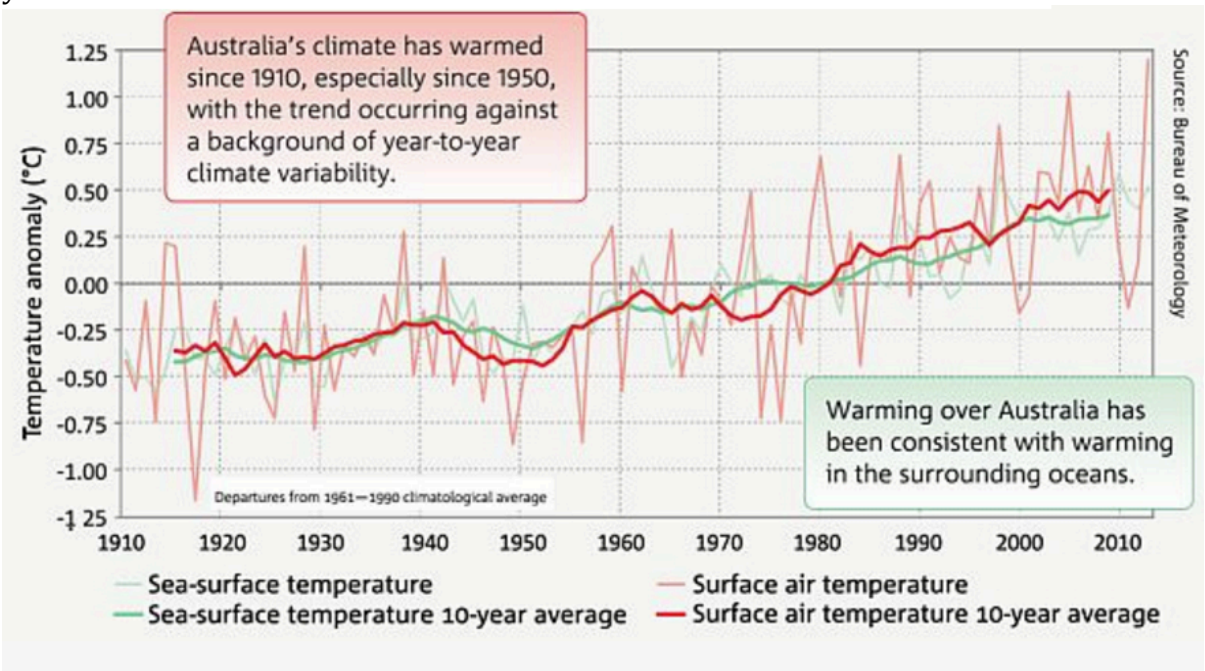
Supplementary Submission to Senate Standing Committee On Rural & Regional Affairs
The integrity of the Water Market in the Murray Darling Basin

My original submission (number 3 in the committees registrations) focused on the major change in the relationship between rainfall in the Darling basin and flows to the lower Darling over the 110 years to 2000 – and that a major factor in this change seemed to be extractions from the river for irrigation.

This supplementary submission **confirms the conclusion, that from the latter part of the 20th century, too much water was extracted upstream for the health of the lower Darling**. It does this by examining the impact of other factors that have been blamed for lower flows to the lower Darling. This includes the extent to which 'climate change', particularly higher temperatures, could have contributed.

