Special Climate Statement 70 update—drought conditions in Australia and impact on water resources in the Murray–Darling Basin

13 August 2020

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Version number	Date of issue
1.0	9 April 2019
2.0	29 November 2019
3.0	13 August 2020

Published by the Bureau of Meteorology

Cover image: Water storage, New South Wales, 2018 (Photo: Mark Wilgar).

Summary

- This statement analyses rainfall and hydrological data from the extremely dry period from January 2017 to December 2019, and the generally wetter conditions from January to April 2020.
- 2018-2019 and 2017-2019 had record lowest two- and three-year rainfall totals, respectively, for the Murray–Darling Basin and for New South Wales.
- Rainfall for the northern Murray–Darling Basin for these periods was lowest on record by a substantial margin, breaking records originally set during the Federation Drought in 1900−1902.
- In Victoria, West Gippsland and East Gippsland each had their driest three years on record from 2017-2019.
- Cool season rainfall from April to September totalled across 2017 to 2019 was the lowest on record across most of New South Wales and in most of subtropical Queensland.
- Average to above average rainfall in most of eastern Australia from January to April 2020 has gone part way to recovering some of the rainfall deficiencies, but significant further rain is required for a substantial recovery in Murray−Darling Basin storage levels.
- Below-average rainfall has continued through mid-2020 in much of southern Western Australia, continuing a dry period which began in early 2018.
- In April 2020, root zone soil moisture has reached at least average levels right across the Murray Darling-Basin as a result of the rain in the Basin since January 2020. This recovery follows a three-year record low period of soil moisture in the Basin.
- There has been limited recovery in water storage levels in the Murray-Darling Basin with the rain since January 2020. Water storage in the northern Basin reached the record low of 5.4% of combined capacity in mid-January, 7.5%lower than at any point during the Millennium Drought.
- Groundwater levels across the Murray–Darling Basin have declined over the period from 2017 to 2019, with partial recovery in some parts of the basin during 2020.
- Nationally, Australian rainfall in 2019 was 40% below average, the lowest on record. New South Wales, South Australia and the Murray-Darling Basin also had their driest years on record.
- The dry conditions have taken place in the absence of an El Niño in the Pacific Ocean, but there was a strong positive phase of the Indian Ocean Dipole (IOD) in 2019, which is typically associated with dry conditions in many parts of Australia. This followed two years of relatively cool sea surface temperatures off the northwest coast of Australia and warm waters near Africa, which also likely suppressed rainfall over Australia.

Introduction

The past three years have seen dry conditions over much of eastern Australia, with both 2018 and 2019 being especially dry. This statement provides an update on an earlier summary that was released in late 2019 (Special Climate Statement 66—an abnormally dry period in Eastern Australia), and captures the northern wet season and the main drawdown period for irrigation in southern and eastern Australia, as well as the more general extreme dry conditions in late 2019.

This updated Statement (Special Climate Statement 70) discusses the persistence of dry conditions to the end of 2019, and the partial recovery which has taken place since the start of 2020. The focus of the Statement is on the period since 2017, especially 2019, which was Australia's driest year on record. During this period, most parts of the continent have experienced rainfall deficiencies of some form, the only real exceptions being parts of northern Queensland, western Tasmania, and southwestern Victoria. The impacts of the low rainfall have been further exacerbated by record high temperatures in 2019, especially in the summers of 2018−19 and 2019−20.

Among the most severely impacted regions have been inland New South Wales and southern inland Queensland. The most intense rainfall deficiencies of the period from 2017 to 2019 predominantly affected this region. Parts of the region, particularly in southern Queensland and northern New South Wales, also experienced large long-term rainfall deficiencies from April 2012 to April 2016 and have thus had below average rainfall for much of the last eight years, interrupted only briefly by wet conditions in mid-2016. Other parts of eastern Australia particularly impacted by multi-year rainfall deficiencies since 2017 include central and east Gippsland in Victoria, and eastern South Australia and far northwest Victoria.

There have also been substantial rainfall deficiencies in southwestern and northwestern Australia. Two successive wet seasons with below-average rainfall have resulted in large two-year rainfall deficiencies in much of the Northern Territory Top End and the Kimberley region of Western Australia. The southwest of Western Australia has also experienced two consecutive years with generally below-average rainfall.

This Statement includes analysis of the severe hydrological impacts of below average rainfall in the Murray−Darling Basin (MDB). There is a focus on the northern Basin, where consistent low inflows to major catchments have resulted in storage levels lower than those witnessed during the Millennium Drought (2001–2009) and long periods of low flows. This analysis includes a look at trends that extend beyond the duration of the current drought and can be explored more deeply at www.bom.gov.au/water.

1. Rainfall deficiencies in eastern and central Australia

1.1. Multi-year rainfall deficiencies

The most prominent rainfall deficiencies in this event have occurred at timescales ranging from around 18 months to three years. Rainfall in most of the Murray–Darling Basin has been substantially below average in each of 2017, 2018 and 2019, a situation not previously seen in rainfall records, with very dry conditions in the ("cool") April to September period followed by only a limited recovery in the ("warm") October to December period in 2017 and 2018, while in 2019 very dry conditions continued to the end of the year. This has led to record low rainfalls over various multi-year periods.

For periods beginning in calendar years, rainfall for the two years 2018−2019, and the three years 2017−2019, has been the lowest on record for the Murray–Darling Basin and for the state of New South Wales.

The most extreme rainfall deficiencies over multi-year periods have occurred in the northern half of New South Wales and adjacent southern inland Queensland (see Figure 1). For example, rainfall for the northern Murray–Darling Basin, which covers that part of the catchment which drains towards the Darling River, has been 43% below the 1961−1990 average for the three years 2017−2019, and 52% below average for the two years 2018−2019. Both of these are record lows by substantial margins, breaking records set during the Federation Drought in 1900−1902. Conditions have been very dry, but less extreme, in the southern Murray–Darling Basin, where three- and two-year rainfall has been 31% and 41% below average respectively (second-lowest and lowest on record). The rainfall deficits have been especially concentrated in the cooler months. Total April−September rainfall for New South Wales for the three years was 324.9 mm, far below the previous record low of 486.6 mm set in 1927−29. Further details on the dry cool season conditions are contained in the **November 2019 version of this statement**.

Another notable area with multi-year rainfall deficiencies is the central and eastern Gippsland region in eastern Victoria, particularly the area from Sale to Lakes Entrance. 2019 was the third successive year of below-average rainfall in this area, and whilst it was generally not as dry as 2017 and 2018, the continuing below-average rainfall has allowed multi-year deficits to accumulate. Both the West and East Gippsland districts had their driest two- and three-year periods on record. The east coast of Tasmania has also had substantial rainfall deficits over this period, although these were eased slightly by heavy rain in September 2019.

In South Australia, rainfall was near average in 2017, but has been well below average in 2018 and 2019. As a result, rainfall for the two years 2018−2019 was at, or near, record low levels over many parts of the state, apart from the Lower South East district and the far west. Record low totals have been set for this period for numerous districts in the eastern half of South Australia, as well as the North Mallee in Victoria.

