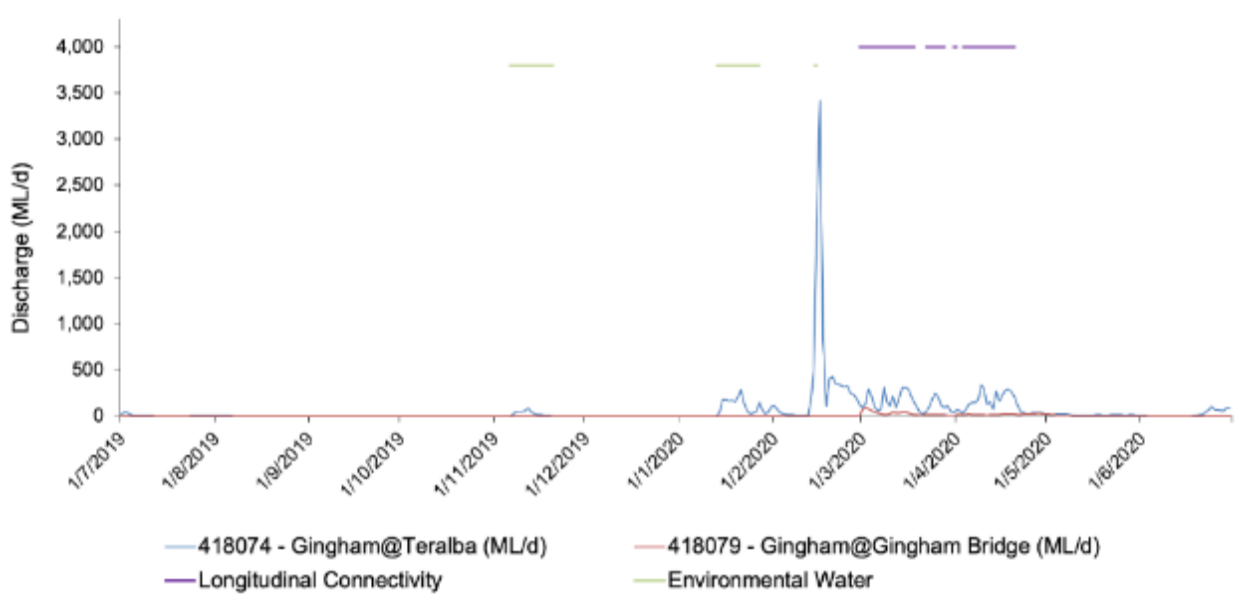

Figure 7 Gingham channel hydrology and connectivity, 2019-20 water year.

Like all of the channels in the lower Gwydir region, the Mehi River had low to no flows during the first part of the water year (Figure 8). The flow event that peaked in mid-February was derived from mid-lower catchment rainfall and while there was overbank flow in the lower reach there was only a brief period of longitudinal connectivity. Environmental water was delivered in 3 pulses, September, December and January in order to improve refuge pool persistence and water quality.

