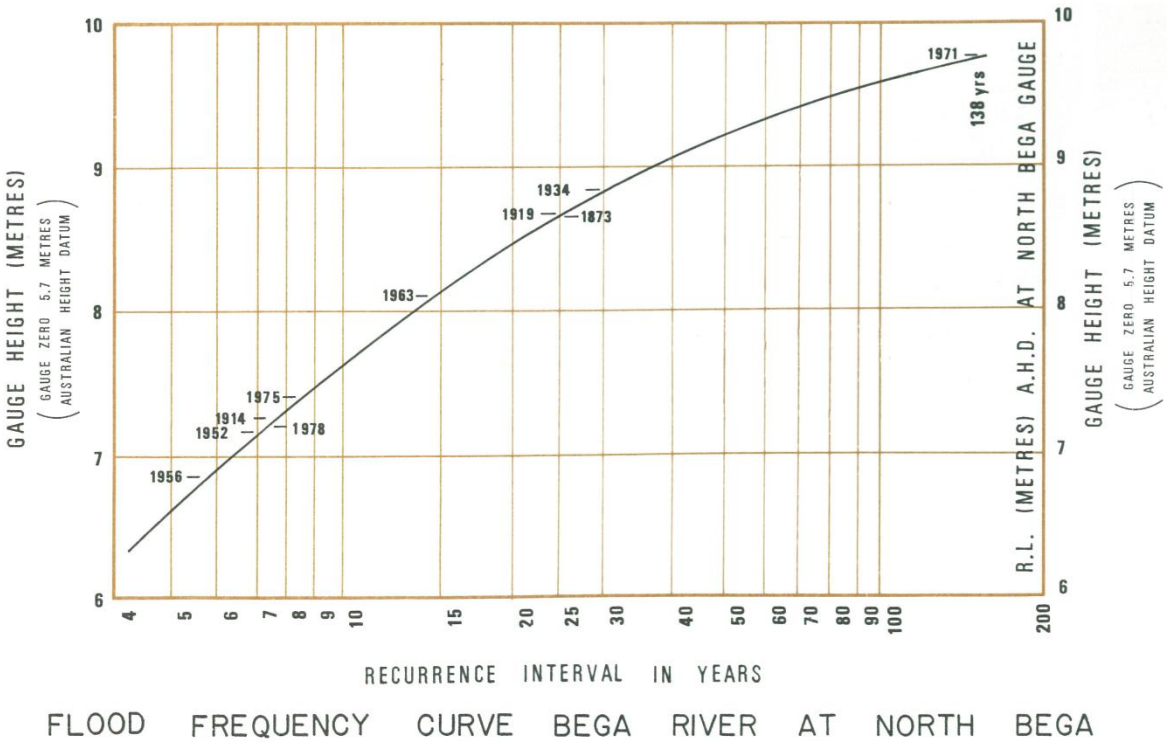
11 FLOOD FREQUENCY ANALYSIS

Australian Rainfall and Runoff (AR&R) recommends that the flood frequency analysis is carried out only for recorded flow data. In the absence of a rating curve that would convert observed flood levels to flows, a flood frequency analysis of water levels was undertaken by the Water Resources Commission (WRC) of NSW in 1979. The results of this analysis are shown in Figure 11.1. This analysis indicated that the 1971 flood event had an equivalent frequency of 138 year ARI. It should be noted that a number of assumptions were used in estimating historic flood levels for years for which the records were not available (refer to Figure 8.1).