In total, of the 103 Australian rainfall districts assessed in this statement, 38 had their driest two years on record in 2018−2019, encompassing all mainland States and Territories except Western Australia, and 27 had their driest three years on record in 2017−2019.

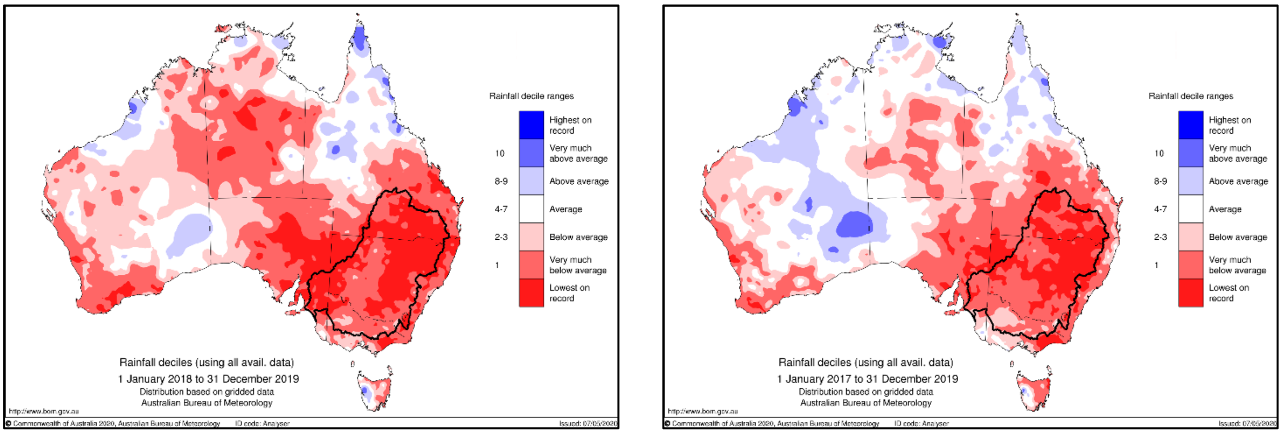


Figure 1. Australian rainfall deciles for the 24 months from January 2018 to December 2019 (left), and 36 months from January 2017 to December 2019 (right) (based on all years since 1900). The boundary of the Murray–Darling Basin is marked in black.

1.2. Low rainfall in 2019

Rainfall for 2019 was below average over many parts of Australia (Figure 2), which was also the nation's driest year on record. Many areas had their driest year on record, including most of the northeast quarter of New South Wales, the southeast quarter of Queensland away from the immediate coastal fringe, most of outback South Australia, most of the central and southern Northern Territory away from the eastern border, and parts of eastern Western Australia. The only large areas with above-average rainfall were parts of northern and northwest Queensland affected by a major rain event and floods in late January and early February[1], and

[1] Further information in **Special Climate Statement 69—An extended period of heavy rainfall and flooding in tropical Queensland**, and earlier editions of this statement.

subsequent passage of tropical cyclone *Trevor*. Other small areas of above-average rainfall were in western Tasmania, and a small area of the Pilbara coast affected by the approach in March of tropical cyclone *Veronica.*

Rainfall was well below average in most tropical areas of Western Australia and the Northern Territory in the 2018−19 wet season (see section 2). There was also a marked lack of penetration of tropical moisture into desert regions of Australia, except for Queensland and eastern border areas of the Northern Territory.

January to April 2019 was very dry in many parts of southern Australia, including southern Western Australia, South Australia, Victoria and much of Tasmania. Regular rainfall returned to the southern coastal fringe from May onwards, but it remained dry further inland. January and February were exceptionally dry in the eastern subtropics on both sides of the New South Wales−Queensland border; a near-normal March was then followed by very dry conditions from April onwards. The later part of the year was especially dry, partly influenced by a sharp warming in the stratosphere over Antarctica in September, and consequently a strongly negative phase of the Southern Annular Mode (SAM) from October to December. Most parts of New South Wales and Queensland, apart from some coastal areas around Sydney and Brisbane, had rainfall at least 60% below average from July to December. Nationally, it was the driest spring, driest November and driest December on record, while the September to December total of 43.4 mm was more than 30% below the previous record for the period, set in 1951.

The consistently low rainfall has resulted in some extreme, below average rainfall anomalies for the year, especially in northern New South Wales and southern Queensland. In this region, rainfall during 2019 was 70 to 80% below average in places, and far below previous records. Several locations, including Stanthorpe, Tenterfield and Texas, experienced rainfall more than 30% below previous record lows, and in some parts more than 40% below. The extreme anomalies also extended to parts of the Mid-North Coast. The northern Northwest Slopes and western Northern Tablelands districts had annual rainfall 49% and 44% respectively below their previous record lows, with five other districts breaking their annual records by more than 30%.

Record low rainfalls also occurred over many parts of inland central and western Australia. Many parts of outback South Australia had less than 30 mm for the year, with Marree only receiving 12.6 mm. Record low rainfalls have also occurred in many parts of eastern Western Australia (e.g. 34.0 mm at Forrest and 37.6 mm at Warburton), extending as far west as the Goldfields district, and in the central and western Northern Territory (27.0 mm at Yulara, 63.6 mm at Tennant Creek). Tennant Creek's total was 86% below their long-term average. An additional area of extreme low rainfalls has been in a region centred on Renmark and Mildura, near the Victoria−South Australia border, and adjacent areas of far southwest New South Wales, with some records set.

Overall, it was the driest year on record for Australia, with a national mean rainfall of 278.0 mm (40% below average), well below the previous record low of 314.5 mm set in 1902. New South Wales and the Murray-Darling Basin also broke records set in 1902. South Australia had its driest year on record and the first with a State average below 100 mm, its total of 79.9 mm falling far below the 111.4 mm set in 1944. Western Australia and the Northern Territory both had their second-driest years on record, and Victoria its tenth. In total, 163 stations with 100 or more years of data had their driest year on record in 2019, encompassing 42 of the Bureau’s rainfall districts and all states except Victoria and Tasmania. Eight of these stations, mostly in northern inland New South Wales and southern Queensland, had rainfall in 2019 more than 50% below their next-driest year, with 34 having rainfall more than 40% below their next-driest year.

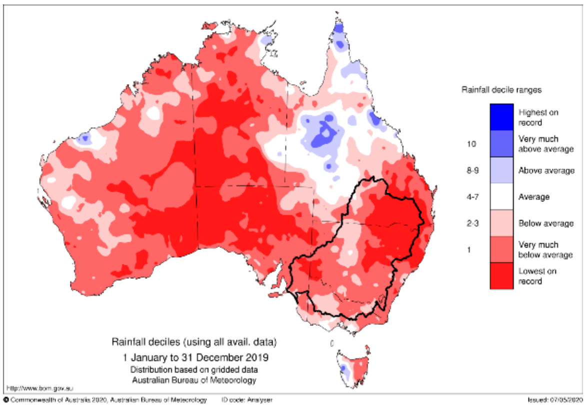


Figure 2. Australian rainfall deciles for 2019 (based on all years since 1900). The boundary of the Murray–Darling Basin is marked in black.