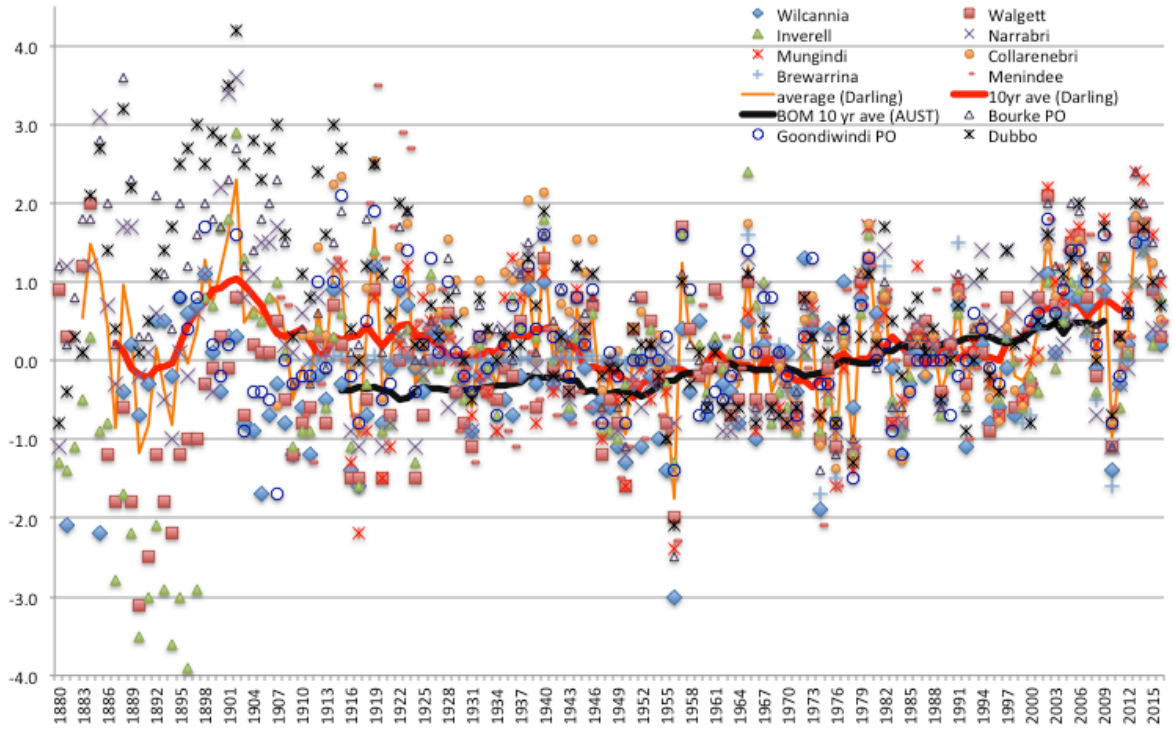
The appropriate starting point for examining climate change and higher temperatures is the Bureau of Meteorology (BoM) which calculated average temperatures for Australia as a whole – and concluded they were on a rising trend – and had risen about 1 deg C over the 100 years from 1910. It is illustrated by the following graph from the BoM website – which demonstrates the uptrend and **very large variability** from year to year.



There are several weaknesses in using this for the Darling basin. The most obvious is the Darling basin is only part of Australia – the second is that inland areas have wider extremes of temperature than coastal areas etc. Thirdly when looking at the drying of river systems, average maximum temperatures are more important than averages including minimums – which are usually about end of the night. Evaporation increases for a one degree rise in temperature are generally higher the higher the temperature. Finally, the BoM time period is shorter than my original study of Darling basin rainfall – which examined rainfall as far back as data were available – ie about the 1880s.

Consequently, I examined maximum temperatures for Darling basin centres for as far back as data was available – and included the period before 1910. I used methodology as

close I could to the BoM study. Thus I calculated 'annual diversion from 1961-1990 average maximum' for as many relevant centres as I could find data for. I then averaged the diversions for each year that I had at least 5 observations (ie from 1883, 6 from 1888 & 7 from 1895) – and then (like BoM) calculated a 10 year moving average. The results are shown in the following chart – which shows annual temperature deviations for 11 centres for all available years since 1880. The average annual deviation for these centres is shown by the thin orange line and a 10 year (centred) moving average is shown by the thicker red line. The thick black line shows the BoM 10 year moving average from the first graph – which looks flatter here because of the wider scale required to get all temperature deviations on the same graph.



