Northern Basin Historic Flow and Usage Report

FINAL

April 2018

Prepared by Barma Water Resources Pty Ltd

Barma Water Resources

Report Prepared by Mr. Daren Barma of Barma Water Resources (BWR) Pty Ltd

Daren is a hydrologist, river system modeller and Director of Barma Water Resources. He has extensive knowledge in water management having been involved in water management related to the Australian and in particular the Murray-Darling Basin for most of the last 27 years.

Daren has carried out numerous technical, policy and planning studies in relation to water resource management. This includes water balance and data analysis projects as part of his work in developing IQQM, eWater Source and hydrodynamic models and water sharing strategies for NSW valleys of the Murray Darling Basin. He has also conducted river system model reviews of the Condamine Balonne, Fitzroy, Cape York and Wet Tropics IQQMs in Queensland. He was the external reviewer for river system models as part of the CSIRO Murray Darling Basin Sustainable Yields Project. Daren has also reviewed the river system models used in development of the Murray Darling Basin Plan and was most recently a member of the CSIRO Scientific Leadership Team for development of an Ecological Elements Scoring Method for SDL adjustments under the Murray Darling Basin Plan.

Disclaimer

To the extent permitted by law, the authors of this report exclude all liability to any person for any consequence, including but not limited to all losses, damages, costs, expenses, and any other compensation, arising directly or indirectly from the use of this report (in part or whole), and information or material contained in it. This report does not purport to give legal advice.

The methodology adopted and sources of information used are outlined in this report. While the authors of this report have made reasonable endeavours to ensure the accuracy and currency of this document, no independent verification of this information was undertaken beyond the agreed scope of works, and the authors assume no responsibility for any inaccuracies or omissions. The information contained within this document should not be relied upon for commercial dealings and the accuracy and currency of this material should be verified by users with the relevant state and local authorities.

Table of Contents

Executive Summary

Cotton Australia engaged Barma Water Resources (BWR) Pty Ltd to undertake an independent assessment of the historic flow and usage characteristics of the Barwon Darling river, along with comparisons to the flow characteristics of the major upstream contributory valleys.

An assessment of flows and water availability has been made for the period 2012/13 to 2016/17. Mid system flows were chosen to represent water availability in the Northern Basin tributaries, and tributary end of system flows were selected to represent water availability in the Barwon Darling. The following observations have been made:

Climate

- A comparison of recent years annual rainfalls from 2012 to 2017 with that experienced during the millennial drought from 2001 to 2009 indicate that rainfalls are below average, but not to the extent that they were during the drought. However, in areas in the Northern and western parts of the Northern Basin such as Toowoomba and Bourke, there have been very few years with above average rainfalls since the millennial drought began.

Water Availability

- Over the past five years (2012/13 to 2016/17), a number of Northern Basin tributaries have experienced total mid system flows and inflows to the Barwon Darling which are similar to those experienced during the millennial drought.

- The sum of **all** mid system tributary flows over the five years from 2012/13 to 2016/17 have been approximately just one and a half times those experienced during the worst period in the millennial drought. Whilst total inflows to the Barwon Darling have been approximately twice the amount experienced during this period.

- The three individual years from 2013/14 to 2015/16 have experienced total mid system tributary flows and inflows to the Barwon Darling with a similar order of magnitude to those experienced during the worst years of the millennial drought.

- The sum of all mid system and tributary inflows to the Barwon Darling over the five years from 2012/13 to 2016/17 are almost half of what would be expected over the long-term from 1922 to 2008.

- The sum of all mid system flows from 2012/13 to 2016/17 have only been lower for approximately thirteen other *five year periods* out of a total of 83 periods from 1922 to 2008, whilst inflows to the Barwon Darling have only been lower for approximately twenty one *five year periods* indicating very dry condition and limited water availability.

- Over the period 2012/13 to 2016/17 three of five years have had more water lost through evaporation from Menindee Lakes than gained through inflows to the Lakes.

- Over the period from 2012/13 to 2016/17, 58% of Menindee inflows have been lost through evaporation.

Usage

- At the time of report preparation tributary usage has been within the diversion limits that have been set for all tributary valleys. Furthermore, as stated in *"MDBA Transition Period Water Take Report 2012–13 to 2015–16 Report on Cap compliance and transitional SDL accounting"*, all Cap valleys in which a cumulative balance is the basis of compliance have remained compliant over the reporting period.

- Over the 2012/13 to 2016/17 period, Barwon Darling annual extraction has ranged from 11% to 30% of the annual system inflow. Average usage in the Barwon Darling over the past five years of 134 GL per annum has been within the systems Annual Share Entitlement total of 251.4GL.

- The Barwon Darling average usage over the past five years of 134GL/Yr is well within the Barwon Darling the long-term average annual extraction limit for the system of 189GL/Yr.

Conclusions

In conclusion, the Northern Basin has experienced well below average conditions in terms of climate and water availability over the 2012/13 to 2016/17 period. These conditions have been felt across the entire Northern Basin and are not limited to specific river systems. Furthermore, despite the highly variable nature of water availability in the Northern Basin, below average water availability conditions have persisted since the onset of the millennial drought.

Usage across the Basin has been constrained by limited water availability over the 2012/13 to 2016/17 period, with diversions remaining within all valleys long-term average annual extraction limits.

1 Introduction

Cotton Australia engaged Barma Water Resources (BWR) Pty Ltd to undertake an independent assessment of the historic flow and usage characteristics of the Barwon Darling river, along with comparisons to the flow characteristics of the major upstream contributory valleys. The aims of the analysis were to:

- Compare the historic mid system average flows of the past five years in upstream tributaries above major extraction points with those that have occurred over the millennium drought and historic long-term
- Compare the historic tributary inflows to the Barwon Darling over the past five with those that have occurred over the millennium drought and historic long-term.
- Compare the historic average flows of the past five years at locations along the Barwon Darling and Lower Darling with those that have occurred over the millennium drought and historic long-term.
- Compare historic usage in the Barwon Darling against water availability.

The assessment has been undertaken using:

- Historic streamflow data from the NSW Governments Water Information Website.
- River system model data provided by the NSW Department of Industry.
- River system model data provided by the Queensland Department of Science Information Technology and Innovation.
- Water usage data provided by the NSW Department of Industry.

Chapter 2 of this report compares the past five years climate and flows at different locations within the Northern Basin (2012/13 to 2016/17). Chapter 3 of this report compares usage to water availability in the Barwon Darling over recent times. Chapter 4 summarises the studies overall conclusions.

2 Climate and Streamflows (2012/13 to 2016/17)

2.1 Recent Climate (2012 to 2017)

As shown in Figure 1, rainfall over the years 2012 to 2016 in Northern section of the Murray Darling Basin has been highly variable. 2012 and 2016 are years in which rainfall has been average to above average (light blue to dark blue) in many locations, whilst the years in between have seen below average rainfall in much of the Northern Basin (light red to dark red).

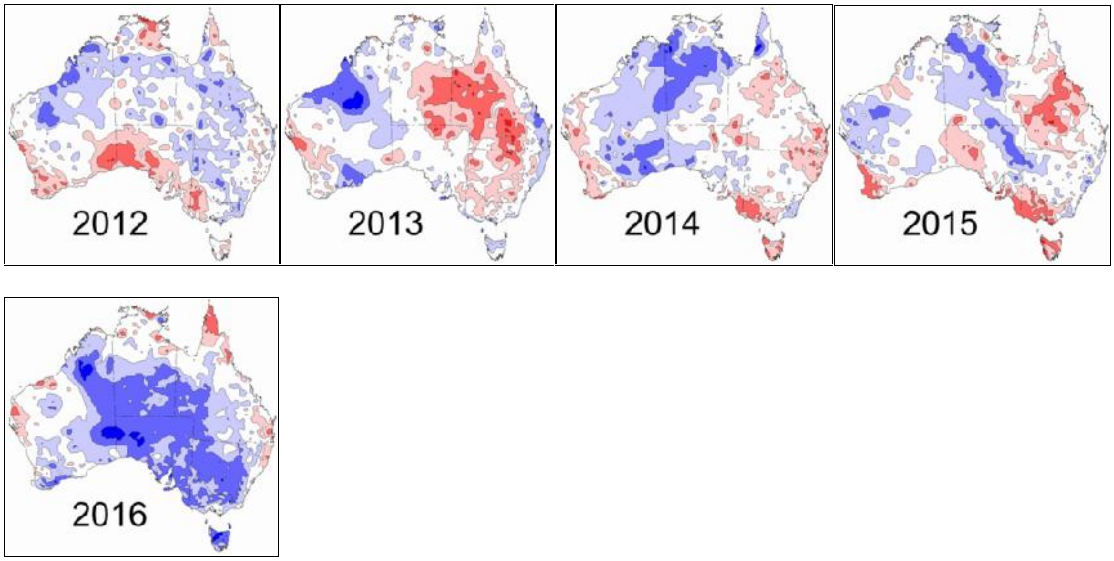


Figure 1 – BOM Rainfall Deciles By Year

The highly variable nature of rainfall in the Northern Basin is also shown in Figure 2, which compares rainfall at a number of key locations in terms of departure from the long-term average. As can be seen rainfall patterns exhibit long periods of relatively wet years and dry years. A comparison of recent years annual rainfalls from 2012 to 2017 (green bars), with those experienced during the millennial drought from 2001 to 2009 (red bars), indicate that rainfalls are below average but not to the extent that they were during the drought. However, in areas in the northern and western parts of the Northern Basin in regions such as Toowoomba and Bourke there have been very few years with above average rainfalls since the millennial drought began.