1.3. A partial recovery in 2020

Near- to above-average rainfall returned to many parts of Australia from January onwards. Much of eastern New South Wales experienced heavy rain in February, while there was more widespread and consistent rain through many parts of the southeast quarter of Australia from February to April. A number of rain events also affected portions of interior Australia. Much of New South Wales, Victoria and Tasmania, and parts of other States, received well above average rainfall for the January to April period (Figure 4), although national rainfall was only slightly above average. Rainfall remained below average in parts of the northern tropics. Southern Western Australia, which is normally dry in the January to April period, received little rainfall.

Rainfall for January to April was 54% above average for Victoria, 43% above average for the Murray-Darling Basin, 38% above average for New South Wales and 34% above average for Tasmania. This was the wettest such period since 1996 for Tasmania, since 2011 for Victoria and since 2012 for New South Wales and the Murray-Darling Basin. The rain was most significant on the western slopes of New South Wales, in central Victoria, and in northern Tasmania. A few locations in each state had their wettest January to April on record, with Melbourne (400.8 mm) having its second-wettest start to the year, after 1924. On the New South Wales coast the wettest month was February, with some locations in the Northern Rivers and Illawarra receiving over 600 mm in a week.

In general, rainfall in the arid interior of Australia in the first four months was close to average, after the extremely dry conditions of 2019. There have, however, been localised heavy falls. On the evening of 3 March, Fowlers Gap, north of Broken Hill, received 97 mm in six hours, which was more than they received (90.2 mm) in the two years from January 2018 to December 2019. Marree, after receiving only 12.6 mm in all of 2019, exceeded that in 15 minutes on 1 February, while on the same day Tennant Creek surpassed its 2019 annual total (63.6 mm) within two hours. Carnegie received at least[2] 270 mm on 10 January (associated with the remnants of Tropical Cyclone *Blake*), the highest daily total on record in the Interior district of Western Australia.

Large parts of the country have received more rainfall in January to April 2020 than they did in all of 2019 (Figure 4). This includes most of outback South Australia, the Northern Territory outside the Top End, Western Australia outside the southwest, and much of northern New South Wales and southern Queensland. Area average 2020 rainfall for New South Wales, South Australia, Western Australia and the Murray-Darling Basin surpassed the 2019 annual total by the end of April. The national January to April total was 258.8 mm. Whilst

[2] The 270 mm was recorded before the gauge overflowed.

this is only 4% above average, it is just 19.2 mm below the final 2019 total of 278.0 mm. By the end of May the national 2020 rainfall total had surpassed the 2019 annual figure.

May and June were relatively dry in many parts of Australia outside the tropics, although many tropical areas had unseasonable rain in May. Rainfall anomalies in May and June had little impact on long-term deficiencies.

The rains received in 2020 to date have lifted long-term rainfall (on timescales of two to three years) above record low levels in many parts of Australia, although some areas of record lows persist at these timescales on both sides of the Queensland-New South Wales border and in parts of eastern South Australia.

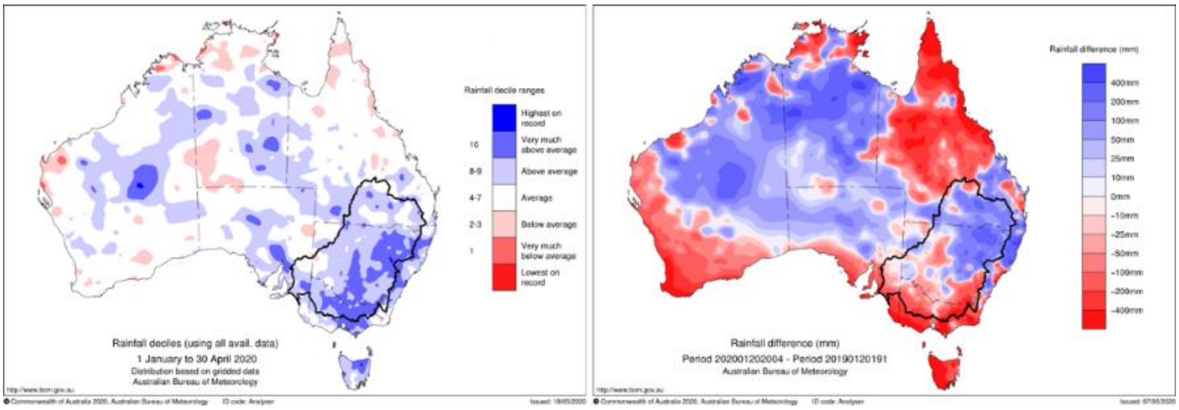


Figure 4. (left) Australian rainfall deciles January-April 2020 (based on all years since 1900). The boundary of the Murray–Darling Basin is marked in black. (right) The difference between January-April 2020 rainfall and annual 2019 rainfall (areas in blue had already received more rain by the end of April 2020 than in all of 2019).

2. Low rainfall in the last two years in northwestern and southwestern Australia

The last two years have also been notably dry in many parts of northwestern and southwestern Australia. Whilst no individual season in these regions has been as extreme as the year of 2019 was in many parts of the eastern states, persistent below-average rainfall has resulted in large rainfall deficiencies accumulating since 2018.

The 2018−19 and 2019−20 wet seasons both saw generally below average rainfall in large parts of northwestern Australia, including the Northern Territory Top End and the Kimberley region of Western Australia. This followed a period of generally above-average rainfall since the 1990s.

The 2018−19 wet season saw generally below-average rainfall, with the Kimberley region (37% below average) and the western Northern Territory Top End (20% below average) having their driest October−April since 1991−92. The 2019−20 wet season had an exceptionally dry start, with rainfall from October to December at or near record low levels in many areas. January to April rainfall in the northern tropics was generally fairly close to average. There were some very heavy localised falls, including an 11 January event which produced 561.0 mm, a Northern Territory record, at Dum in Mirrie (west of Darwin) and 515.2 mm at Wagait Beach. However, the very dry start to the wet season resulted in rainfall for the season as a whole (October to April) being well below average in many parts of the northern tropics. Northern Australia (north of 26 °S) had its driest wet season since 2004-05.

It is relatively rare for northwestern Australia to experience significantly below-average wet seasons in two successive years. At Darwin Airport, 1177.8 mm fell in the 2018−19 wet season (October to April) and 1180.0 mm in the 2019−20 wet season, the seventh- and eighth-driest on record respectively. This was the first instance of wet season rainfall below 1200 mm in two consecutive years. Darwin's rainfall for the 24 months from May 2018 to April 2020 was also the lowest on record. Although neither individual wet season was exceptional in its own right, over the two-year period, there were areas in both the Top End and the Kimberley where rainfall was the lowest on record (Figure 5). The North Kimberley district (32% below average) had its second driest two-year period on record after 1951−53, whilst the western Top End and the East Kimberley had their driest since 1960−62 and 1969−71 respectively.