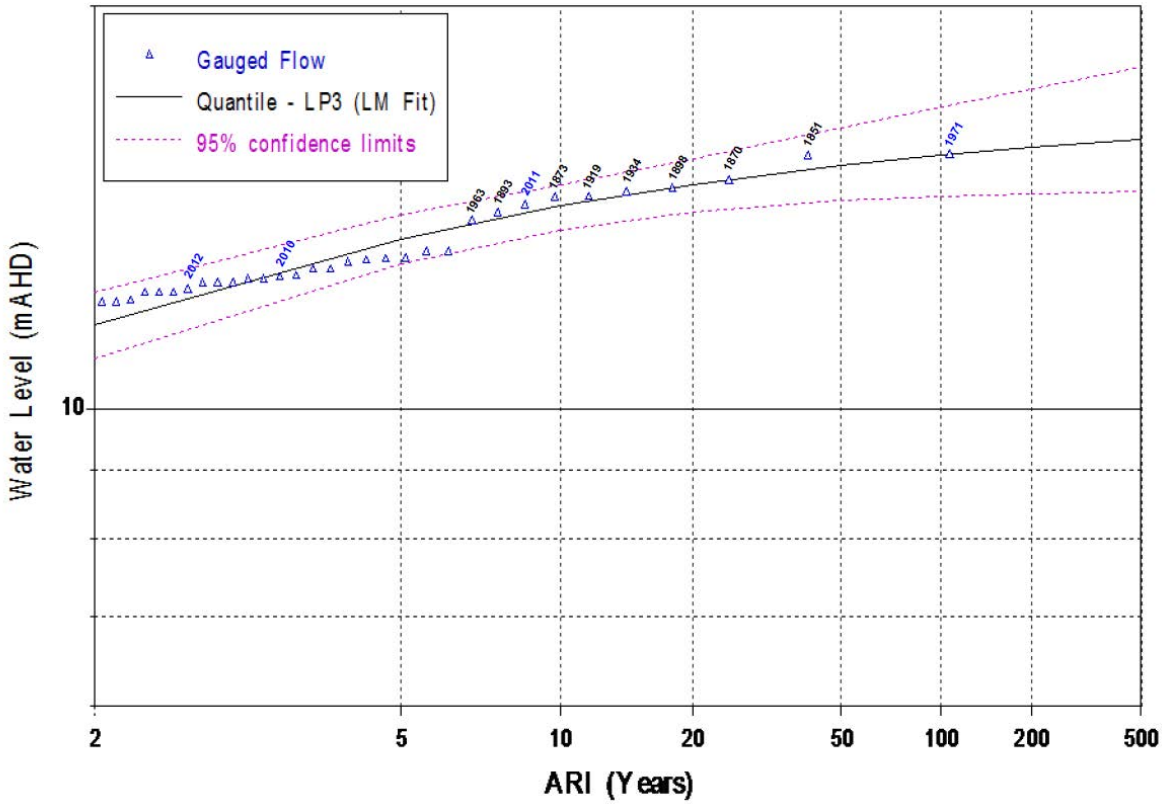
Figure 11.1: Flood Frequency Curve by WRC – Bega River at North Bega (WRC, 1979)



A revised flood frequency analysis for Station 219900 at North Bega was undertaken as part of this study based on current available data. The revised flood frequency analysis included an annual series analysis and a partial series analysis in line with guidelines in AR&R 1997, (Book IV, Section 2). The partial series analysis incorporated historic floods where a threshold depth of 3m was applied. A depth of 3m was chosen to include a significant number of medium to large sized events in the analysis while excluding many of the smaller, less significant events. The threshold depth of 3m resulted in 83 flood events being included in the partial series analysis.

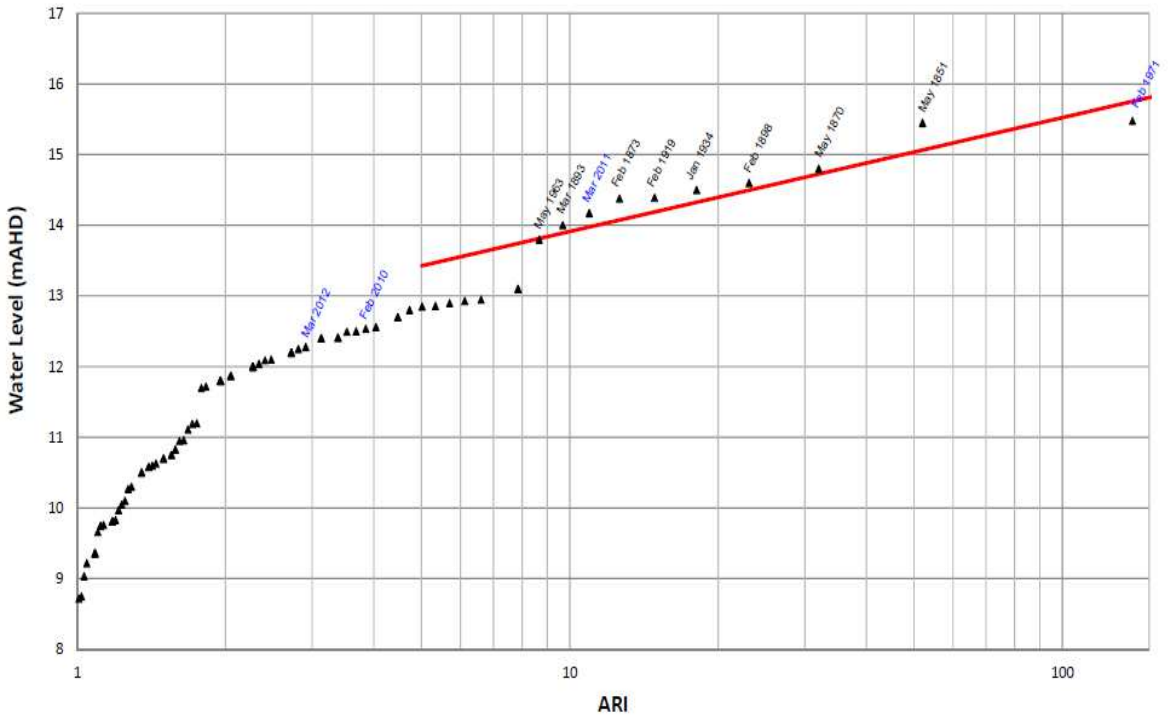
Since the partial series analysis can include multiple flood events in a given year (compared to a single maximum event in annual series analysis) the flood estimates from the partial series analysis is believed to be more appropriate, particularly in the medium to large flood events.