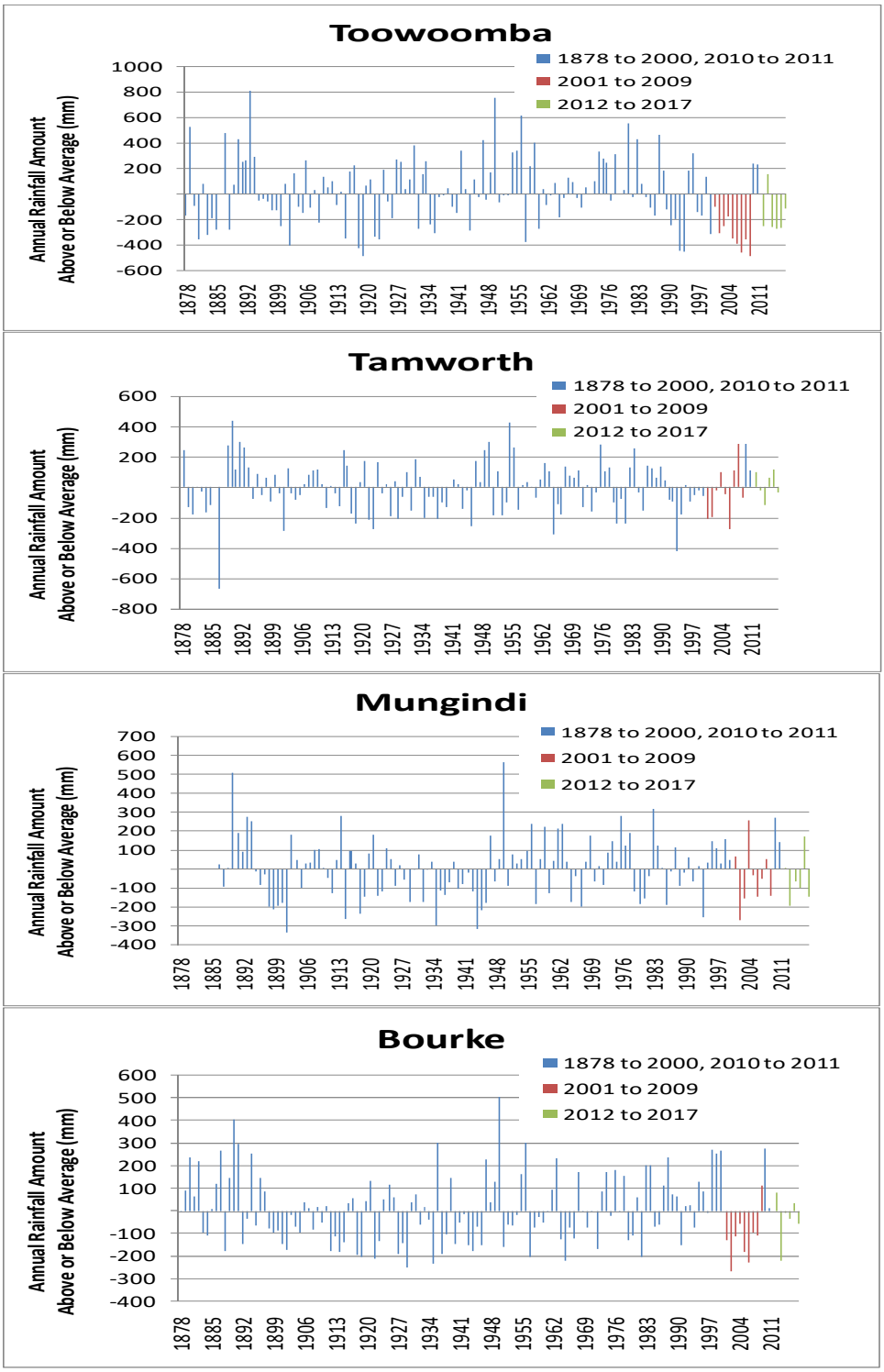


Figure 2 – Long-term Annual Rainfall Departure from Average

2.2 Long-term Streamflow Variability

The highly variable nature of rainfall in the Northern Basin manifests itself in a highly variable streamflow regime. This can be seen for mid system tributary flow and Barwon Darling tributary inflow totals in Figure 3 and Figure 4, where there are many sequences of years where flows are below average, and shorter periods where flows greatly exceed the average.