Southwestern Australia, where most rainfall occurs during the cool season (April to October), has also had consecutive years with below-average rainfall. As in northwestern Australia, neither year was individually exceptional, with April to October rainfall for 2018 and 2019 the 20th and 7th lowest on record (from 120 years) respectively. However, the combination of two dry years, and the lack of any major out-of-season rain events during the summer, has resulted in large two-year rainfall deficits over almost the entire region. Whilst only a few individual locations, mostly in the eastern parts of the Great Southern (Figure 5), have had their driest 24 months on record, the extensive nature of the dry conditions means that the southwestern region as a whole has had its driest 24 months on record for the 24 months ending April 2020. Unlike most of eastern Australia, this region has remained dry (as is climatologically normal for that time of year) for the first four months of 2020, Near- to below-average rainfall continued in May and June, with the three-month rainfall for April to June 2020 in the lowest decile in many parts of southern Western Australia, especially away from the coast..

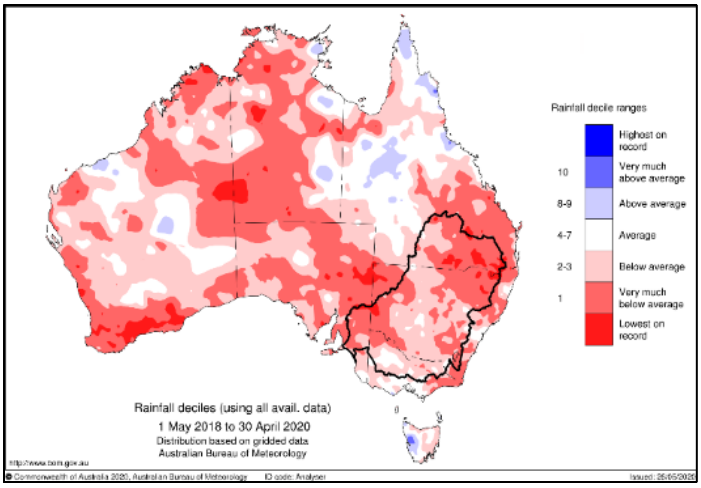


Figure 5. Rainfall deciles for the 24 months from May 2018 to April 2020, showing the extent of the dry conditions over this period in northwestern Australia and southern Western Australia.

3. Temperature

The dry conditions experienced over the past three years were exacerbated by record-high temperatures. Unusually warm temperatures have dominated Australia's climate in recent years, and particularly so in the drought affected regions. The last three years have been the three warmest on record for both the MDB and for New South Wales, with 2019 the warmest year on record in both regions, 2018 second-warmest and 2017 the third-warmest. While droughts are often associated with above average temperatures, these values are typically 1 °C or more above values for previous drought years such as 1972, 1982, and 1994. High temperatures increase the stress on landscapes affected by rainfall deficiencies and add to water demand and evaporation.

Nationally, 2019 was the warmest year on record (1.52 °C above the 1961−1990 average), whilst Western Australia joined New South Wales in setting a state record. Annual mean maximum temperatures were the highest on record for most of the western half of the country, as well as for most of eastern New South Wales and southeast Queensland.

Following Australia's warmest summer on record in 2018−19, and warmest March in 2019, temperatures were less extreme through mid-2019 but became very high again later in the year. This culminated in December, which was **the hottest on record nationally**, and for every State and Territory except Victoria and Tasmania. Although the remainder of the summer was not as hot, 2019−20 was still Australia's second-hottest summer, behind 2018−19. In total, Australia had 42 consecutive months with above-average temperatures from

November 2016 to April 2020, a sequence which breaks the previous record of 32 months from August 2012 to March 2015. The above-normal temperatures have also increased evaporative demand.

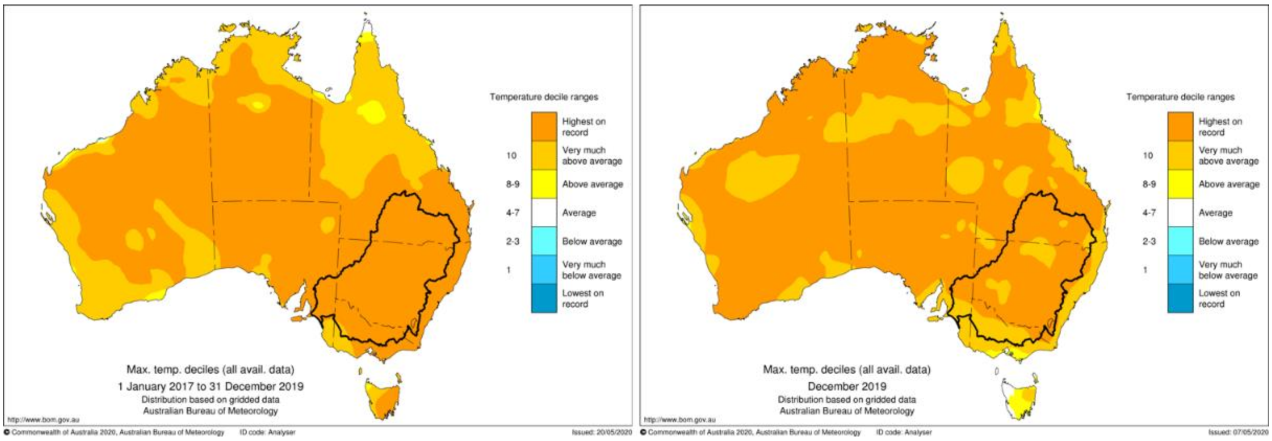


Figure 6. Maximum temperature deciles for the three-year period 2017 to 2019 (left) and December 2019 (right). Deciles are calculated with respect to the whole period from 1910. The boundary of the Murray–Darling Basin is marked in black.

4. Water resources in the Murray–Darling Basin

Water resources are greatly influenced by the occurrence and frequency of rainfall across the landscape, and by temperature and consumptive water use. During the first part of the summer of 2019/20 water availability in the soil, major storages, rivers and groundwater in the Murray–Darling Basin reached historic lows. The rainfall over many parts of the Basin since January 2020 has resulted in some recovery in these resources. Key aspects of water resources availability through the extended dry conditions of the past three years and the impact of the rain to April 2020 are described below.

4.1. Soil moisture

4.1.1. Record low soil moisture in December 2019

The dry conditions in the Murray–Darling Basin began in January 2017 and many areas remained dry for the subsequent three years (36 months) to December 2019.

Mean root zone (0-100 cm) soil moisture levels for the 36 month period January 2017 – December 2019 set new record lows in large areas of the Murray–Darling Basin, particularly in the east from where the bulk of the water is sourced (Figure 7). The river catchments that experienced lowest on record soil moisture for this period represent the major water yielding catchments for the Darling River in particular. These values provide an indication of the moisture stress experienced by vegetation and the severity of agricultural drought in these regions.

