

## THE CONTRIBUTION OF RIVER MURRAY TRIBUTARIES TO THE FLOODING OF BARMAH FOREST

by  
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### ABSTRACT

*The Barmah River Red Gum forest are part of a larger tract of such forests along the River Murray. It is known that river flooding provides an important source of water for the sustenance of these forests. The contribution of River Murray tributaries to the flooding of these forest was examined. The main stem of the River Murray above lake Hume was the single most important source. Removal of this would lead to a 55 percent decrease in forest flooding. Removal of either the Ovens or the Mitta Mitta would lead to a 30 percent reduction in flooding, while removal of the Kiewa river would lead to a 15 percent reduction in flooding. No particular tributary can be regarded as a source of extreme forest floods since all tributaries more or less act in concert. A backwater influence of high water levels at the down stream confluence of the Goulburn and Murray Rivers leads to high water levels in the River at Barmah. However, because of the short-lived nature of such high water levels it is unlikely that such floods penetrate very far into the forest unless they are also associated with flows in the River Murray.*

### INTRODUCTION

The Barmah Forest is portion of the major Barmah-Millewa red gum forest on the River Murray (Figure 1). These forests exist in an intimate relation with the River Murray and are known to depend on flooding for their survival (Dexter, 1978). This paper will consider:

1. From which tributaries of the River Murray does forest flooding originate?
2. What have been the "great floods" of the forest, and how have the different tributaries of the river Murray contributed to these?
3. What is the influence of flooding in the Goulburn River in causing backwater flooding of the forest?

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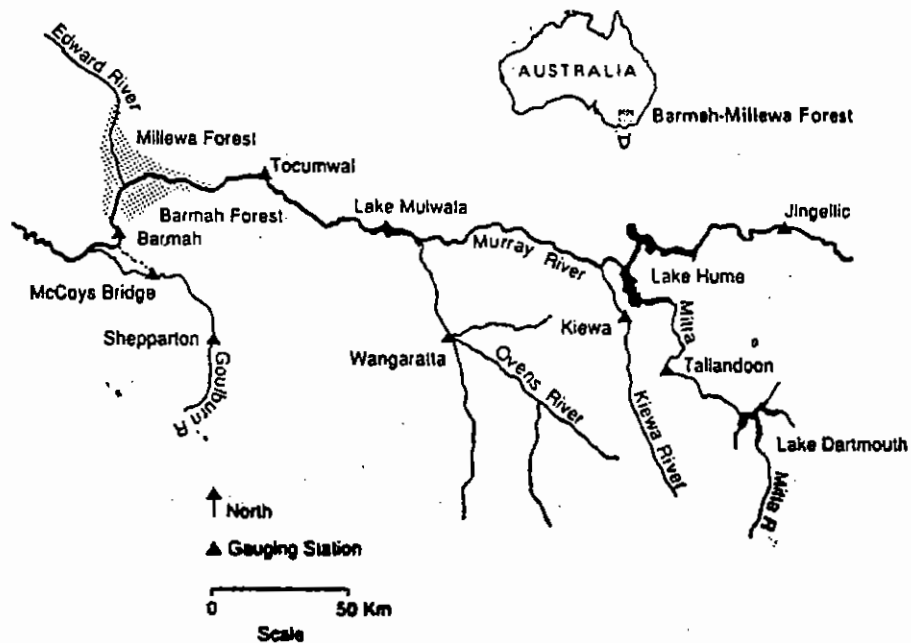


Figure 1. The Location of major tributaries passing water to the Barmah Millewa forest and gauging used in the study.

### RED GUM FOREST FLOODING

A previous study made a statistical analysis of information available from flood maps and daily flow records of the River Murray at Tocumwal (Bren *et al.*, 1987). The result showed that best available predictor of flooding was the maximum mean daily flow at Tocumwal for each month. The predictive equation derived was:

$$P = -435.40 + 47.60 \ln(F) \quad F < 68,500$$

$$P = 93.5 \quad F > 68,500$$

Where

P = Percentage of forest flooded in a given month.

F = Maximum daily flow in the calendar month, ML day<sup>-1</sup>.

This work showed that the River Murray behaved as a partially-regulated system, with general control of summer irrigation flows at the capacity of the channels through the forest, but with diminished control (because of inadequate storage) of winter-spring flows.