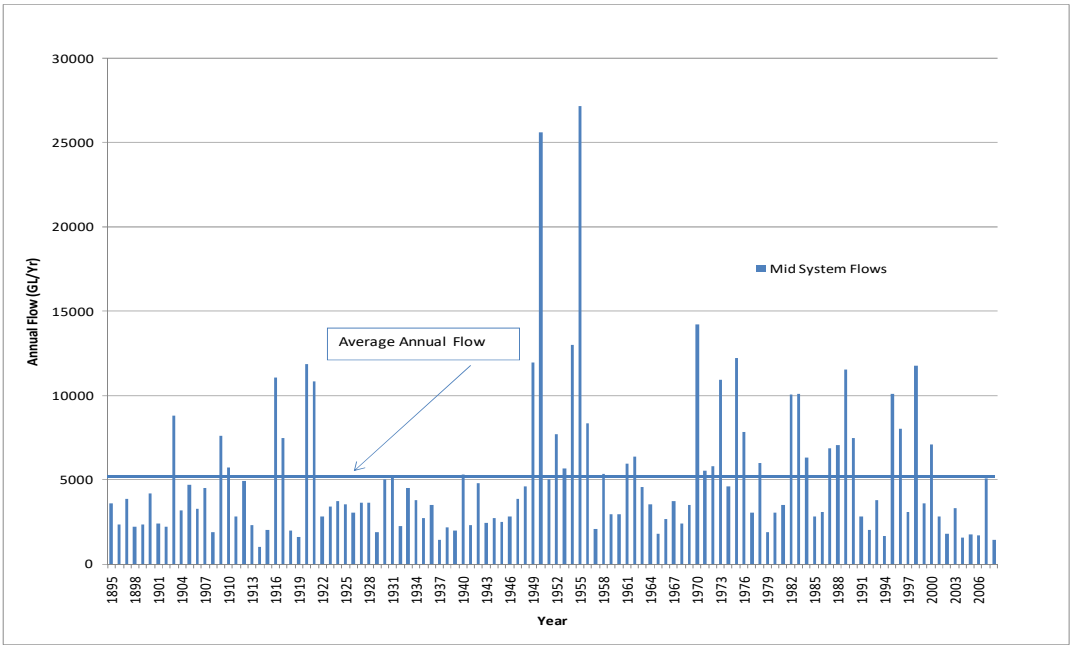


Figure 3 - Mid System Flow Comparison

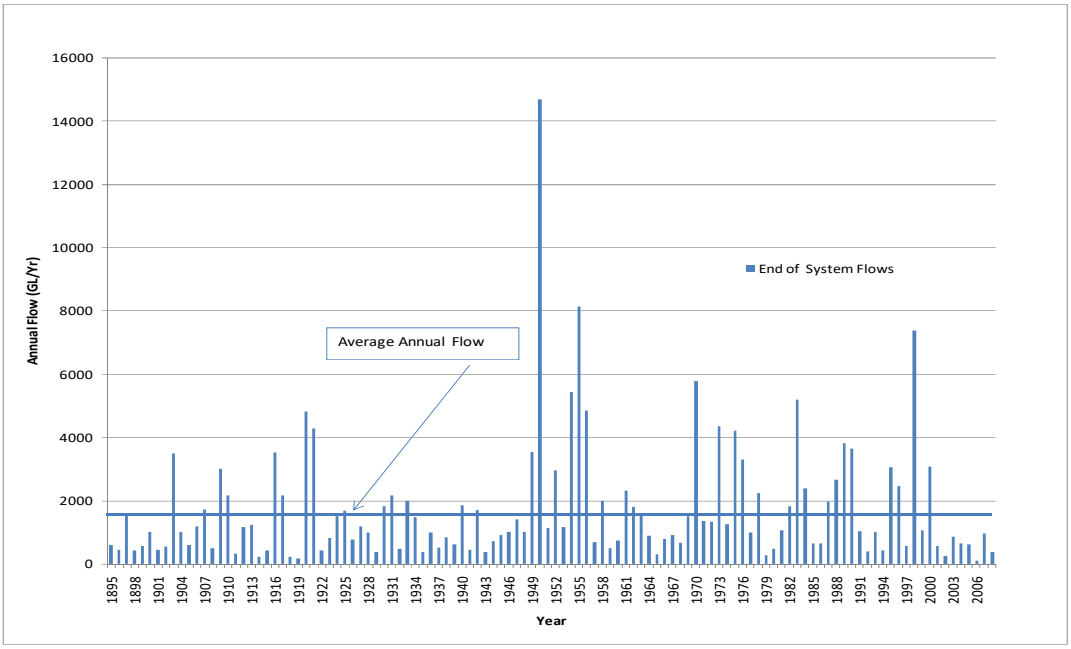


Figure 4 – End of System Flow Comparison

2.3 Recent Streamflows (2012/13 to 2016/17)

2.2.1 Mid System Flows

Recent Annual Streamflows Compared to Millennium Drought Flows

The past five years historic flows for major tributaries of the Barwon Darling at locations upstream of the majority of irrigation extractions are presented in Table 1. Mid system flows over the past five years broadly reflect the climatic conditions presented in Figure 1. *It should be noted in the case of the Condamine Balonne the mid system point of St George is downstream of significant amounts of irrigation and as such will represent a significant under estimate of water availability. At the time of report preparation predevelopment flows up to the year 16/17 were not available for incorporation into the analysis.*

In order to put the past five years flows into the context of times of limited resource availability they have been compared to flows over the millennial drought from 2002/03 to 2006/07. Results are presented in Table 2 and Figure 3. Total flows over the period 2012/13 to 2016/17 are one and a half times those under the worst five year period during the millennial drought. However, as illustrated in Figure 3, the years 2013/14 to 2015/16 (red bars) have total annual mid system flows that are as low as those experienced during the drought (blue bars).

Table 1 – Northern Basin Five Yr Historic Mid System Flows (12/13 to 16/17)

Past Five Years Historic Flows (GL/Yr)	2012/13	2013/14	2014/15	2015/16	2016/17
Mid River Flow					
416002 - Mactintyre River at Boggabilla	868.4	325.9	239.1	264.6	1624.1
417204A - Moonie River at Fenton	197.8	15.7	4.5	1.1	102.3
418013 - Gwydir River at Gravesend Rd Bridge	709.7	584.7	299.4	188.8	611.7
419012 - Namoi River at Boggabri	585.7	373.5	119.0	80.1	629.4
421001 - Macquarie River at Dubbo	1175.9	456.1	198.4	304.3	2117.9
422201F - Balonne River at St. George	1545.0	174.2	213.0	125.0	420.6
423203A - Warrego River at Wyandra	3.8	8.1	134.0	147.8	387.4
424201A - Paroo River at Caiwarro	12.6	134.1	117.2	153.1	167.5
Total Mid System Trib Flow (GL/yr)	**5098.9**	**2072.3**	**1324.6**	**1264.8**	**6060.9**

Table 2 - Historic Mid System Flows (12/13_16/17) Compared to 5Yr Historic Flows (02/03_06/07)

	Average Annual Mid System Flows (Current Development)		
	Average Annual Flow 2012/13 to 2016/17 (GL/Yr)	Average Annual Flow 2002/3 to 2006/7 (GL/Yr)	Percentage
416002 - Macintyre River at Boggabilla	664.1	275.4	241%
417204A - Moonie River at Fenton	66.1	79.6	83%
418013 - Gwydir River at Gravesend Rd Bridge	478.6	404.1	118%
419012 - Namoi River at Boggabri	357.3	220.7	162%
421001 - Macquarie River at Dubbo	850.1	343.9	247%
422201F - Balonne River at St. George	495.3	198.1	250%
423203A - Warrego River at Wyandra	136.2	229.0	59%
424201A - Paroo River at Caiwarro	116.8	215.4	54%
Total Mid System Trib Flow (GL/yr)	**3164.5**	**1966.3**	**161%**

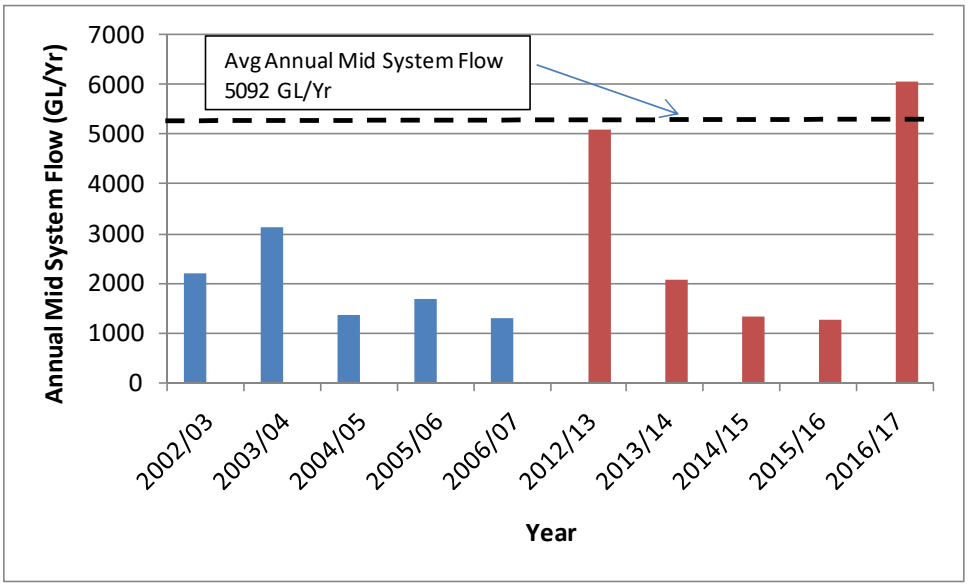


Figure 5 - Mid System Flow Comparison

Recent Annual Streamflows Compared to Longer Term Annual Flows

Recent flows can also be compared to flows over a longer climatic period. In Table 3 flows over the period 2012/13 to 2016/17 are compared to flows over the period from 1922 to 2008. As can be seen from the Table, the average mid system flows over the period from 12/13 to 16/17 is less than the modelled long-term average for all tributaries. The total historic mid system flow for all the tributaries of the Northern Basin is just a little over half of the long-term average flows for recent development further indicating that water availability has been below average across much of the northern basin during this period. This is further emphasised when comparing the past five years average annual flows with blocks of five year average flows for the period 1895 to 2008 in Figure 6. As

can be seen, five year average flows have only been lower for approximately thirteen other five Year periods out of a total of eighty three periods from 1922 to 2008 (15 % of this time), with the flow period from 2002/03 to 2006/07 being the worst on record.

Table 3 - Historic Mid System Flows (12/13_16/17) Compared to Long-term Current Development Five Yr Historic Flows (1895 to 2008)

	Average Annual Mid System Flows (Current Development)		
	Average Annual Flow 2012/13 to 2016/17 (GL/Yr)	Long-term Average Modelled Flow (GL/Yr)	Percentage
416002 - Macintyre River at Boggabilla	664.1	755.5	88%
417204A - Moonie River at Fenton	66.1	69.4	95%
418013 - Gwydir River at Gravesend Rd Bridge	478.6	737.3	65%
419012 - Namoi River at Boggabri	357.3	715.6	50%
421001 - Macquarie River at Dubbo	850.1	1057.3	80%
422201F - Balonne River at St. George	495.3	888.2	56%
423203A - Warrego River at Wyandra	136.2	419.9	32%
424201A - Paroo River at Caiwarro	116.8	449.3	26%
Total Mid System Trib Flow (GL/yr)	**3164.5**	**5092.5**	**62%**