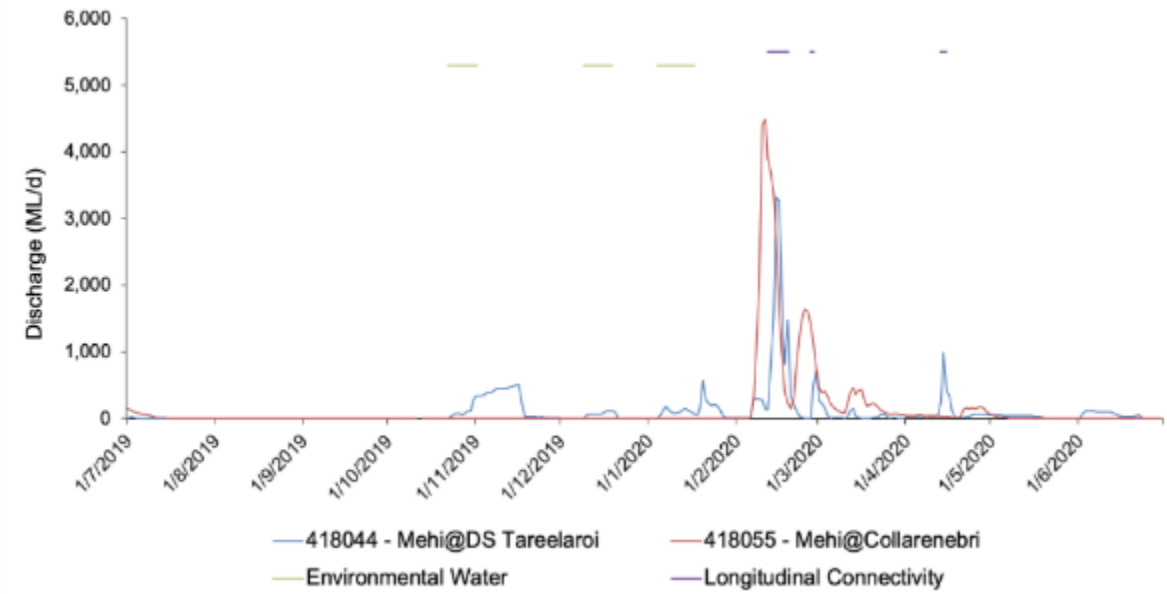

Figure 8 Mehi River hydrology and connectivity, 2019-20 water year.

Connectivity in Moomin Creek followed a similar pattern to that shown in the Mehi River (Figure 9). The first part of the year was extremely dry and the channel remained disconnected until mid-February. After the relatively large flow in mid-February there were 5 brief periods of connection driven by rainfall/runoff events. There was no environmental water delivered into the Moomin system in the 2019-20 water year.

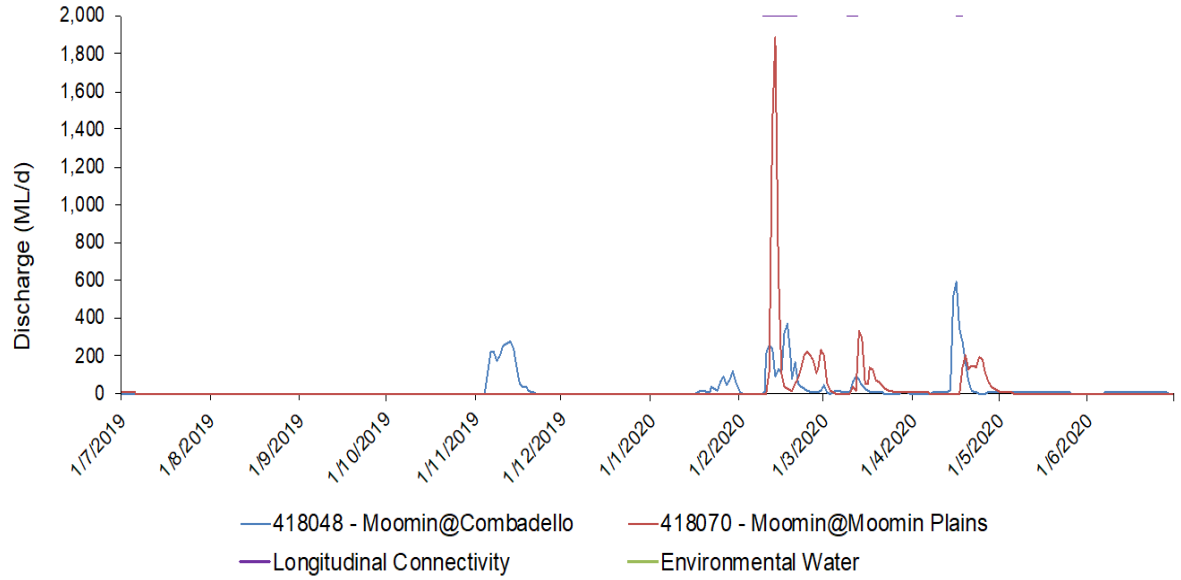

Figure 9 Moomin Creek hydrology and connectivity, 2019-20 water year.

Flows in Mallowa Creek were very small and infrequent during the 2019-20 water year (Figure 10). The 2 very brief periods of connectivity were entirely due to environmental water releases in November and March.