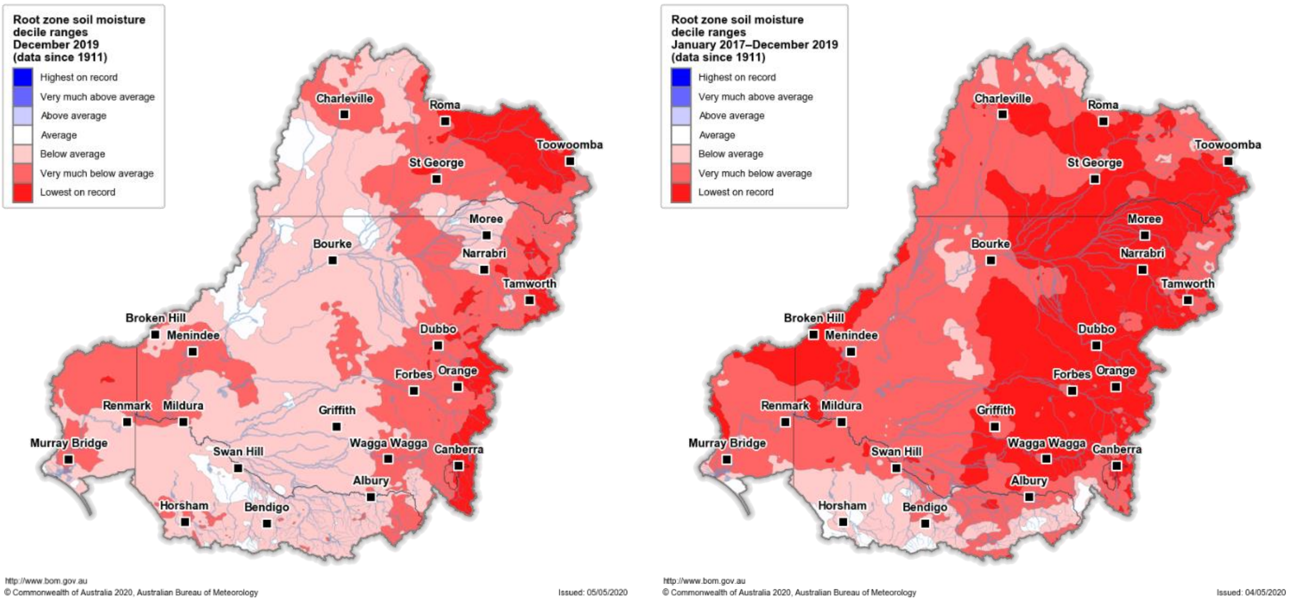


Figure 7. Root zone soil moisture deciles for December 2019 and the 36-month period January 2017 – December 2019 in the Murray–Darling Basin. From the AWRA-L v 6 model for the top 100 cm of the soil profile, based on data from January 1911- April 2020.

4.1.2. Summer and Autumn rain replenishes surface soil moisture in the Murray–Darling Basin

The rain from January to April replenished root zone soil moisture to at least average levels across most of the Murray–Darling Basin (Figure 8). In the Namoi catchment, the catchment average soil moisture has gone from lowest on record in December 2019 to highest on record in April 2020.

The soil moisture started to increase during January 2020. In particular, the soils in the major water yielding catchments of the Namoi, Gwydir, and Border Rivers saw increases of more than 15% in available soil water content. However, although the rain replenished the soil moisture to average levels in some northern areas, most of NSW remained very much below average at the end of January.

The northern Basin received good follow-up rain in February with soil moisture in some areas increasing to very much above average. However, it was not until the rain in March and April that the soil moisture throughout central NSW started to increase. By April 2020 large areas in NSW and Victoria reached very much above average soil moisture (Figure 8). The Alpine areas of Victoria and the upper Namoi, Macquarie and Castlereagh river catchments had increases of more than 50% in available soil water content since the start of the year. Since April, the soil moisture has dried out to near average levels across most of the Basin with only smaller areas in the south and east remaining above average and areas in the north and west falling to below average.

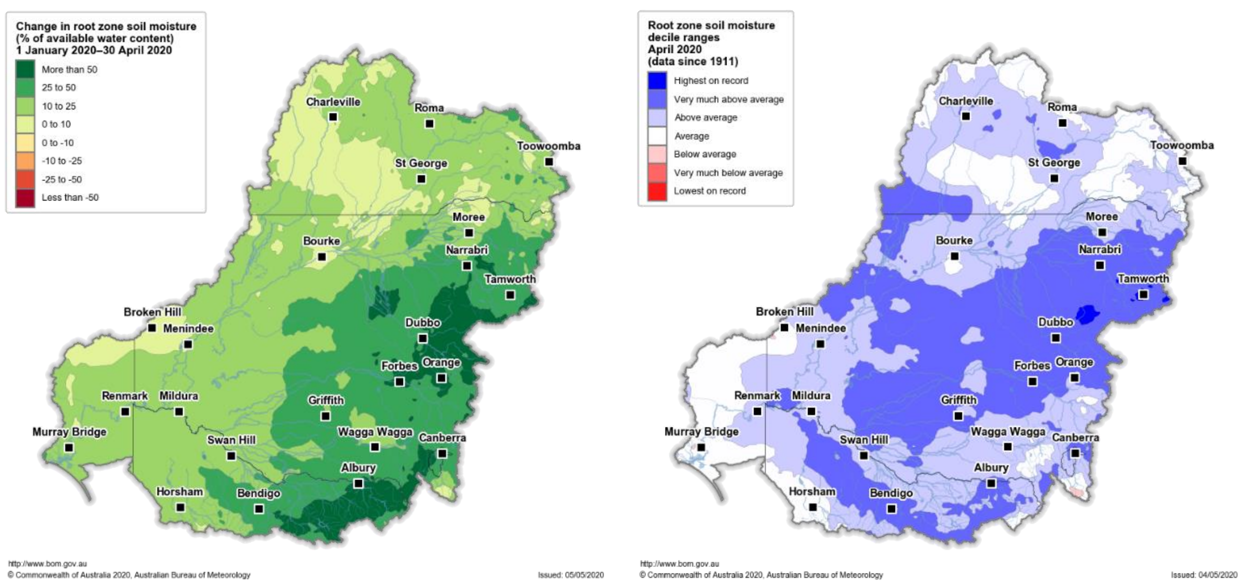


Figure 8. Soil moisture increases in the Murray–Darling Basin. a) Change in root zone soil moisture (% of available water content) from 1st of January 2020 to 30th of April 2020 and b) Monthly average root zone soil moisture deciles in April 2020. From the AWRA-L v6 model for the top 100 cm of the soil profile, data spans January 1911- April 2020.Major water storages

The major storages in both the northern and southern Murray–Darling Basin continued to decline well into summer due to water releases, high evaporation and limited inflows. Storage volumes in the northern Murray–Darling Basin reached a combined volume of only 5.4 % of capacity in mid-January (Figure 9). This is more than 7.5 % lower than at any point during the Millennium Drought. Split Rock and Keepit water storages in the Namoi catchment decreased to below 1% capacity in December. Many towns in the region raised their water restriction levels and invested in alternative water sources, such as groundwater and trucking water, to augment their water supply.