### DATA AND ANALYSIS

The major source of data were the routine gauging records of the Rural Water Commission of Victoria (S.R. & W.S.C., 1984). Figure 1 shows the location of the gauging stations. Table 1 shows approximate water travel times between stations. The analysis generally used only monthly records, since these are suited to the level of accuracy of the study. Occasionally, daily records were used to provide detailed information. The parameter used was the maximum mean daily flow for a given month (mdf, units ML day<sup>-1</sup>). This was selected because it was the best predictor at Tocumwal (equation 1). In general, this had a high correlation with other flow parameters such as monthly flow or the instantaneous peak flow reached.

TABLE 1. SYSTEM TRAVEL TIMES FOR REGULATED FLOWS IN THE RIVER MURRAY AND TRIBUTARIES

Station to Station	Travel time - Days
Jingellic to Lake Hume	1.5 days
Lake Hume - Lake Mulwala	4 days
Lake Mulwala - Barmah forest	2.5 days
Wangaratta - Lake Mulwala	2 days
Tallandoon - Lake Hume	1.5 days

Note: Flood travel times are generally greater than the times quoted above because of the hydraulic roughness of the flood plains.

Analysis particularly relied on two techniques. The first was the well-established hydrology technique of double-mass plotting, used to analyze sequential data from two or more streams. In this, the cumulative value of a variable describing one stream is plotted against the cumulative value of the variable for the other (Figure 2). The constancy of the gradient is an excellent indicator of the constancy of the relation between the two streams. The distance between successive points

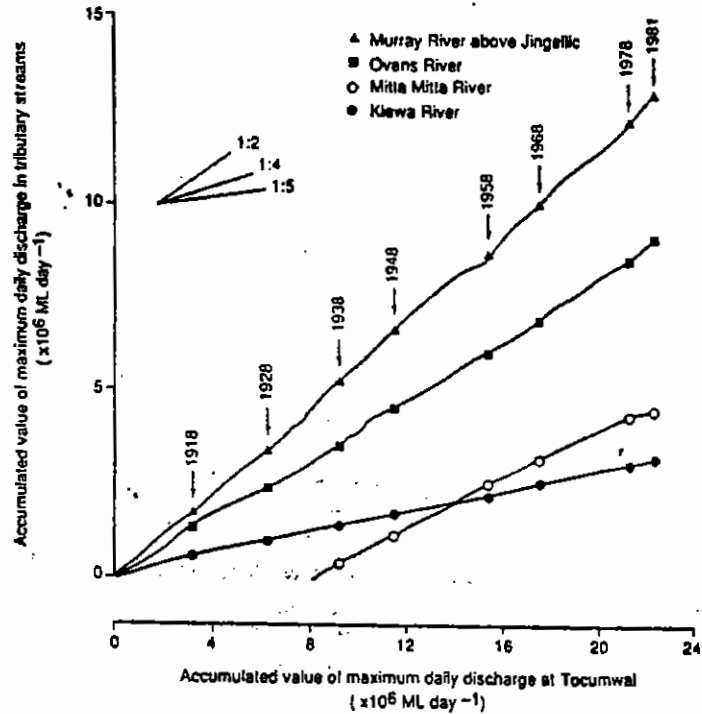


Figure 2. Double-mass plots showing the accumulated value of the maximum daily discharge for each month in tributary streams as a function of the accumulated value of maximum daily discharge at Tocumwal.

of the mdf in a tributary stream from that of the downstream main stream (at Tocumwal) to obtain an estimate of what the flow would have been if that tributary had not been present. Such a procedure can only be regarded as approximating this situation. In particular, the time of travel between streams depends substantially on the rates of flow within streams, and the flood peak flows attenuated with passage down stream. Further, mdf's quoted for two stations on a stream net work in a given month may occur for entirely different events. Notwithstanding these deficiencies, however, it does give an approximate indicator of the contribution of each of the tributaries to the peak flow.

### THE INFLUENCE OF THE UPSTREAM TRIBUTARIES

The major tributaries of the River Murray above Barmah Forest are:

1. **The Ovens River.** The catchment contains relatively small dams on the Buffalo and King River Tributaries.
2. **The Kiewa River.** This is substantially unregulated, although hydroelectric works in the upper catchment may influence daily flows.
3. **The Mitta Mitta River.** This contains the large Dartmouth dam, which commenced filling in 1979. Dartmouth dam is used to provide irrigation flows.
3. **The main stem of the River Murray above Lake Hume.** The station at Jingellic was regarded as representative of this. It contains one or more major, unexploited dam sites.