Figure 11.2: Flood Frequency Curve at Bega River – Annual Series Analysis*



Station 219900

Figure 11.3: Flood Frequency Curve at Bega River – Partial Series Analysis*



Station 219900

The analysis established the following ARI frequency for the observed recent major flood events of a potential interest for calibration of the models.

Table 11.1: Estimate of ARI of Recent Major Flood Events from Flood Frequency Analysis

Flood Event	Average Recurrence Interval (ARI) Years (based on plotting position)	
	Annual Series Analysis	Partial Series Analysis
February 1971	107*	139*
March 2011	8	11
February 2010	3	4
March 2012	3	3
March 1983	2	3

**Fitted estimate of February 1971 event from flood frequency analyses indicates approximately 100 year ARI*

Based on the fitted frequency curve the estimated flood levels at Bega for a range of design flood events are summarised in Table 11.2.

Table 11.2: Estimate of Design ARI Flood Level Based on Results from Flood Frequency Analysis

Average Recurrence Interval (ARI) Years	Water Level at Station 219900 (mRL* / mAHD)	
	Annual Series Analysis	Partial Series Analysis
5 (approx. 20% AEP)	7.7 / 13.4	7.7 / 13.4
10 (10% AEP)	8.5 / 14.2	8.2 / 13.9
20 (5% AEP)	9.0 / 14.7	8.7 / 14.4
50(2% AEP)	9.5 / 15.2	9.3 / 15.0
100 (1% AEP)	9.8 / 15.5	9.8 / 15.5

**Gauge 0.0 at 5.7m AHD*

The flood frequency was also assessed for the stations 219025, 219003, 219017, 219006, 219022 and 219001 (upstream of Bega) where flow data was available (refer Figure 6.2). The results at these stations are, however, significantly skewed due to the shortness of the recorded flow data sets and may not be a true representation of the frequency of recorded floods. It was noted that for these flood frequency analyses, the 2010 annual maximum peak value occurred in February for stations 219025, 219003 and 219017, while the annual maximum peak value for stations 219006, 219022, and 219001 occurred during May. For the purposes of the equivalent ARI of the February 2010 event, the February value was used for all flood frequency analyses in Table 11.3.

Table 11.3: Estimate of ARI for Historic Floods from Flood Frequency Analyses Using Annual Series Analyses

Station	Data Period	Average Recurrence Interval (ARI) Years (based on plotting position)				
		Feb 1971	Mar 2011	Feb 2010	Mar 2012	Mar 1983
219025	1977-2012	n/a	60	14	3	8
219003	1944-2012	115	43	3	3	27
219017	1967-2012	74	28	12	2	8
219006	1952-2012	100	38	2	2	23
219022	1972-2012	n/a	67	2	3	15
219001	1949-2012	40	2	2	2	5

These results show a significant variation of frequencies for the four historic events listed. This indicates a potential large variation in the spatial distribution of flows throughout the catchment. For example, the equivalent ARI of the February 1971 event varies from a 40 year ARI event based on the analysis from Station 219001 to a 115 year ARI from Station 219003. From the previous flood frequency analysis of water levels at Bega (Station 219900) the equivalent ARI gives the February 1971 event as having a 107 year ARI from the annual series and 139 year ARI from the partial series with a fitted quantile estimate of about 100yr ARI. Figures 11.4 to 11.9 show the curves from the flood frequency analyses of flows at the above flow gauging stations.