The rain since January has brought limited increases to the water storages in the northern Murray–Darling Basin. The exceptions were some of the smaller weirs and on-river storages in the far north of the Basin which filled very quickly following significant rain in February. The increase in total storage in the northern Basin from

January to June 2020 was only 12% or 566 GL, leaving the majority of storages at less than 20% of capacity (Figure 9). Many of the northern basin catchments have experienced prolonged dry conditions and significant follow up rainfall is still needed to replenish these water storages.

The total water storage in the southern Murray–Darling Basin was better placed going into summer with a combined storage of 45% of capacity at the beginning of December. It then reached a minimum of 37% at the end of February, 19% higher than the lowest point of the Millennium drought. April typically represents the end of the irrigation season and generally the major draw down period on the water storages in the southern Basin. However, water allocations were low this year and the 2019/20 season did not draw down beyond the point of the previous season, leaving water storages at a similar level to this time last year (Figure 9). Since May, and the start of the winter filling season in the southern Basin, total storage has already increased by 10% to 50%, 7% higher than June 2019. This increase has been driven by increases in all three of the very large storages of Hume, Dartmouth and Eildon. This is an encouraging start to the winter filling season given the past three filling seasons have had insufficient inflows to replenish the seasonal drawdown. The filling season in the southern Basin will generally continue until the end of September.

One of the most significant water storage increases in the southern Basin was in the Menindee Lake system which went from 0 in March to 27% of capacity at the end of June. This water was delivered via the Darling River and will provide valuable supply to communities in western NSW.

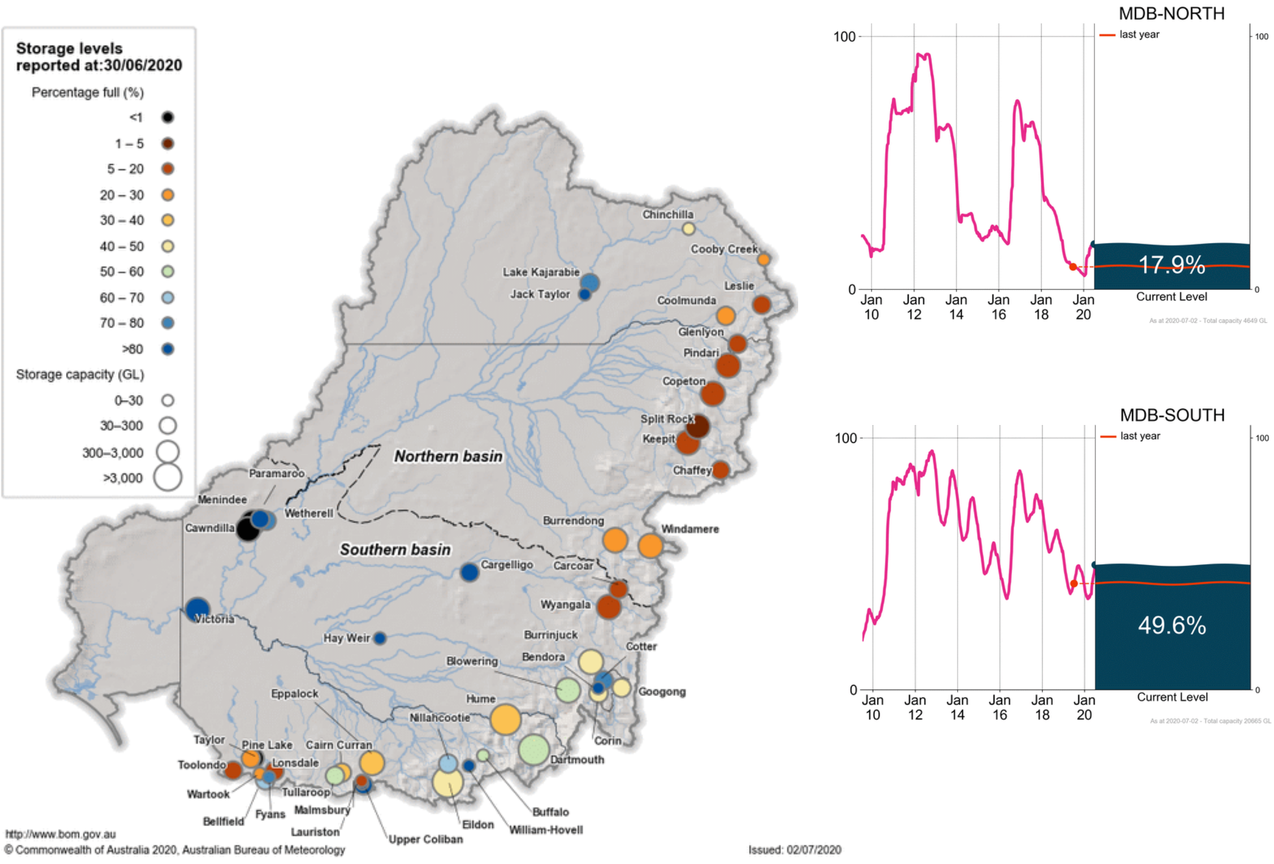


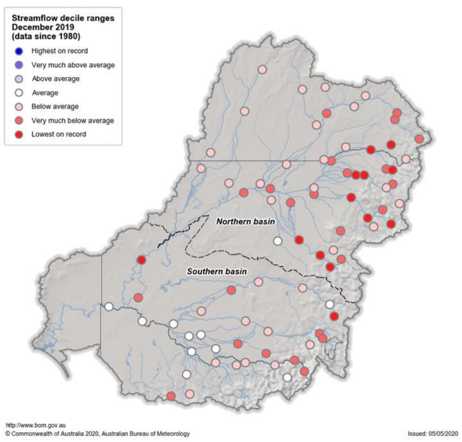
Figure 9**.** Total storage volumes in the northern and southern Murray–Darling Basin at June 30th 2020.

4.2. Streamflow

The rivers of the Murray–Darling Basin reached record low flows in December 2019 (Figure 10) but have seen some recovery following the rain through to April 2020. Very few of the northern Basin rivers were flowing at all in December and while this is not especially unusual for some of the northwestern rivers, the rivers in the northeast saw lowest on record flows. There were some minor flows still running through the upper tributeries of the Namoi, Macquarie, Gwydir and Border Rivers, likely due to releases from the storages. None of these minor flows made it to the lower sections of the rivers or into the Darling River.

The exceptionally dry conditions in the northern Basin over the 36 months to December 2019 resulted in very limited natural inflows to the rivers. This was particularly so at locations in the upper catchments of the northern Basin tributaries (Figure 10) where the majority of inflows to the Darling River originate.