The River Murray main course contains two regulating structures, the large Lake Hume, and the smaller Lake Mulwala. Lake Hume provides both irrigation storage and flood control. Lake Mulwala is used for lifting water into irrigation canals and provides a small amount of regulation of summer flows. In general it is kept close to full, and hence has relatively little effect on the river hydrographs.

Figure 2 shows cumulative double-mass plots of the streams involved as a function of the cumulative value of the maximum monthly mean daily flow at Tocumwal. The constant gradient of the plots shows a substantially constant relationship between the flow in each of the tributaries. This suggests that there is not much variation in relative behaviour between tributaries. Table 2 shows the relative gradients (expressed as percentages). These gradients give the relative importance of each stream in providing the monthly maximum mean daily flow at Tocumwal. The influence of Dartmouth Dam in changing the relationship between the Mitta Mitta and the other tributaries can be seen as a change in gradient of the Mitta Mitta line about 1978.

TABLE 2. GRADIENTS OF EACH TRIBUTARY DOUBLE-MASS CURVES RELATIVE TO THE ACCUMULATED PEAK FLOW AT TOCUMWAL

Tributary	Relative Gradient (%)
Ovens River at Wangaratta	41
Kiewa River at Kiewa	15
Murray River at Jingellic	59
Mitta Mitta River at Tallandoon	32

To better define the relative importance of each of these tributaries to the actual flooding of the forest, estimates were made of the reduction of flooding of the forest if each of these tributaries was not present. The method was:

1. By applying equation 1 to the observed monthly sequence of mdf's at Tocumwal, an observed monthly sequence of percentage of the forest inundated was computed. From this sequence the value of the mean percentage of the forest inundated was computed by taking the average between 1908 and 1981.
2. Sequences of monthly mdf at Tocumwal in the absence of each of the tributaries were then computed by subtracting the mdf of the tributary from the mdf at Tocumwal. Then, by applying equation 1, the estimated monthly sequence of forest flooding in the absence of that tributary were computed. Figure 3 shows the sequences covering the decade from 1970-1980. This decade was selected because it shows both major and minor flooding.
3. From each of these synthetic sequences, the mean percentage of the forest flooded was computed. Then, by comparison with the value computed in (1) above, the reduction in flooding which would occur if this tributary was removed will be computed. Table 3 shows the results. This actually gives a more accurate picture of the influence of each tributary on forest flooding than the double-mass plots alone since to some extent the coincidence of high flows is taken into account.

**TABLE 3. ESTIMATED REDUCTION IN FOREST FLOODING IF EACH THE MAJOR TRIBUTARIES WAS NOT PRESENT**

If this tributary was not present	Then forest flooding would decrease by (%)
Ovens River	32
Kiewa River	15
Murray River above Jingellic	55
Mitta Mitta River	30

Note: This is a better indicator of the importance of each tributary to forest flooding than Table 2.

The above reasons represent the best available estimate of the importance of these tributaries in contributing to flooding of Barmah forest. It should be noted that the analysis assumes complete removal; any realistic scenario could only involve a partial modification of tributary flows. In fact, the problem of "how would the river behave if a tributary is changed?" is extremely complex because of effects of changing time of travel, and attenuation of flood peaks travelling downstream.

The results of Table 3 and Figure 3 show again that River Murray at Jingellic is the most important source of flooding. Removal of either the Ovens or the Mitta Mitta inflow has a clear but relatively short-lived influence, while removal of the Kiewa River flow has only a small influence on forest flooding. This main-stem Murray catchment contains a feasible site for a major dam, and it is likely that such a structure could have a severe effect on the flooding of the forest. We could detect