Table 11.4 shows the estimated gauge levels for various flood frequencies for the upstream gauge sites listed in Table 11.3. The gauge levels were estimated from the latest rating curve at each site, combined with discharges determined from flood frequency analysis.

Table 11.4: Estimate of Design ARI Gauge Flood Level Based on Results from Flood Frequency Analysis

Station	Data Period	Gauge Height for Average Recurrence Interval (ARI) Years				
		5	10	20	50	100
219025	1977-2012	6.5	8.2	9.6	11.0	11.8
219003	1944-2012	4.0	4.8	5.6	6.7	7.4
219017	1967-2012	3.8	4.9	5.8	6.8	7.6
219006	1952-2012	3.3	4.2	5.1	6.1	6.8
219022	1972-2012	2.6	3.6	4.9	6.8	8.5
219001	1949-2012	*	*	*	*	*

Note*: Rating curve provided for low flow only – insufficient to extrapolate to flood discharges

The results may also contain an additional degree of uncertainty due to potential variations in the flow rating curves established by limited gauging of relatively low flows and significant level of extrapolation in the high flow area. Details of the reliability of gauged rating curves are further discussed in Section 14.3.4. It is recommended that the Flood Frequency Analysis is further reviewed if the rating curves are revised by NSW Office of Water (NOW) in the future.

Figure 11.4: Flood Frequency Curve at Station 219025 – Brogo River @ Angledale

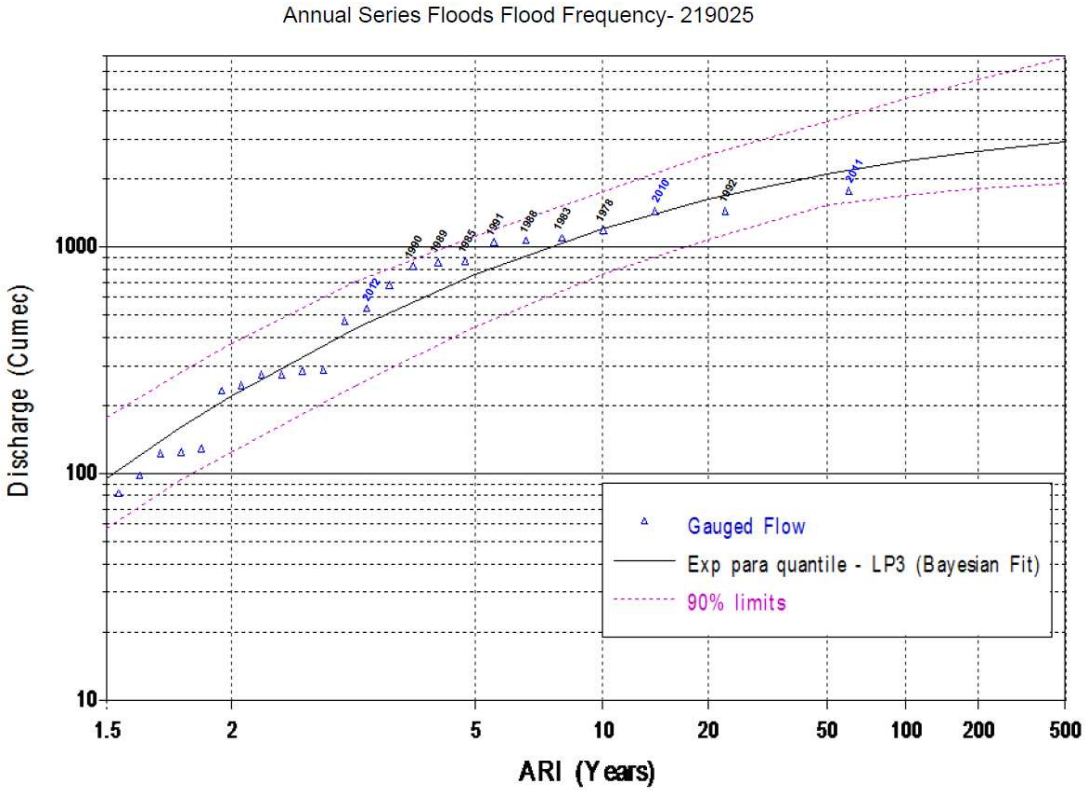


Figure 11.5: Flood Frequency Curve at Station 219003 – Bemboka River @ Morans Crossing