Significant rainfall in the upper catchments from January to April meant that all of the major rivers in the northern Murray–Darling Basin have flowed in 2020. The ephemeral rivers of the far north largely dried up by the end of April but not before delivering some water to important environmental assets such as the Narran Lakes and to the Darling River. The majority of the water that flowed down the Darling River came from the north eastern rivers.



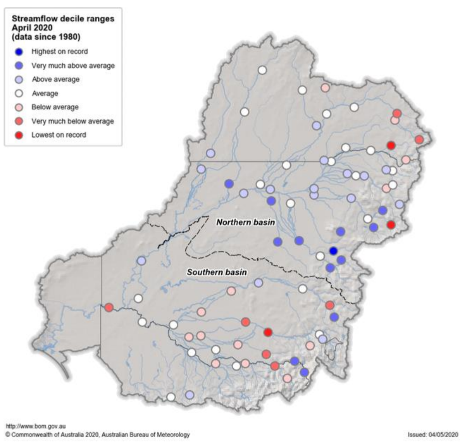


Figure 10. Streamflow deciles at gauges during December 2019 (left) and April 2020 (right).

The flow that started in the upper catchments in January made it all the way down the Darling to join the Murray River at Wentworth in mid-April. Figure 11 shows the flow past river gauges in the Barwon and then Darling Rivers. The flow occurred in a series of peaks corresponding to different rain events and storage releases. The decrease in the height of the curve at each station represents the losses due to the filling of dry riverbeds and waterholes and evaporation. The water is also retained in weirs and storages along this regulated river.

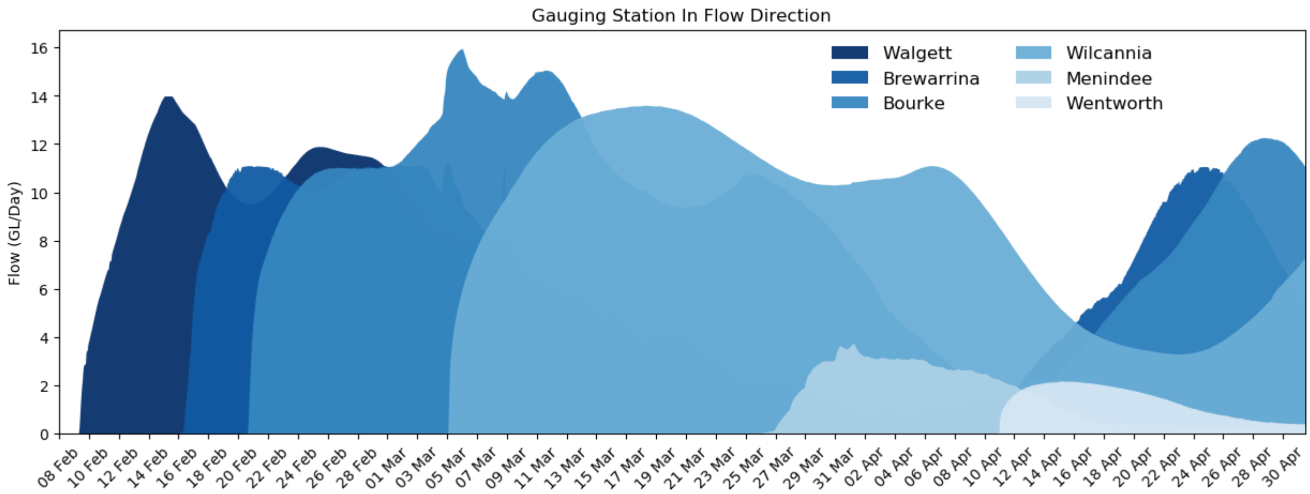


Figure 11. Stream flow down the Barwon–Darling River System at stream gauges Walgett (422001), Brewarrina (422002), Bourke (425003), Wilcannia (425008), Menindee (425012) and Wentworth (425007). Data available from the Bureau's Water Data Online http://www.bom.gov.au/waterdata/.

Although the recent flows in the Darling River are valuable, they are only average for this time of year. The Darling River at Wilcannia has been very low for several years and aside from a wetter than average 2016 winter-spring season, streamflow has mostly been below average since 2013, including lowest on record in late 2019 (Figure 12). In the longer context, apart from three years between 2010 and 2012, the Darling River has not seen above average flow for more than a few months at a time since March 2002.

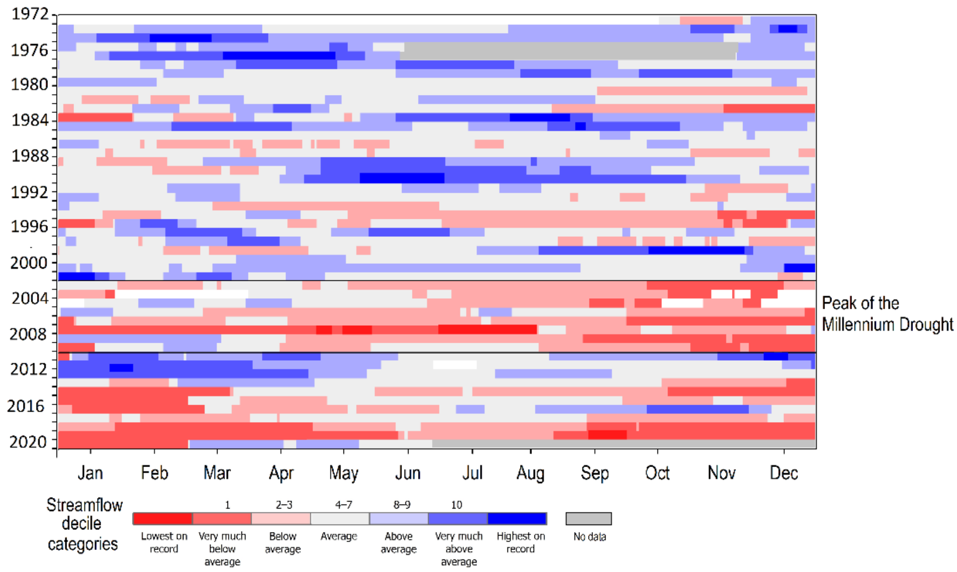


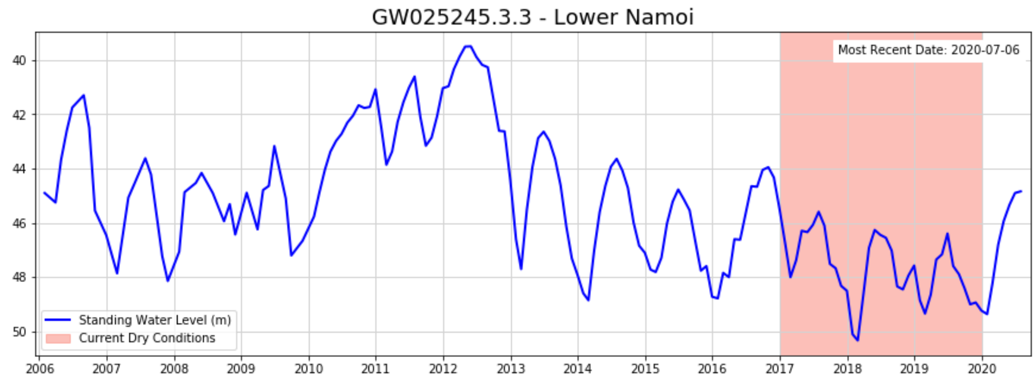
Figure 12. Daily streamflow deciles for Darling River inflows from upstream catchments as measured at Wilcannia.