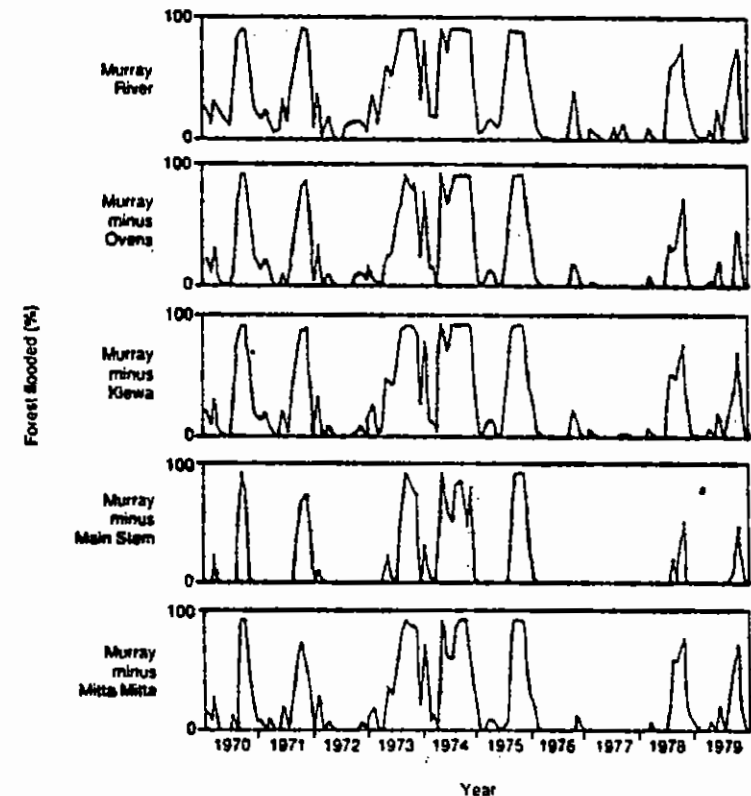


Figure 3. Computed sequences of the percentage of Barmah Forest flooded during the decade from the 1970-1980 with flows from major tributaries removed.

## MAJOR FLOOD FLOWS AND FOREST FLOODING

Major river floods in the vicinity of the forest occurred in the 1867, 1870, 1917, 1955-1956, and 1974-1975. The definition of a "major flood" is rather arguable; however after examination of the records we have used the criterion of a monthly mdf in excess of 150,000 ML day<sup>-1</sup> at Tocumwal. Based on the flood flow frequency curve presented by Anonymous (1986), flows in excess of this have probability of occurrence of about 0.05 in a given year. Figure 4 gives a direct comparison for such flood events between 1908 and 1982 at Tocumwal, including hydrographs and mdf's of the tributaries for the months containing the peak flows.

Floods can have their major source in either the Ovens, the Mitta, or the main stem, but no one particular source is consistently associated with these major floods. The June 1917 and May 1974 floods appear to have been dominated by the flows in the Ovens River, indicating that this can exert a very important short-term influence on the forest. That such dominance is not visible from the Mitta or the main stem probably reflects the proximity of the Ovens river inflow to the forest compared to these other sources.

## GOULBURN RIVER BACKWATER INFLUENCE ON BARMAH FOREST FLOODING

The Goulburn River joins the River Murray 40 km downstream of the forest. Generally, its behaviour has no influence on the forest. During River Murray floods most of the floodwaters pass down the Edward River system many kilometers to the north, leaving flow in the river Murray in the vicinity of the Goulburn confluence relatively small and within channel capacity (Bren *et al.*, 1987). At times of Goulburn River floods, much of the Goulburn water flows in an adjacent and effectively parallel stream system a few kilometers to the north of the main channel. This joins the River Murray and the Goulburn, it has been observed that the high water levels in the Goulburn lead to a "backwater effect" directly upstream of the junction. In this downstream flow is effectively blocked in the River Murray, leading to a rapid rise in water levels. When this occurs the disruption to River Murray flow may be so great that water actually flows from small tributaries entering near Barmah township "upstream" to the Edward River. Figure 5 shows two measured sequences of data illustrating the reduce channel flow at Barmah associated with high flows in the Goulburn. Local observations suggest that this phenomena occurred in 1916, 1931, 1956, 1974, 1975 and probably to a lesser extent in many other occasions. The effect appears substantially unrelated to the flow in the River Murray at Barmah but, rather, reflects the occurrence of unusually high water levels in the Goulburn River.