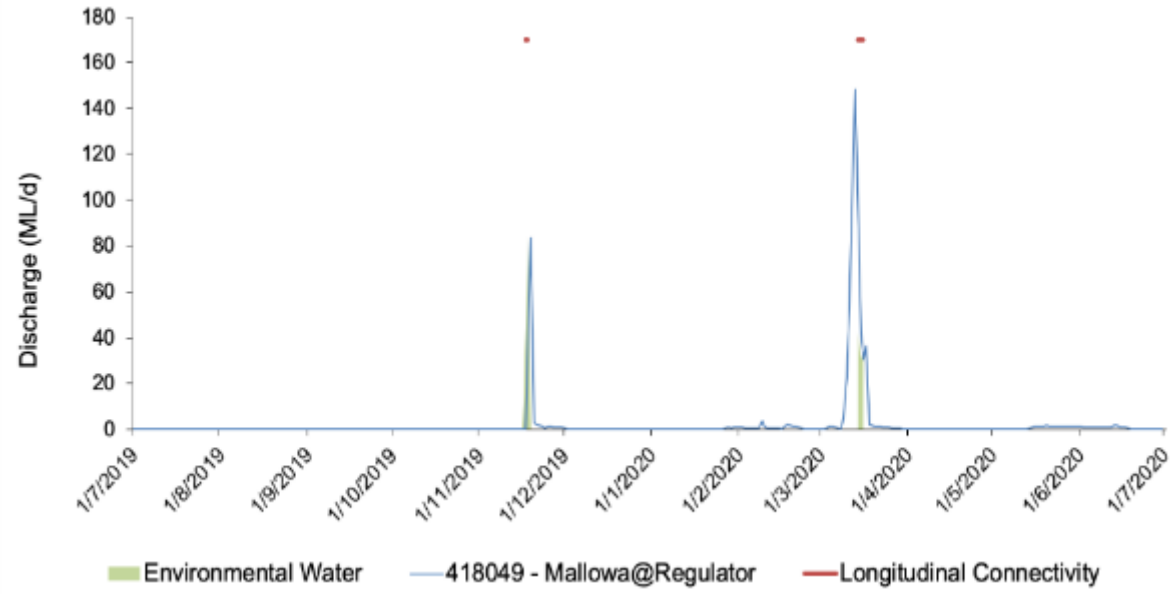

Figure 10 Mallowa Creek hydrology and connectivity, 2019-20 water year.

3.3 Wetland inundation

3.3.1 Inundation extent

The MDBA were able to provide 37 Sentinel cloud free images over the study area. Of these, 2 images were found to be clearly rain affected and were removed from analysis (27 Feb 20 and 13 Mar 20). The water year started with approximately 180 ha of inundation combined across the three mapping areas (Table 6, Figure 11). The mapped inundated area declined steadily from July 2019 to October 2019 when the minimum mapped area of <6 ha persisted until early February 2020. Rainfall and flows from

January and February led to a period of relatively high inundation across the 3 areas with combined inundation peaking at approximately 1,900 ha in mid-February. Inundation remained over 1200 ha until May when the inundated area began to decline consistently leaving approximately 300 ha inundated in late June.

Table 6 Mapped inundation by wetland area.