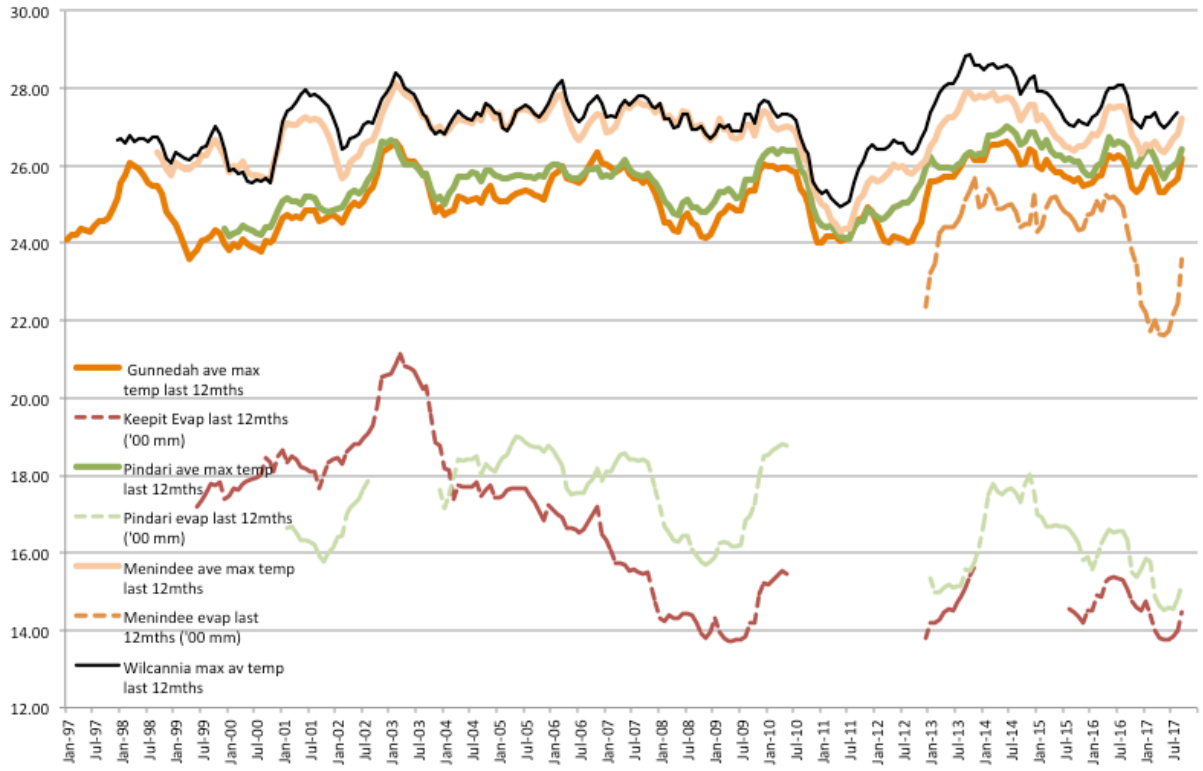
Some points worthy of note include;

- comparisons with rainfall data show that average temperature deviations show a fairly strong inverse relationship with deviations from average rainfall. Thus we have large downward temperature deviations in very wet years - 1956 was the wettest of several wet years in the 1950s - and 2010 was also very wet. There are also strong upward deviations in droughts – especially the 'Federation' drought and the extended dry periods thru the 1930s and 40s.
- some large and scattered deviations in some of the early years – which at first sight might appear to be a data quality issue. However some available evidence suggests it may not be poor data quality. Several centres in central western NSW had several exceptionally hot years in the 2 decades before 1910 – with many of the records set in that period still standing. As well as Dubbo & Narrabri (which are included in my 11 centres and calculations), nearby Gunnedah and Coonabarabran also had some exceptionally high average temperatures in this period – and well below average temperatures in some years. Incidently, there were also some very wide swings in annual rainfall totals in this period.
- no doubt BoM chose 1910 for the starting point of their study because the available sample of (reliable) temperature observation was much larger than for the decades before 1910. However there seems little doubt that (as far as the

Darling basin is concerned) the BOM study overstates the long term rise in temperatures (so far). I don't doubt that 'climate change' is with us, and getting worse. However, **record low flows to the lower Darling since 2000 should not be blamed on unprecedented drought or higher temperatures**.