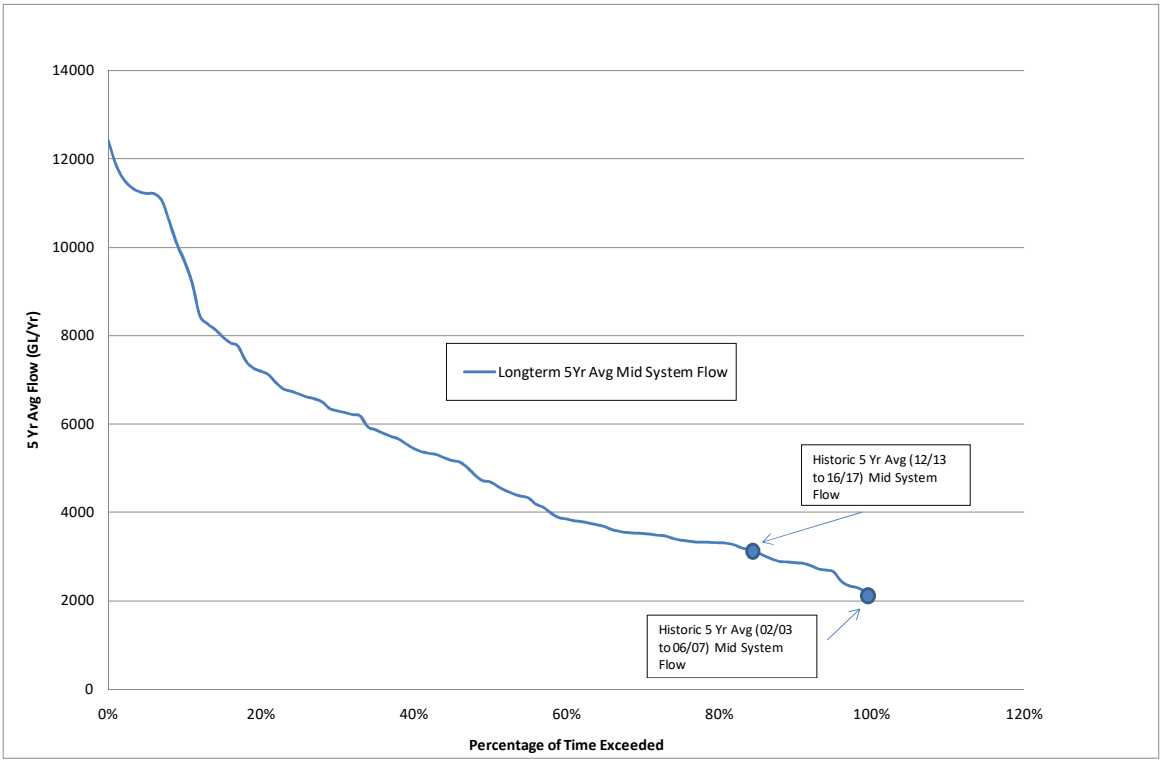


Figure 6 – Percentage of Time Five Year Average Mid System Flows are Exceeded

Conclusions

The following conclusions can be made relating to Northern Basin tributary mid system flows:

- A number of northern basin tributaries have experienced average mid system flows over the past five years which are similar to those experienced during the millennial drought.
- Total mid system tributary flows over the five years from 2012/13 to 2016/17 have been approximately just one and a half times those over the worst period in the millennial drought.
- The three years from 2013/14 to 2015/16 have experienced mid system flows with a similar order of magnitude to those experienced during the worst years of the millennial drought.
- Average Northern Basin mid system flows over the five years from 2012/13 to 2016/17 are almost half of what would be expected over the long-term from 1922 to 2008.
- Total Northern Basin mid system flows from 2012/13 to 2016/17 have only been lower for approximately thirteen other five Year periods out of a total of eighty three periods from 1922 to 2008 indicating very dry conditions and limited water availability.

2.2.2 Barwon Darling Inflows

Recent Annual Streamflows Compared to Millennium Drought Flows

A similar analysis to mid system flows can be undertaken for inflows into the Barwon Darling. Much of the flow in the Darling's tributaries is extracted for irrigation, finishes up in wetlands, or is lost as seepage and evaporation from channels and floodplains, before it enters the main stem of the Barwon Darling system.

Tributary inflows over the 2012/13 to 2016/17 period are presented in Table 4 and compared to the mid system flows. The Border Rivers, the Namoi and the Macquarie systems have provided the greatest proportion of inflows over this period.

Over 2012/13 to 2016/17 the total inflow to the Darling from its tributary rivers has been less than half the total "mid-river" flow in the tributaries (33%). In three of the past five years it has been less than 25%. The ratio of mid river flow to inflow to the Darling varies greatly from tributary to tributary. Low ratios indicate that the channel systems in

their lower reaches are particularly "inefficient". By contrast, higher ratios indicate the river channel systems are relatively efficient.

Table 4 – Northern Basin Five Yr Historic Barwon Darling Inflows Flows (12/13 to 16/17)

	12/13	13/14	14/15	15/16	16/17	% Contribution
Approximate Inflow to Darling						
416001 – Barwon River at Mungindi	595.5	76.9	100.5	79.0	398.4	**24%**
416052 – Gil Gil Creek at Galloway	63.8	12.3	21.1	6.8	12.5	**2%**
418055 – Mehi River at Near Collarenebri	193.3	28.1	31.4	6.6	49.7	**6%**
419026 – Namoi River at Goangra	208.4	48.6	4.5	25.9	471.5	**15%**
419049 - Pian Creek at Waminda	17.4	2.3	1.5	5.5	23.4	**1%**
421011 – Marthaguy Creek at Carinda	72.3	0.8	6.9	44.0	484.5	**12%**
421107 – Marra Creek at Billybingbone	28.9	4.9	3.6	15.9	165.1	**4%**
421012 – Macquarie River at Carinda	120.7	9.9	1.9	2.4	304.9	**8%**
421023 - Bogan River at Gongolgan	40.8	21.6	8.3	35.9	508.4	**12%**
422005 – Bokhara River at Bokhara	32.1	0.5	2.3	2.0	5.8	**1%**
417001 – Moonie at Gundablouie	181.1	19.0	2.7	3.3	106.6	**6%**
422006 – Culgoa River at D/S Collerina	213.0	29.9	37.2	28.5	86.3	**8%**
423001 - Warrego River at Fords Bridge	5.9	4.9	12.4	9.0	50.0	**2%**
Total Mid System Trib Flow (GL/yr)	**5098.9**	**2072.3**	**1324.6**	**1264.8**	**6060.9**	**3164.3**
Total Inflow to Darling (GL/Yr)	**1773.2**	**259.7**	**234.3**	**264.8**	**2667.1**	**1039.8**
Inflow as a % of Mid System Flow (GL/Yr)	**35%**	**13%**	**18%**	**21%**	**44%**	**33%**

Table 5 compares the past five years of inflows into the Barwon Darling with those over the period 2002/3 to 2006/07 during the millennium drought. Similar findings to mid system flows are apparent.

A number of Northern Basin tributaries have experienced average inflows to the Barwon Darling over the past five years which are similar to those experienced during the millennial drought. Total inflows to the Barwon Darling over the 5 years from 2012/13 to 2016/17 have been only two times the amount experienced over the worst period in the millennial drought, and as illustrated in Figure 5, the three years from 2013/14 to 2015/16 have experienced very low Barwon Darling inflows with a similar order of magnitude to those experienced during the worst years of the millennial drought.

Table 5 - Historic End of System Flows (12/13_16/17) Compared to 5Yr Historic Flows (01/02_06/07)

	Average Annual End of System Flows (Current Development)		
	Average Annual Flow 2012/13 to 2016/17 (GL/Yr)	Average Annual Flow 2001/02 to 2006/07 (GL/Yr)	
416001 – Barwon River at Mungindi	250.1	142.7	175%
416052 – Gil Gil Creek at Galloway	23.3	41.4	56%
418055 – Mehi River at Near Collarenebri	61.8	44.4	139%
419026 – Namoi River at Goangra	151.8	118.4	128%
419049 - Pian Creek at Waminda	10.0	7.4	136%
421011 – Marthaguy Creek at Carinda	71.0	3.6	1990%
421107 – Marra Creek at Billybingbone	43.7	4.3	1015%
421012 – Macquarie River at Carinda	88.0	3.8	2336%
421023 - Bogan River at Gongolgan	123.0	4.4	2827%
422005 – Bokhara River at Bokhara	8.5	8.1	104%
417001 – Moonie at Gundablouie	62.6	69.3	90%
422006 – Culgoa River at D/S Collerina	79.0	39.2	202%
423001 - Warrego River at Fords Bridge	16.4	18.6	88%
Total End of System Flow (GL/yr)	**989.2**	**505.4**	**196%**