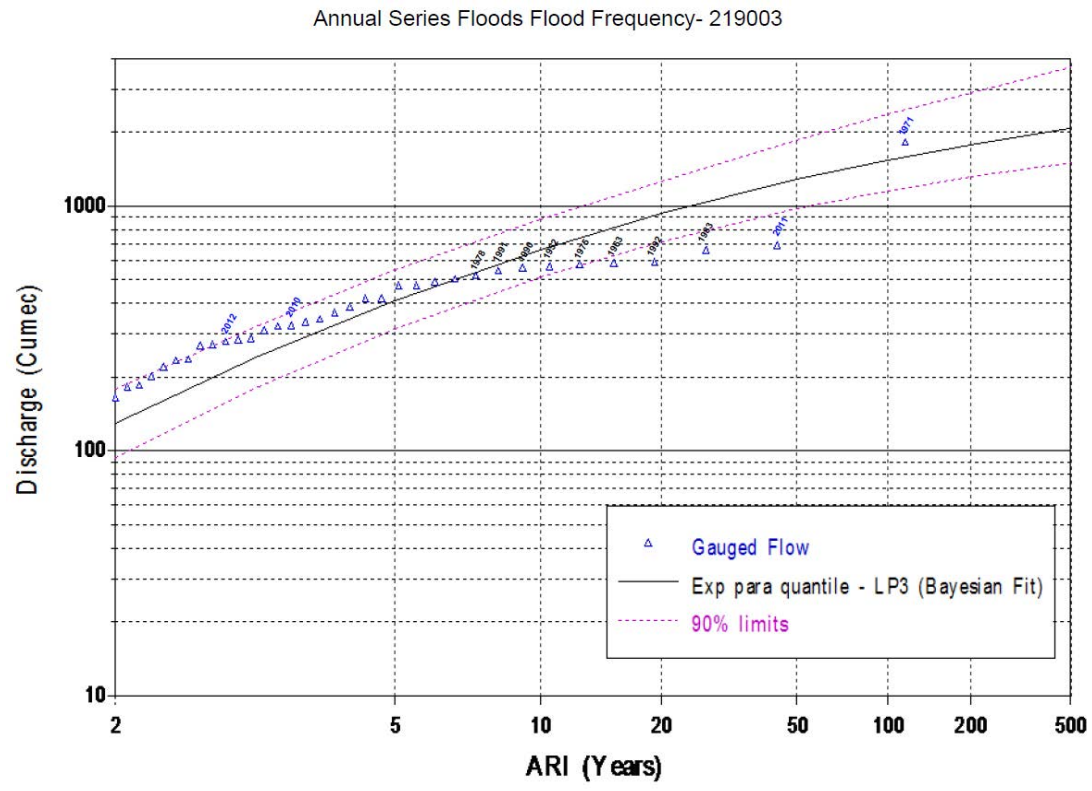


Figure 11.6: Flood Frequency Curve at Station 219017 – Double