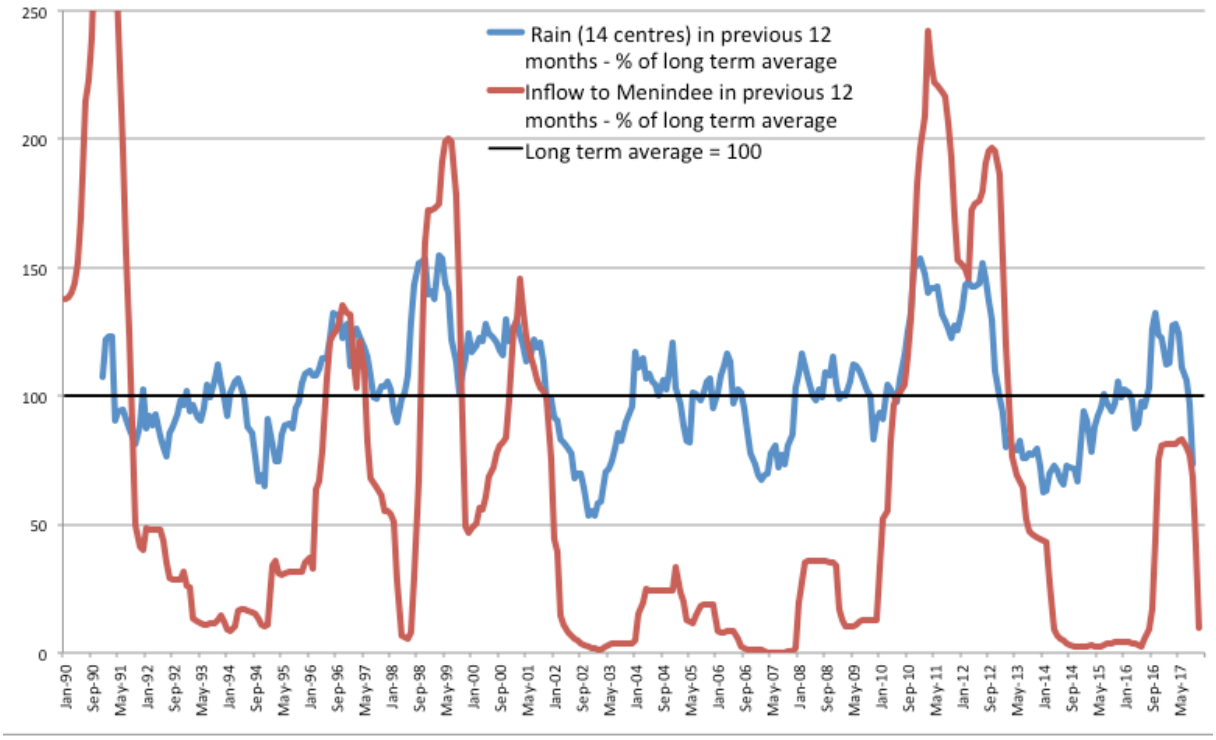
There is no doubt that higher average temperatures have a significant impact on 'end of system' flows in a river as long and slow flowing as the Darling – and climate change will make it worse. However drying of river systems from high temperatures is a regular phenomenon that has long been with us.

Measures of evaporation can be a useful guide to the impact of high temperatures on river flows, especially as evaporation generally rises faster the higher the temperature. Unfortunately, data on evaporation in the Darling basin is only readily available for comparatively recent periods. The following graph shows average temperatures and evaporation for as far back as the data is readily available. To avoid 'seasonal' influences, all data is on a '12 months ended' basis. Expressing total evaporation as 'per hundred mm' – gives a comparable scale to 'degrees of temperature'. Note how the record temperatures in September 2017, lifted the average temperature for the 12 months to September by 0.4 degrees – and produced a much sharper rise in evaporation at Menindee - by 1.1 hundred mm to 2300 mm in the 12 months to September. This followed falls through the previous year of observations. Similarly, movements in average temperature at Pindari dam also produced larger movements in evaporation at Pindari. The dotted red line shows evaporation at Keepit over a longer period and the smaller rises and falls in temperature at the nearest weather centre at Gunnedah.



Given the record high temperatures and low rainfall in September 2017, it seems sensible to update the monthly graph in my original submission. In the absence of exceptional rains in coming weeks, virtually all the small volume of water that is

likely to reach Menindee in October and November is already in the rivers. This includes sizable amounts of 'environmental water' released into the Macquarie, Gwyder and Macintyre rivers in August/September. Thus it is possible to estimate flow to Wilcannia/Menindee to the end of November – which is done in the following graph. It reminds us how quickly the flows to the lower Darling can fall after the record rains in western NSW over the few months to September 2016.



Rob Foster
9 October 2017