Image date	Gingham (ha)	Lower Gwydir (ha)	Mallowa (ha)	Total
12-Jul-19	90.9	37.3	52.4	180.6
17-Jul-19	75.8	46.0	63.8	185.6
27-Jul-19	32.7	26.1	34.3	93.0
6-Aug-19	27.6	19.4	22.5	69.6
16-Aug-19	14.4	6.9	7.3	28.6
21-Aug-19	8.5	2.6	2.1	13.2
26-Aug-19	8.1	3.5	3.5	15.0
31-Aug-19	6.1	2.3	2.3	10.8
5-Sep-19	14.3	1.8	2.2	18.3
10-Sep-19	4.4	1.4	1.9	7.7
15-Sep-19	4.5	1.7	2.2	8.3
15-Oct-19	1.6	0.6	1.4	3.7
20-Oct-19	1.2	0.5	1.3	3.0
25-Oct-19	0.9	0.4	1.5	2.9
9-Nov-19	0.6	0.5	1.2	2.2
14-Nov-19	3.5	0.5	1.3	5.3
19-Nov-19	2.8	0.5	1.4	4.6
4-Dec-19	0.5	0.6	1.3	2.4
9-Dec-19	0.5	0.5	1.5	2.5
14-Dec-19	0.5	0.5	1.3	2.2
19-Dec-19	0.4	0.5	1.6	2.5
29-Dec-19	0.4	0.2	1.0	1.6
2-Feb-20	252.4	18.0	0.6	271.0
17-Feb-20	1,092.4	402.7	420.5	1,915.6
18-Mar-20	1,157.3	592.1	105.7	1,855.0
23-Mar-20	776.1	369.4	82.0	1,227.4
12-Apr-20	1,035.6	381.1	28.3	1,444.9
22-Apr-20	1,023.2	379.6	19.6	1,422.4
2-May-20	716.1	127.9	16.4	860.3
12-May-20	697.3	110.5	15.9	823.6
17-May-20	423.3	91.9	13.4	528.5
6-Jun-20	345.1	78.6	14.3	438.0
11-Jun-20	392.6	114.4	17.6	524.5
16-Jun-20	371.0	122.0	22.6	515.5
26-Jun-20	238.5	64.0	15.5	318.0

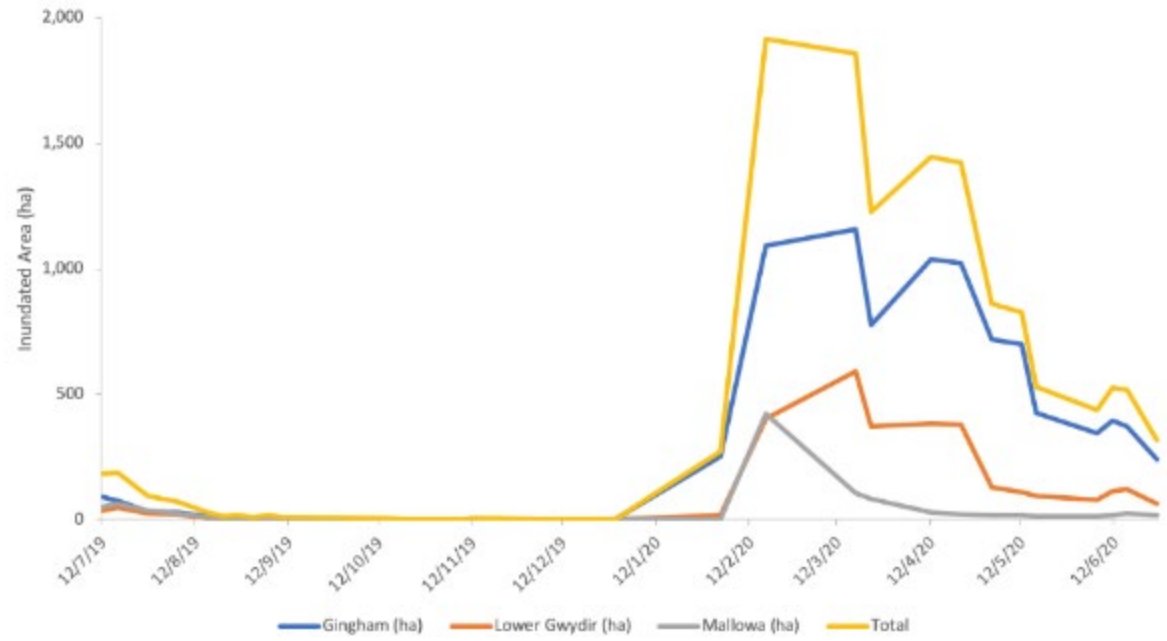

Figure 11 Mapped inundation by wetland area.