## CONCLUDING REMARKS

Clearly, the main stem of the River Murray is the major source of flood flows at Tocumwal, with other tributaries contributing variable amounts. This main stem is regulated substantially by the Hume dam. However, the possibility of this being further regulated additional large dams would be of considerable concern from the

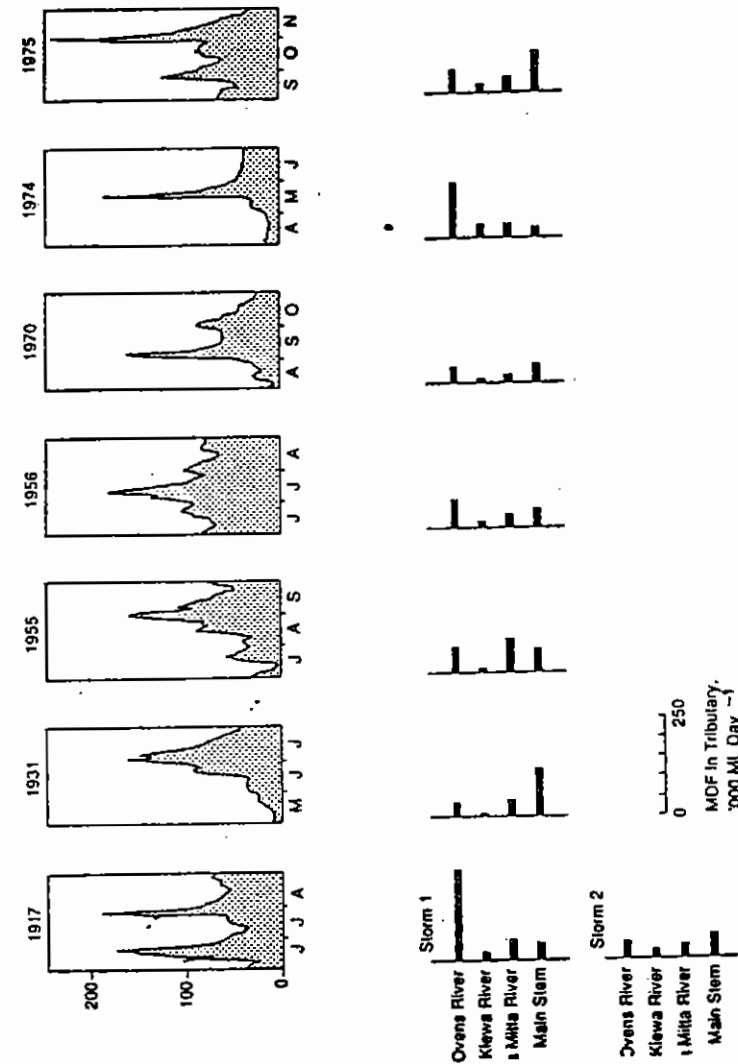


Figure 4. Hydrograph (at Tocumwal) of floods in excess of 150,000 ML/day for which daily flow data is available. The two peaks for 1917 are referred to as "storm 1" and "storm 2", respectively.

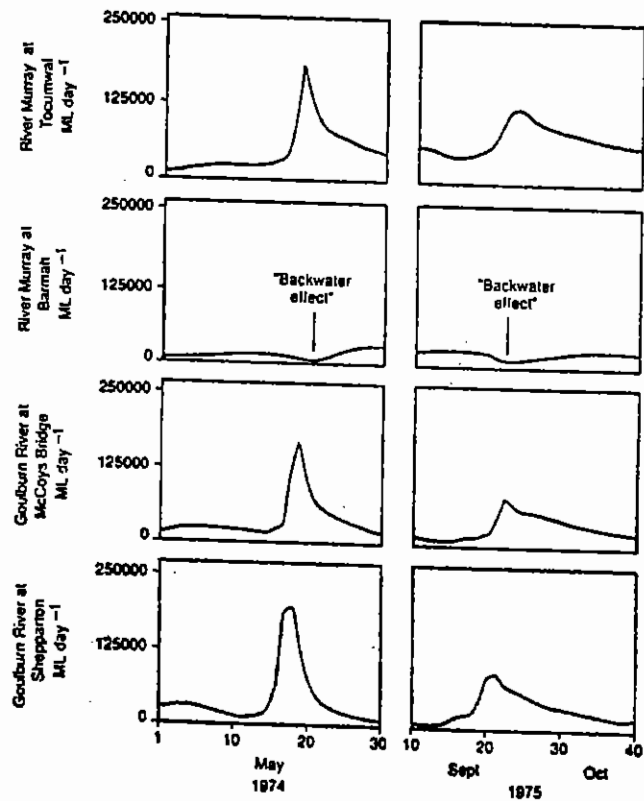


Figure 5. Two measured sequences of data showing the influence of a high flow in the Goulburn river on reducing the flow in the river Murray at Barmah.

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