In line with the flow in the Darling River, most of the rivers in the northern Basin have now dropped to average or very much below average levels. Minimal releases being made down river of the major storages maintain some flow in most of the eastern catchments, but the far northern rivers have now largely dried up again.

4.3. Groundwater

Groundwater levels across the Murray–Darling Basin declined in response to the prolonged dry period. Aquifer systems were impacted by low rainfall and decreasing stream recharge and by increased pumping for consumptive use. Figure 13 highlights this decline as seen in the Lower Namoi groundwater system in the northern Murray-Darling Basin and the Murrumbidgee Alluvial system in southern Basin. The groundwater levels in the Lower Namoi reached lowest on record (since 1970) in early 2018 at over 2 m lower than during the Millennium Drought. The Murrumbidgee Alluvial system decreased significantly in both the 2017 and 2018 draw down season but did not quite reach the record low levels seen in 2007.

The recovery in the Lower Namoi groundwater levels in the first half of 2020 has been the largest since 2016, Water levels remain below the long-term average but are higher than they have been since November 2016. The Murrumbidgee Alluvial groundwater levels have only recovered to the levels seen in 2019. Alluvial aquifers are strongly influenced by rainfall and streamflow recharge reflecting the need for further rain through central NSW to significantly replenish groundwater systems.



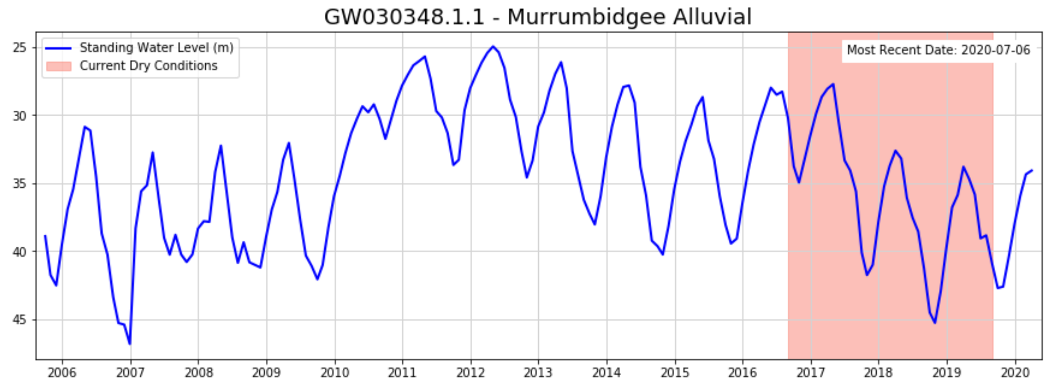


Figure 13. Groundwater level as depth below surface at bores in the (a) Lower Namoi and (b) Murrumbidgee groundwater system.

5. The current event compared to past droughts

The Murray–Darling Basin previously experienced major multi-year droughts in 1895–1903, 1938–1946, and 2001–2009. The general pattern in inland New South Wales and Queensland has been one of a relatively dry first half of the 20th Century, a relatively wet second half of the 20th Century (with especially wet decades in the 1950s and the 1970s), then a return since 2001 to drier conditions (except during the extremely wet 2010–11 and 2011–12 La Niña events). The more limited evidence available suggests that rainfall in the late 19th Century was comparable to that of the 1950–2000 wet period.

While each of these droughts has a different spatial and temporal footprint, the current event has reached levels of intensity on two to three-year timescales unmatched in any of the previous events of the Basin, although it has not yet persisted for as long as the previous major multi-year droughts. The recent drought has reached its maximum intensity in the northern Basin, with the southern Basin being less severely affected, whereas the reverse was true during the 2001−2009 drought.

Compared to earlier droughts, the current drought has taken place against a backdrop of rising temperatures due to global warming. Since 1970, most of the region has been warming at a rate of between 0.2 °C and 0.4 °C per decade**,** with a total warming of more than 1 °C. For the Murray–Darling Basin, the last seven years have had mean temperatures at least 1 °C above the 1961–1990 average, ranking amongst the ten warmest on record for the Basin (with 2019 being the warmest).

6. Influence of major climate drivers

The dry conditions of the last three years have occurred through a mix of broadscale climate drivers that influence Australia's climate. Notably, the dry conditions have occurred in the absence of an El Niño (the last significant El Niño ended in early 2016). Whilst long-term droughts have occurred in the interior of Australia in the absence of El Niño, this is rare in eastern Australia.

A major influence on the climate in winter and spring 2019 was the presence of a very strong positive phase of the Indian Ocean Dipole (IOD). This is typically associated with dry conditions in many parts of Australia. The 2019 event, which eventually broke down at the end of the year, was amongst the strongest positive IOD events on record, alongside those of 1997, 1994 and 1961[3]. Indian Ocean temperatures did not reach the criteria for an IOD event in 2017 or 2018, although sea surface temperatures off the northwest coast of Australia were relatively cool in winter and spring 2018 and warm near Africa**,** which likely suppressed rainfall**.**

The cool seasons of 2017, 2018 and 2019, particularly 2019, were marked by a **large number of high-pressure systems** and small number of low-pressure systems over southern Australia While this pattern is to be expected during drought periods it highlights the significant shift in weather patterns affecting Australia.

There are downward trends in rainfall since the 1990s in southern parts of eastern Australia, particularly Victoria, and in the higher rainfall areas of the Murray–Darling Basin, typically near and to the west of the Great Dividing Range. These trends were described in **the State of the Climate 2018 report** and are concentrated in the April to October period, with little change during summer. A major influence on this drying has been the strengthening and extension of the subtropical high pressure ridge during winter, shifting rain-bearing weather systems south. An

[3] IOD years have been assessed since 1960. A lack of reliable sea surface temperature data in key regions prevents a full assessment of IOD behaviour prior to 1960.

underlying drying trend contributes to the likelihood and intensity of rainfall deficits in this region. Similar declines in cool season rainfall in southwest Australia have been linked to climate change.

References and further information

Data used in this statement is current as of 15 July 2020 and is subject to the Bureau's routine quality control processes. Maximum temperature observations prior to 1910 have not been used unless it is known that they were measured using standard equipment comparable to post-1910 standards.

Further information is available from:

http://www.bom.gov.au/climate

http://www.bom.gov.au/water

Australia's changing climate:

http://www.bom.gov.au/state-of-the-climate

Monthly Drought Statement:

http://www.bom.gov.au/climate/drought