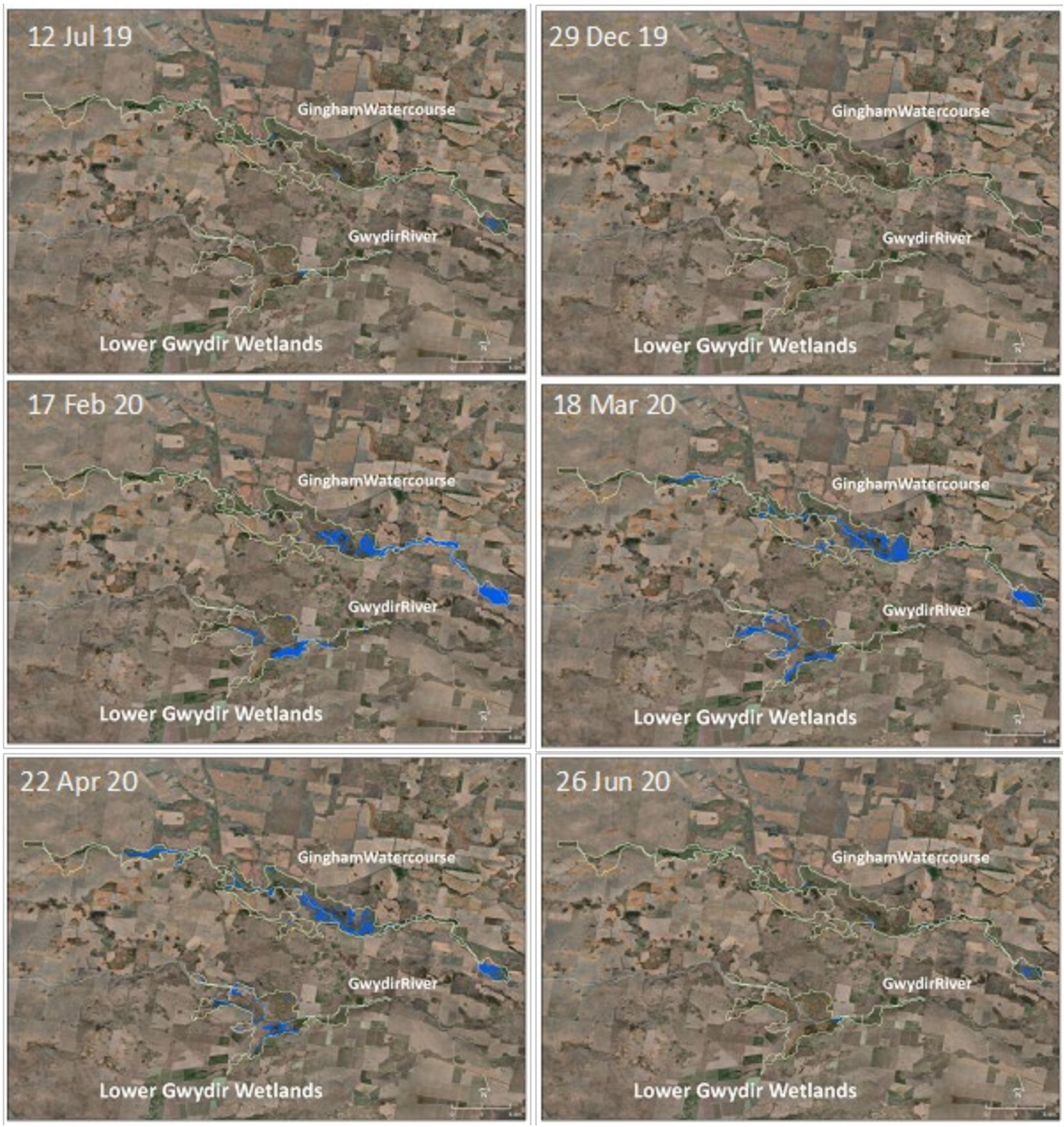

Figure 12 Gingham and Lower Gwydir inundation map sequence.