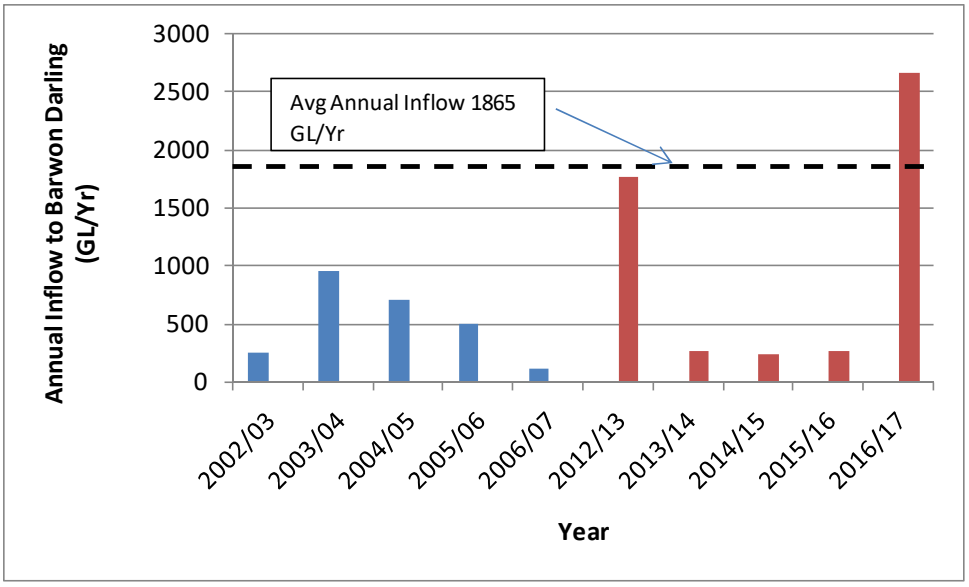


Figure 7 - Barwon Darling Tributary Inflow Comparison

Recent Annual Streamflows Compared to Longer Term Annual Flows

A comparison of recent tributary inflows to the Barwon Darling with long-term average annual inflows from 1922 to 2008 is presented in presented in Table 6. The results indicate that total inflows to the Barwon Darling are only half of what occurs on average over the longterm. This again shows that that recent historical inflow conditions have

been much drier than those which occur on average, and is further illustrated by Figure 8 when comparing the past 5 years average annual flows with block of five year average flows for the period 1895 to 2008. As can be seen, the total tributary system inflows to the Barwon Darling from 2012/13 to 2016/17 have only been lower for approximately twenty one other five year periods out of a total of eighty three periods from 1922 to 2008 (25 % of the time), with the flow period from 2002/03 to 2006/07 being the worst on record.

Table 6 - Historic Barwon Darling Inflows (12/13_16/17) Compared to Long-term Current Development 5Yr Historic Flows (1895 to 2008)

	Average Annual End of System Flows (Current Development)		
	Average Annual Flow 2012/13 to 2016/17 (GL/Yr)	Long-term Average Modelled Flow (GL/Yr)	Percentage
416001 – Barwon River at Mungindi	250.1	357.4	70%
416052 – Gil Gil Creek at Galloway	23.3	64.4	36%
418055 – Mehi River at Near Collarenebri	61.8	89.1	69%
419026 – Namoi River at Goangra	151.8	547.2	28%
419049 - Pian Creek at Waminda	10.0	45.2	22%
421011 – Marthaguy Creek at Carinda	71.0	71.0	100%
421107 – Marra Creek at Billybingbone	43.7	25.3	173%
421012 – Macquarie River at Carinda	88.0	79.5	111%
421023 - Bogan River at Gongolgan	123.0	229.4	54%
422005 – Bokhara River at Bokhara	8.5	26.3	33%
417001 – Moonie at Gundablouie	62.6	70.6	89%
422006 – Culgoa River at D/S Collerina	79.0	202.2	39%
423001 - Warrego River at Fords Bridge	16.4	58.0	28%
Total End of System Flow (GL/yr)	**989.2**	**1865.5**	**53%**

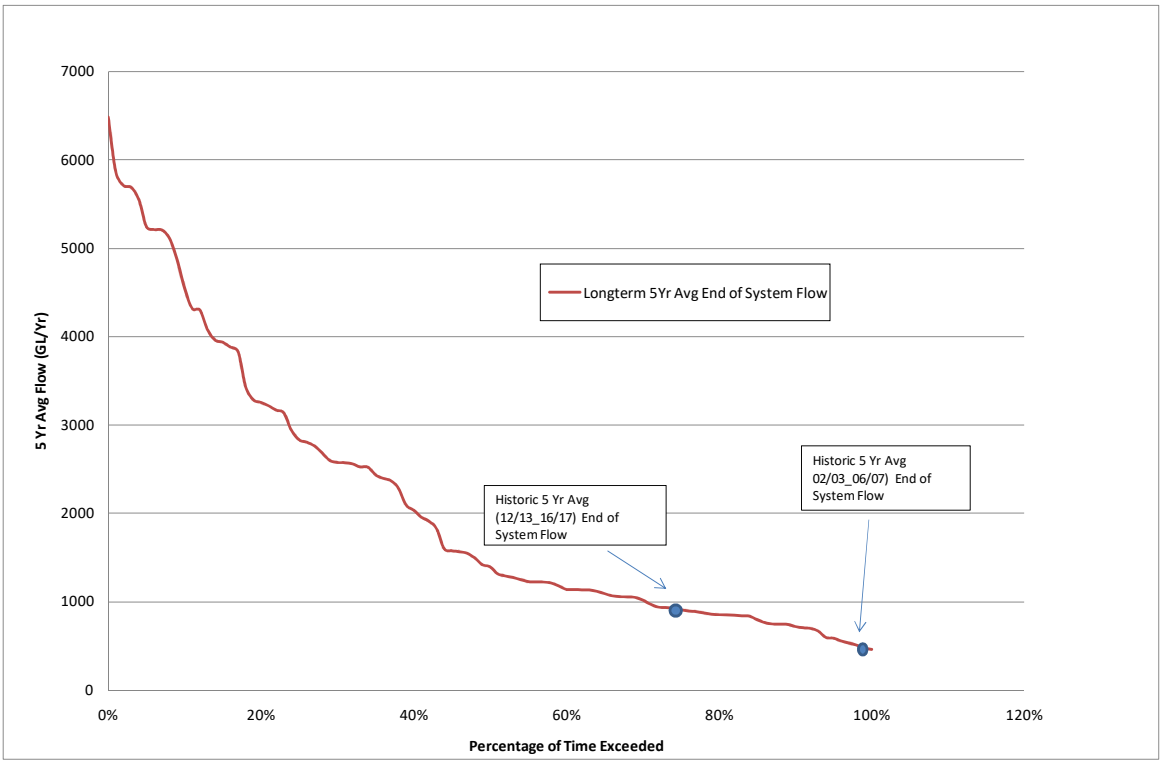


Figure 8 - Percentage of Time Five Year Average End of System Flows are Exceeded

Conclusions

The following conclusions can be made relating to Northern Basin tributary inflows to the Barwon Darling:

- As with mid system flows a number of Northern Basin tributaries have experienced inflows to the Barwon Darling over the past five years which are similar to those experienced during the millennial drought.
- Total inflows to the Barwon Darling over the 5 years from 2012/13 to 2016/17 have been approximately only twice the amount experienced over the worst period in the millennial drought.
- The three years from 2013/14 to 2015/16 have experienced very low Barwon Darling inflows with a similar order of magnitude to those experienced during the worst years of the millennial drought.
- Average inflows to the Barwon Darling over the 5 years from 2012/13 to 2016/17 are almost half of what would be expected over the long-term from 1922 to 2008.
- The total tributary system inflows to the Barwon Darling from 2012/13 to 2016/17 have only been lower for approximately twenty one other five year periods out of a total of eighty three periods from 1922 to 2008 indicating very dry conditions.

2.2.3 Barwon Darling Streamflows

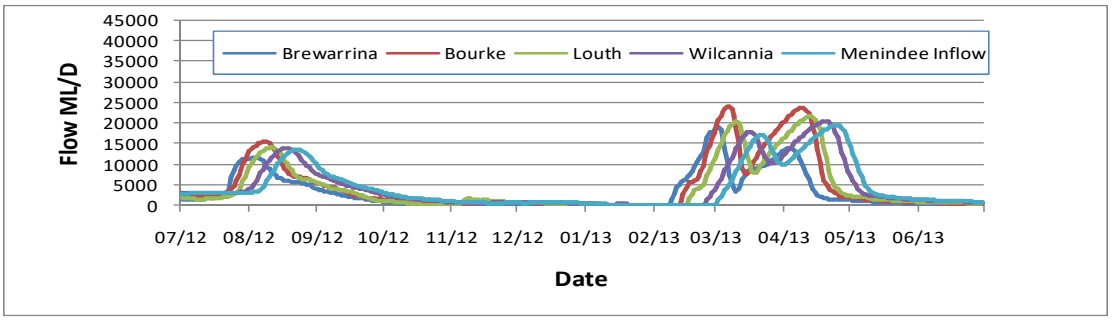
Recent Annual Streamflows Compared to Millennium Drought Flows