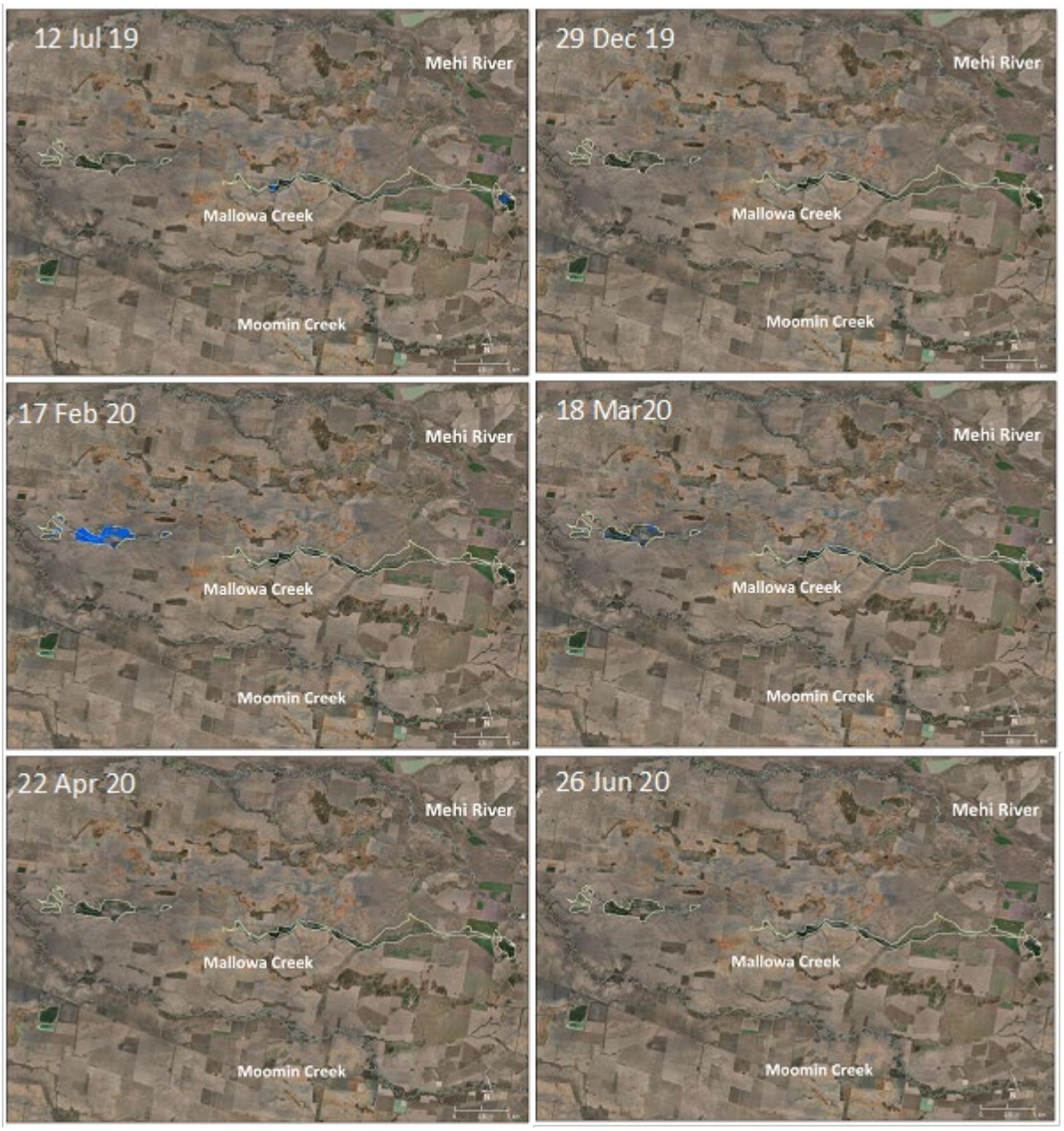

Figure 13 Mallowa inundation map sequence.

3.3.2 Inundation of vegetation communities and volume estimation

Using the maximum mapped inundation extent, the area of vegetation communities inundated within the water year was mapped (Table 7). The mapping shows that a substantial area at Coolabah - River Coobah-Lignum woodland wetland was inundated across all three wetland areas on 17 Feb 2020. Other communities with substantial inundation included: Cumbungi rushland; Cumbungi/Marsh Club-Rush and areas of sedgeland and marsh grassland.