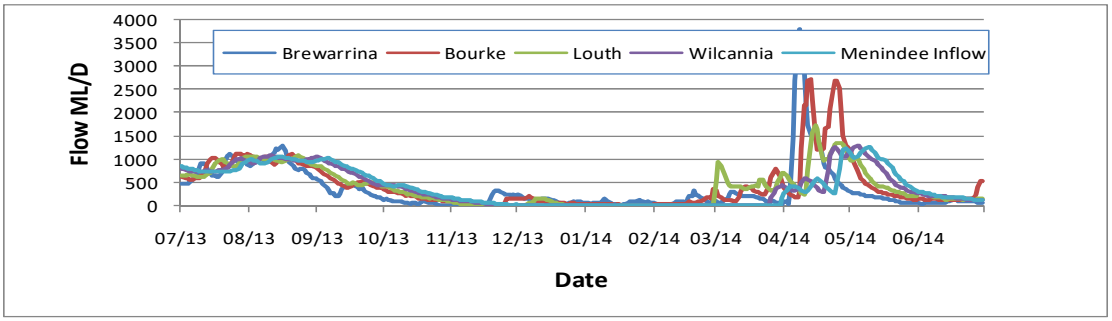
The previous analysis of mid system tributary flows and inflows to the Barwon Darling has highlighted the limited water availability and drier than average conditions that have existed over the past five years. An analysis of flows once they enter the Barwon Darling system is presented in this section. Table 7 and Figure 8 show annual and daily flows at a number of locations along the river. As can be seen despite irrigation extractions the Barwon Darling River gains flows between Brewarrina and Bourke due to tributary inflows but then loses flows below Bourke and the Menindee Lakes Scheme where extractions and inflows are lower, but losses are higher.

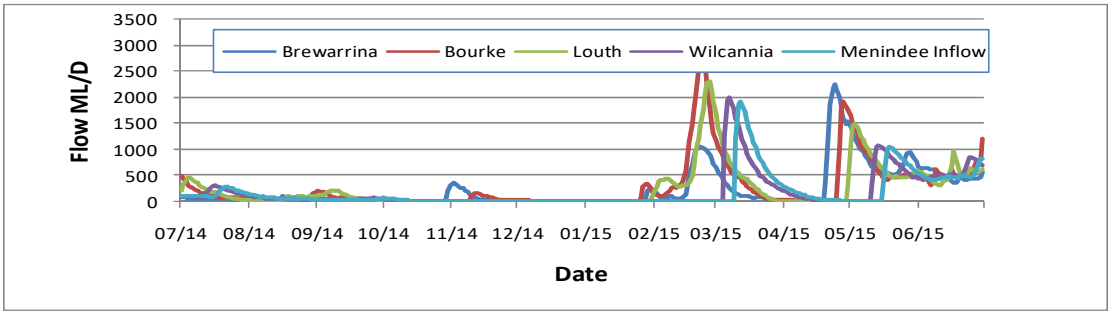
Table 7 - Barwon Darling Flows

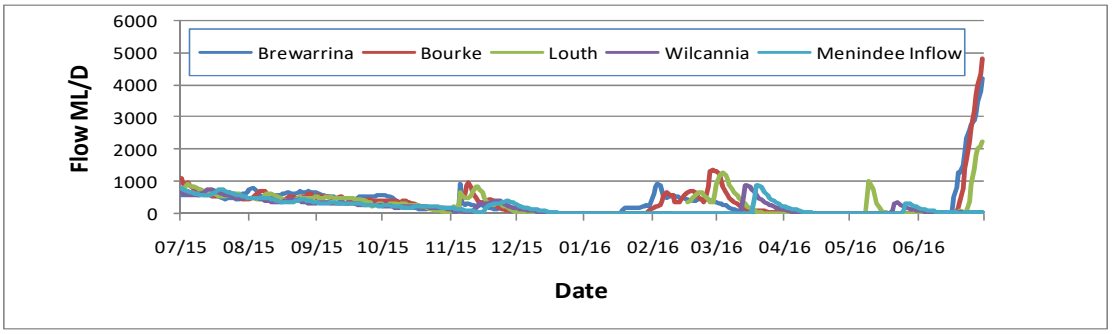
Past Five Years Historic Flows	12/13	13/14	14/15	15/16	16/17	Average	% Change
Barwon Darling Flows (GL/Yr)							
422002 – Barwon River at Brewarrina	1204.5	128.8	83.9	118.5	1604.7	628.1	
425003 – Darling River at Bourke	1715.8	154.4	99.1	124.9	2494.8	917.8	+46%
Menindee Inflows	1635.9	140.1	60.2	68.7	2029.7	786.9	-14%
425012 – Darling River at Weir 32	1427.8	235.1	57.6	19.3	531.9	454.3	-42%

Table 8 and Figure 10 present a comparison between flows in the Barwon Darling over the five years from 2012/13 to 2016/17 to those from 2002/03 to 2006/07. Results of Table 8 show that recent average flows have been approximately two to three times greater than those over the worst five year period in the millennial drought. However, as illustrated by Figure 10, three of the five years (2013/14 to 2015/16) have experienced very low Bourke annual flow volumes of a similar order of magnitude to those experienced during the worst years of the millennial drought. Furthermore, most of the years since the millennium drought commenced have had well below average annual flows.









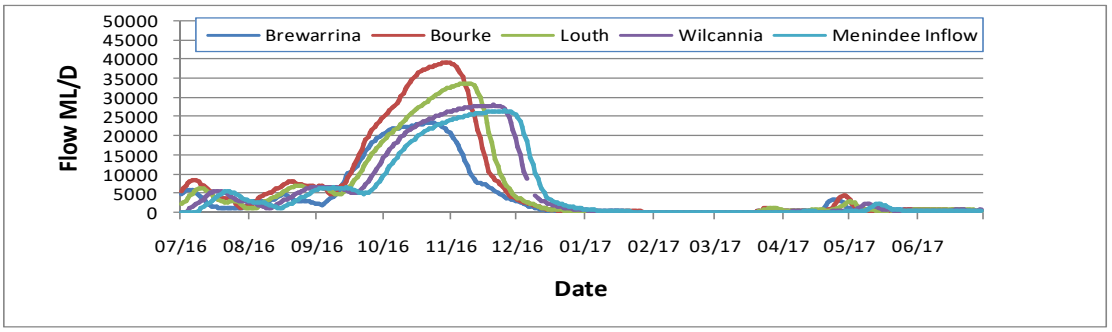


Figure 9 - Historical Flow Hydrographs at Brewarrina and Bourke (2012 to 2017)

Table 8 - Barwon Darling Flows (2012/13 to 2016/17) compared to (2002/03 to 2006/07)

Past Five Years Historic Flows	Average Annual Flow 2012/13 to 2016/17 (GL/Yr)	Average Annual Flow 2002/03 to 2006/07 (GL/Yr)	Percentage
422002 – Barwon River at Brewarrina	628.1	326.5	192.4%
425003 – Darling River at Bourke	917.8	342	268.4%
Menindee Inflows	786.9	247	318.6%
425012 – Darling River at Weir 32	454.3	76.7	592.3%

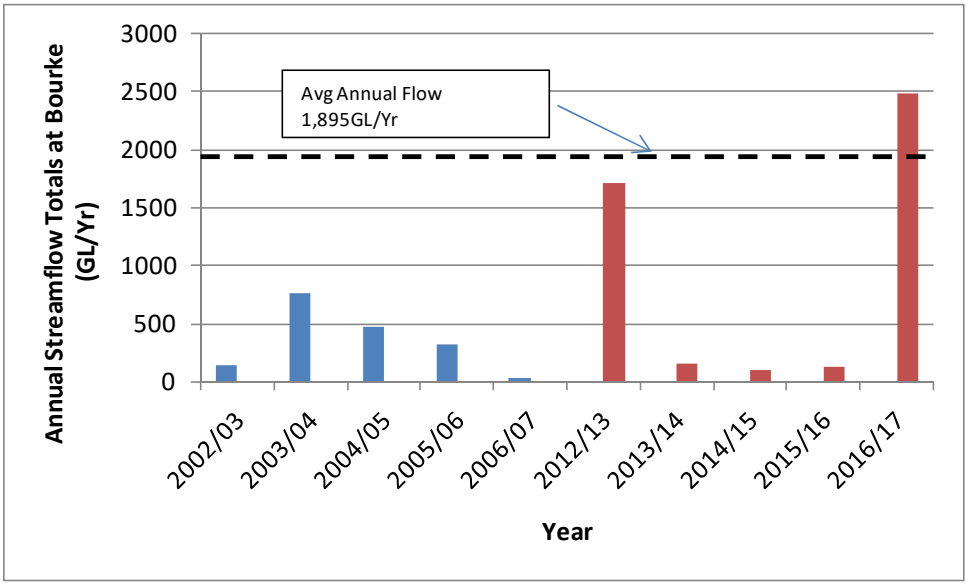


Figure 10 - Barwon Darling Bourke Flows Comparison

Recent Annual Streamflows Compared to Longer Term Annual Flows

The average of the past five years annual historic flows in the Barwon Darling are compared to long-term average annual flows from 1895 to 2008 in Table 9. As can be seen from the Table, average flows for the past five years are less than half of long-term flows along the river system indicating considerably drier than average conditions. This has been exacerbated downstream, of the Menindee Lakes Scheme due to the large losses associated with evaporation from the Scheme. This is also presented in the form of a water balance for the Scheme in Table 10 and Table 11. The results of Table 11 show that that over the period 2012/13 to 2016/17 three of five years have had more water lost through evaporation than gained through inflows, and that on average over the five years from 2012/13 to 2016/17, 58% of Menindee inflows have been lost through evaporation.