*Table 7 Vegetation communities inundated at the largest mapped extent (17/2/20) 2019-20 water year. * Inundation depth and hence volumes were not available for the Mallowa Wetlands. ^ Farms dams and water storages were not included in total volume calculations.*

Wetland	Vegetation community	Area inundated (ha)	% of mapped community	Total Area (ha)	Volume – ML*
Gingham	Belah woodland	0.4	0%	112.6	0.38
	Cleared land	4.6	31%	14.8	4.56
	Coolabah - River Coobah - Lignum woodland wetland	278.5	23%	1,196.3	278.46
	Coolibah open grassy/chenopod grassy woodland	0.6	0%	223.9	0.55
	Cultivated land	38.0	8%	484.2	37.98
	Cumbungi rushland	276.4	36%	767.8	829.32
	Farm Dam^	0.9	18%	5.4	9.46
	Marsh Club-Rush very tall sedgeland	5.0	46%	10.9	10.03
	Natural / ephemeral water body	20.7	26%	79.9	124.47
	Poplar Box shrubby woodland on sandy loam soils	0.1	1%	9.3	0.12
	River Cooba swamp/Lignum shrubland	270.8	23%	1,191.2	541.62
	River Red Gum woodland	1.7	7%	25.6	1.73
	Shallow freshwater wetland sedgeland	101.3	8%	1,305.9	202.66
	Water Couch marsh grassland	92.4	25%	364.9	184.74
	Gingham Total	**1,091.4**		**5,792.7**	**2,216.62**
Lower Gwydir	Channel	1.5	6%	23.4	8.91
	Common Reed	3.4	7%	47.7	6.73
	Coolabah - River Coobah - Lignum woodland wetland	13.0	4%	345.9	12.97
	Cultivated land	21.0	10%	203.3	21.04
	Cumbungi rushland	3.1	4%	76.4	9.35
	Cumbungi/Marsh Club-Rush very tall sedgeland	133.1	25%	541.2	399.41
	Farm Dam^	1.1	22%	4.9	10.96
	Marsh Club-Rush very tall sedgeland	11.0	5%	213.5	21.92
	Marsh Club-Rush very tall sedgeland/Common Reed tall grassland	6.0	54%	11.1	11.93

Wetland	Vegetation community	Area inundated (ha)	% of mapped community	Total Area (ha)	Volume – ML*
	Natural / ephemeral water body	2.5	31%	8.3	15.25
	River Cooba swamp/Lignum shrubland	115.2	35%	326.4	230.30
	River Red Gum woodland	17.0	14%	120.4	17.01
	Shallow freshwater wetland sedgeland	2.9	1%	253.8	5.88
	Shallow freshwater wetland sedgeland/Cumbungi rushland	12.0	3%	467.9	24.09
	Water Couch marsh grassland	37.7	7%	507.9	75.37
	Water Couch marsh grassland/Shallow freshwater sedgeland	19.3	6%	324.5	38.64
	Water storage^	1.5	33%	4.7	15.20
	Lower Gwydir Total	**401.3**		**3,481.3**	**898.78**
Mallowa	Cleared land	0.7	15%	4.6	
	Coolabah - River Coobah - Lignum woodland wetland	309.1	18%	1,715.2	
	Coolibah open grassy/chenopod grassy woodland	0.1	0%	63.6	
	Cultivated land	20.7	8%	273.7	
	Farm Dam	1.8	88%	2.1	
	River Cooba swamp/Lignum shrubland	87.4	48%	184.0	
	Mallowa Total	**419.8**		**2,243.2**	
	Overall Total	**1,912.6**		**11,517.1**	

3.3.3 Inundated ANAE areas

Using the maximum mapped inundation extent, the area of ANAE classes inundated within the water year was mapped for each wetland (Table 8). Within the Gingham, Lower Gwydir and Mallowa wetlands, 10 ANAE types were inundated during the 2019-20 water year including one lacustrine type, two riverine types and seven palustrine types. The mapping shows that a substantial area of Pt2.2.2: Temporary sedge/grass/forb marsh was inundated along with Pt1.3.1: Coolibah riparian zone or floodplain and Pt1.4.1: River cooba riparian zone or floodplain during the 2019-20 water year.

Table 8 ANAE areas inundated at the largest mapped extent (17/2/20) 2019-20 water year.

Wetland	ANAE wetland typology	Area inundated (ha)	Inundation (%)	Total area (ha)
Gingham	Lt1.1: Temporary lake	8.0	80%	10.1
	Pt1.3.1: Coolibah riparian zone or floodplain	246.0	25%	975.9
	Pt1.4.1: River cooba riparian zone or floodplain	165.9	13%	1,258.2
	Pt2.1.2: Temporary tall emergent marsh	85.4	51%	167.2
	Pt2.2.2: Temporary sedge/grass/forb marsh	344.2	14%	2,517.5
	Pt3.1.2: Clay pan	24.3	57%	42.3
	Rp1.4: Permanent lowland stream	2.1	30%	7.1
	Rt1.4: Temporary lowland stream	55.0	36%	150.8
	Gingham Total	**930.8**		**5,129.1**
Lower Gwydir	Pt1.1.1: River red gum riparian zone or floodplain	16.4	14%	116.2
	Pt1.3.1: Coolibah riparian zone or floodplain	6.9	3%	254.1
	Pt1.4.1: River cooba riparian zone or floodplain	111.2	29%	384.7
	Pt2.1.2: Temporary tall emergent marsh	21.0	10%	205.2
	Pt2.2.2: Temporary sedge/grass/forb marsh	221.0	9%	2,350.8
	Lower Gwydir Total	**376.5**		**3,311.0**
Mallowa	Pt1.3.1: Coolibah riparian zone or floodplain	321.4	18%	1,836.5
	Pt1.4.1: River cooba riparian zone or floodplain	10.8	36%	29.7
	Pt1.7.1: Lignum riparian zone or floodplain	25.2	41%	60.8
	Pt2.2.2: Temporary sedge/grass/forb marsh	0.3	3%	10.1
	Rp1.4: Permanent lowland stream	3.0	72%	4.2
	Mallowa Total	**360.7**		**1,941.3**
	Overall Total	**1,668.0**		**10,381.4**

4 Discussion and conclusions

The 2019-20 water year hydrological patterns can be considered as two separate periods. The first part of the year contained some of the driest weather on record and flows were either very low or zero. The second period commencing in February 2020 contained several months of above average rainfall and periods of relatively high flow, connectivity and wetland inundation. Environmental water was used to try and achieve low flow connectivity in the dry period and to extend wetland inundation in the wetter period. A total of 7,659 ML or Commonwealth and 4,467 ML of state held environmental water was delivered in the water year.

A moderate inundation event commenced in February 2020 in the Gingham and Gwydir wetlands inundating around 1,500 ha. This event included a small amount of water for the environment from supplementary water access in these channels. Inundation decreased from the February peak although over 300 ha remained inundated at the end of June 2020. Peak inundation in the Mallowa of around 400 ha similarly occurred in February 2020 but did not coincide with inflows into this channel. It is likely that this inundation was driven by local runoff below the Mallowa Regulator gauge. The influence of the delivery of supplementary water for the environment in March 2020 may have prolonged this inundation in the Mallow system throughout the year. This inundation event wet key wetland vegetation communities including substantial areas of Coolabah - River Coobah - Lignum woodland and rush, sedge and grassland communities. Overlay of the inundation extent with the mapped ANAE classes showed that large areas of Temporary sedge/grass/forb marsh, Coolibah riparian zone or floodplain and River cooba riparian zone or floodplain all received water during this inundation event.

5 References

BOM. 2020. Bureau of Meteorology. Moree Airport (053115). bom.gov.au/climate/averages/tables/cw_053115.shtml. Accessed July 2020.

Brooks, S., Cottingham, P., Butcher, R, & Hale, J. 2013. *Murray Darling aquatic ecosystem classification: Stage 2 report.* Prepared by Peter Cottingham & Associates for the Commonwealth Environmental Water Office and Murray Darling Basin Authority, Canberra.

Commonwealth of Australia. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Gwydir River System Selected Area.* Commonwealth of Australia.

Gordon, N.D., McMahon T.A. and Finlayson, B.L. 1992. *Stream Hydrology - An introduction for Ecologists.* Brisbane, Wiley.

Xu. 2006. Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. *International Journal of Remote Sensing.* 27:14.