Table 9 - 5Yr Historic Flows (12_17) Compared to Long-term 5Yr Historic Flows (1895 to 2008)

	Average Annual End of System Flows (Current Development)		
	Average Annual Flow 2012/13 to 2016/17 (GL/Yr)	Long-term Average Modelled Flow (GL/Yr)	Percentage
422002 – Barwon River at Brewarrina	628.1	1468.23	43%
425003 – Darling River at Bourke	917.8	1895.5	48%
Menindee Inflows	786.9	1693.3	46%
425012 – Darling River at Weir 32	454.3	1326.4	34%

Table 10 – Menindee Lakes Scheme Water Balance

Year	Inflow (GL/Yr)	Rain on Storage (GL/Yr)	Evaporation from Storage (GL/Yr)	Storage Release (GL/Yr)	Change In Storage (GL/Yr)
2012/13	1,678	102	789	1,658	-667
2013/14	136	43	631	418	-871
2014/15	65	28	260	125	-292
2015/16	68	11	85	28	-34
2016/17	2,030	71	790	624	686
Average	**795**	**51**	**511**	**571**	**-235**

Table 11 – Menindee Lakes Scheme % of Inflow Lost through Evaporation and Seepage

Year	Inflow (GL/Yr)	Net Evap (GL/Yr)	% Of Inflow Lost to Net Evap and Seepage
2012/13	1,678	687	41%
2013/14	136	588	432%
2014/15	65	232	357%
2015/16	68	74	109%
2016/17	2,030	719	35%
Average	795	460	58%

Conclusions

- The Barwon Darling River gains flows between Brewarrina and Bourke due to tributary inflows but then loses flows below Bourke and the Menindee Lakes Scheme.

- Total flows in the Barwon Darling over the five years from 2012/13 to 2016/17 have been approximately two to three times greater than those over the worst five year period in the millennial drought. However three of the five Yrs (2013/14 to 2015/16) have experienced very low annual flow volumes of a similar order of magnitude to those experienced during the worst years of the millennial drought.

- Average flows over the five years from 2012/13 to 2016/17 are almost half of what would be expected over the long-term from 1922 to 2008.

- Over the period 2012/13 to 2016/17 three of five years have had more water lost through evaporation from Menindee Lakes than gained through inflows to the lakes, and that on average over the five years from 2012/13 to 2016/17, 58% of Menindee inflows have been lost through evaporation.

3 Historic Usage and Water Availability (2012/13 to 2016/17)

3.1 Historic Usage and Water Availability.

At the time of report preparation Barwon Darling tributary usage is within the long-term average annual extraction limits that have been set for all valleys. Furthermore, as stated in the *MDBA Transition Period Water Take Report 2012–13 to 2015–16 Report on Cap compliance and transitional SDL accounting* all Cap valleys in which a cumulative balance is the basis of compliance have remained compliant over the reporting period.

Usage for the Barwon Darling is presented for the 2012/13 to 2016/17 period in Table 12. Barwon Darling annual extraction has ranged from 11% to 30% of the annual system inflow. Average usage in the Barwon Darling over the past 5 years of 134 GL per annum has been within the Annual Share Entitlement Volume of 253GL indicating that pumping opportunities have been less frequent when annual inflows are below average.

The average usage over the past five years of 134GL/Yr is well within the Barwon Darling long-term average annual extraction limit for the system of 189GL/Yr (Source: Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources 2012).

An assessment of the Barwon Darling and Lower Darling combined annual diversions against Cap diversions over the period from 1997/8 to 2015/16 are also presented in Figure 11. As can be seen there are very few individual years in which annual diversions (red bars) have exceeded the Cap targets (blue dashes). Furthermore, cumulative diversions as illustrated by the green line are in credit and well with the Cap.

It should be noted that daily usage data was not available for the Barwon Darling so a comparison of periods of extraction with flows at a daily time scale and an assessment of compliance with license conditions could not be undertaken as part of this study.

Table 12 - Historic Usage (12/13 to 16/17) Barwon Darling

RIVER SECTION	12/13	13/14	14/15	15/16	16/17	Share
BOOMI RIVER CONFLUENCE TO UPSTREAM MOGIL MOGIL WEIR POOL MANAGEMENT ZONE						0.2
UNREGULATED RIVER (A CLASS)	0	0				0.0
UNREGULATED RIVER (B CLASS)	0	0				0.1
BOOROOMA TO BREWARRINA MANAGEMENT ZONE						49.8
DOMESTIC AND STOCK					0	0.4
LOCAL WATER UTILITY	0	0			0	1.0
UNREGULATED RIVER					0	1.5

UNREGULATED RIVER (A CLASS)	943	100	2631	5426.6	7622.2	1.7
UNREGULATED RIVER (B CLASS)	16245	12966	0	6677	24915.8	13.1
UNREGULATED RIVER (C CLASS)	39020	3279	0	3024	38312	32.2
BOURKE TO LOUTH MANAGEMENT ZONE						26.3
DOMESTIC AND STOCK	17	17	0	0	0	0.0
LOCAL WATER UTILITY	0	15		25	17	0.0
UNREGULATED RIVER (A CLASS)	8	0	0			0.9
UNREGULATED RIVER (B CLASS)	15251	3637	0	1577	10514	13.6
UNREGULATED RIVER (C CLASS)	10514	2655	0	1459	19264	11.7
BREWARRINA TO CULGOA RIVER JUNCTION MANAGEMENT ZONE						14.1
UNREGULATED RIVER (A CLASS)	218.5	108.5	0	426.4	441.6	0.4
UNREGULATED RIVER (B CLASS)	14649	7562	0	3808	25460.4	13.6
UNREGULATED RIVER (C CLASS)	0					0.0
COLLARENEBRI TO UPSTREAM WALGETT WEIR POOL MANAGEMENT ZONE						9.4
DOMESTIC AND STOCK	17	17	0	0	0	0.0
UNREGULATED RIVER (A CLASS)	0	0		0	320	0.5
UNREGULATED RIVER (B CLASS)	7165	8342	5243	11242	22695	8.9
CULGOA RIVER JUNCTION TO BOURKE MANAGEMENT ZONE						103.6
DOMESTIC AND STOCK	8.5	8.5	0			0.1
LOCAL WATER UTILITY	0	1712	0	1671	1954	3.5
UNREGULATED RIVER (A CLASS)	221	204	11299	13724	13010	14.1
UNREGULATED RIVER (B CLASS)	66035	15917	0	11510	86221	82.6
UNREGULATED RIVER (C CLASS)	1538	530	0	0	15	3.4
DOWNSTREAM MOGIL MOGIL TO COLLARENEBRI MANAGEMENT ZONE						18.4
LOCAL WATER UTILITY	0	198.1				0.4
UNREGULATED RIVER (A CLASS)	0	0			1218	0.3
UNREGULATED RIVER (B CLASS)	203	400	1012	1469	1047	10.7
UNREGULATED RIVER (C CLASS)	0	0				7.0
DOWNSTREAM WALGETT TO BOOROOMA MANAGEMENT ZONE						14.5
UNREGULATED RIVER (A CLASS)	0	0		1279	5537.7	0.9
UNREGULATED RIVER (B CLASS)	4819	4877	322	1274	21197.3	8.4
UNREGULATED RIVER (C CLASS)	3552	4495	0	750	888	5.1
LOUTH TO TILPA MANAGEMENT ZONE						0.9
UNREGULATED RIVER (A CLASS)	0	0				0.0
UNREGULATED RIVER (B CLASS)	0	0				0.8
MUNGINDI TO BOOMI RIVER CONFLUENCE MANAGEMENT ZONE						7.5
UNREGULATED RIVER (A CLASS)	8	37	8	20	36	0.0
UNREGULATED RIVER (B CLASS)	5684	7279	8636	9612.4	11053.2	7.5
UNREGULATED RIVER (C CLASS)	0					0.0
TILPA TO WILCANNIA MANAGEMENT ZONE						2.4
LOCAL WATER UTILITY	0	0			0	0.4
UNREGULATED RIVER (A CLASS)	0	0				0.5

UNREGULATED RIVER (B CLASS)	0	0				1.5
WALGETT WEIR POOL MANAGEMENT ZONE						3.3
UNREGULATED RIVER (A CLASS)	0	0	60.5	0	455	0.3
UNREGULATED RIVER (B CLASS)	3190	4050	595	871	6672	3.0
WILCANNIA TO UPSTREAM LAKE WETHERELL MANAGEMNMT ZONE						1.1
UNREGULATED RIVER (B CLASS)	0	0				1.1
Total Usage (GL/Yr)	**189.3**	**78.4**	**29.8**	**75.8**	**298.9**	**251.4**
Total Inflow to Barwon Darling (GL/Yr)	**1773.2**	**259.7**	**234.3**	**264.8**	**2667.1**	
Proportion of Inflow Extracted (GL/Yr)	**11%**	**30%**	**13%**	**29%**	**11%**	
Total Flow at Bourke (GL/Yr)	**1715.8**	**154.4**	**99.1**	**124.9**	**2494.8**	

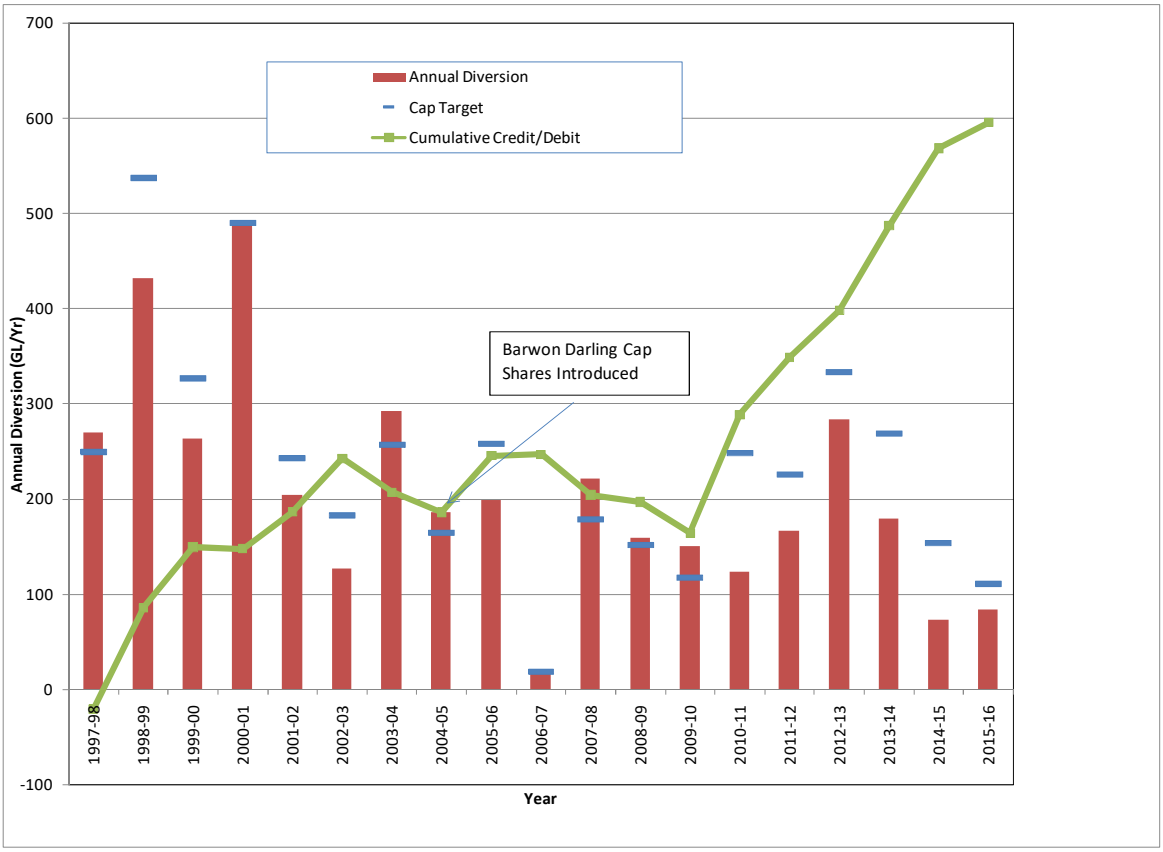


Figure 11 - Barwon Darling and Lower Darling Cap Performance

Conclusions

At the time of report preparation tributary usage has been within the diversion limits that have been set for all valleys. Furthermore, as stated in *"MDBA Transition Period Water Take Report 2012–13 to 2015–16 Report on Cap compliance and transitional SDL accounting"*, all Cap valleys in which a cumulative balance is the basis of compliance have remained compliant over the reporting period.

Barwon Darling annual extraction has ranged from 11% to 30% of the annual system inflow. Average usage in the Barwon Darling over the past 5 years of 134 GL per annum has been within the Annual Share Entitlement.

The Barwon Darling average usage over the past five years of 134GL/Yr is well within the Barwon Darling the long-term average annual extraction limit for the system of 189GL/Yr.

4 Conclusions

An assessment of flows and water availability has been made for the period 2012/13 to 2016/17. Mid system flows were chosen to represent water availability in the Northern Basin tributaries, and tributary end of system flows were selected to represent water availability in the Barwon Darling. The following observations have been made:

Climate

- A comparison of recent years annual rainfalls from 2012 to 2017 with that experienced during the millennial drought from 2001 to 2009 indicate that rainfalls are below average, but not to the extent that they were during the drought. However, in areas in the Northern and western parts of the Northern Basin such as Toowoomba and Bourke, there have been very few years with above average rainfalls since the millennial drought began.

Water Availability

- Over the past five years (2012/13 to 2016/17), a number of Northern Basin tributaries have experienced total mid system flows and inflows to the Barwon Darling which are similar to those experienced during the millennial drought.

- The sum of **all** mid system tributary flows over the five years from 2012/13 to 2016/17 have been approximately just one and a half times those experienced during the worst period in the millennial drought. Whilst total inflows to the Barwon Darling have been approximately twice the amount experienced during this period.

- The three individual years from 2013/14 to 2015/16 have experienced total mid system tributary flows and inflows to the Barwon Darling with a similar order of magnitude to those experienced during the worst years of the millennial drought.

- The sum of all mid system and tributary inflows to the Barwon Darling over the five years from 2012/13 to 2016/17 are almost half of what would be expected over the long-term from 1922 to 2008.

- The sum of all mid system flows from 2012/13 to 2016/17 have only been lower for approximately thirteen other *five year periods* out of a total of 83 periods from 1922 to 2008, whilst inflows to the Barwon Darling have only been lower for approximately twenty one *five year periods* indicating very dry condition and limited water availability.

- Over the period 2012/13 to 2016/17 three of five years have had more water lost through evaporation from Menindee Lakes than gained through inflows to the Lakes.

- Over the period from 2012/13 to 2016/17, 58% of Menindee inflows have been lost through evaporation.

Usage

- At the time of report preparation tributary usage has been within the diversion limits that have been set for all tributary valleys. Furthermore, as stated in *"MDBA Transition Period Water Take Report 2012–13 to 2015–16 Report on Cap compliance and transitional SDL accounting"*, all Cap valleys in which a cumulative balance is the basis of compliance have remained compliant over the reporting period.

- Over the 2012/13 to 2016/17 period, Barwon Darling annual extraction has ranged from 11% to 30% of the annual system inflow. Average usage in the Barwon Darling over the past five years of 134 GL per annum has been within the systems Annual Share Entitlement total of 251.4GL.

- The Barwon Darling average usage over the past five years of 134GL/Yr is well within the Barwon Darling the long-term average annual extraction limit for the system of 189GL/Yr.

Conclusions

In conclusion, the Northern Basin has experienced well below average conditions in terms of climate and water availability over the 2012/13 to 2016/17 period. These conditions have been felt across the entire Northern Basin and are not limited to specific river systems. Furthermore, despite the highly variable nature of water availability in the Northern Basin, below average water availability conditions have persisted since the onset of the millennial drought.

Usage across the Basin has been constrained by limited water availability over the 2012/13 to 2016/17 period, with diversions remaining within all valleys long-term average annual extraction limits.

REFERENCES

DOI (Water) Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources 2012

MDBA Transition Period Water Take Report 2012–13 to 2015–16 Report on Cap compliance and transitional SDL accounting November 2017

WMAWater State of the Darling Stage 1 Hydrology Overview Technical Report November 2006