Creek near Brogo

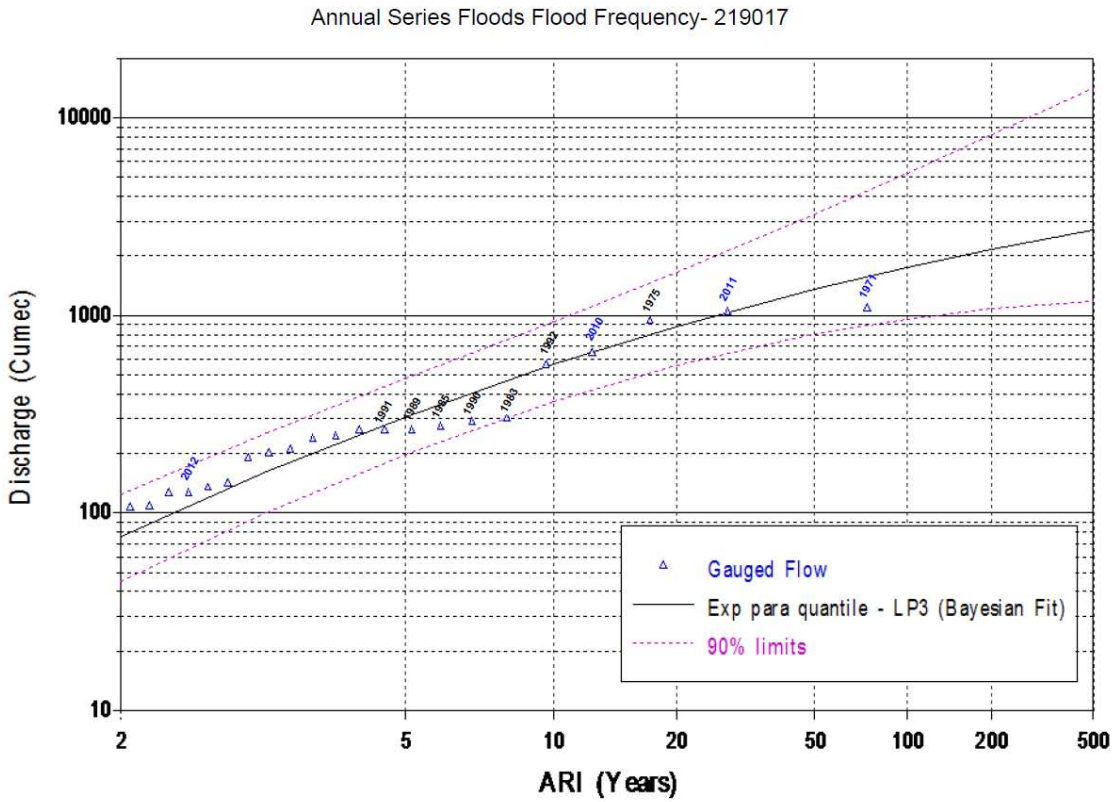
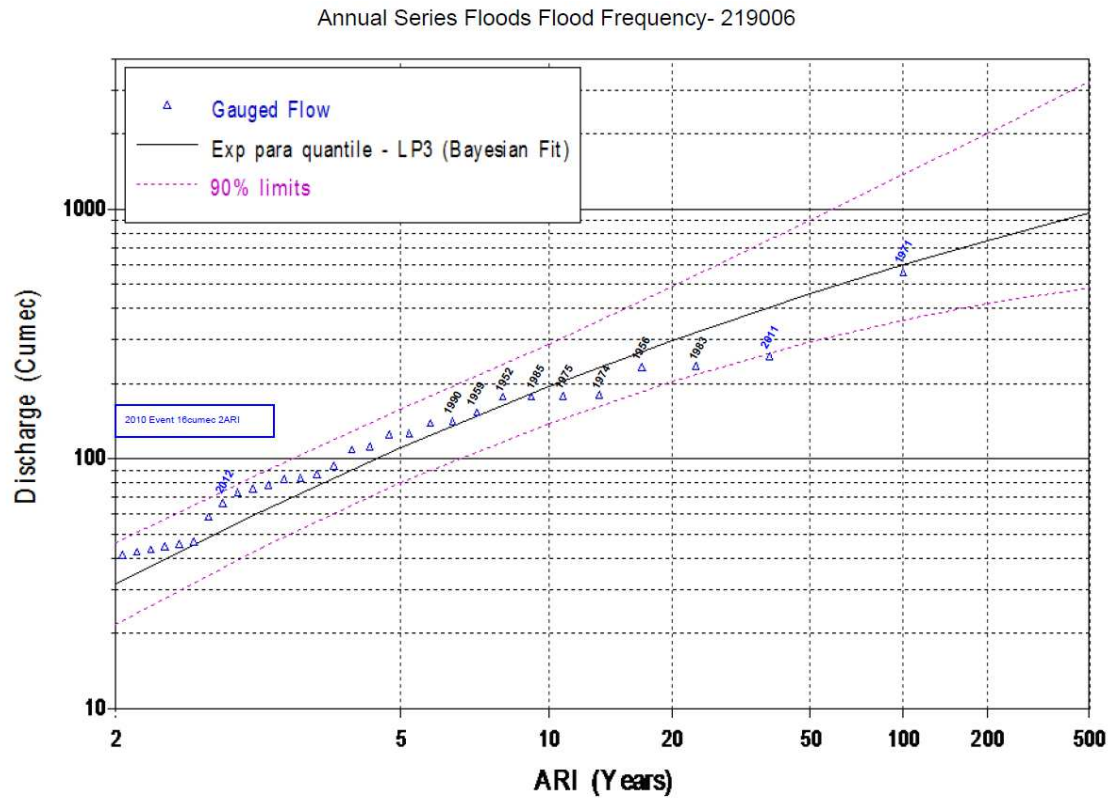
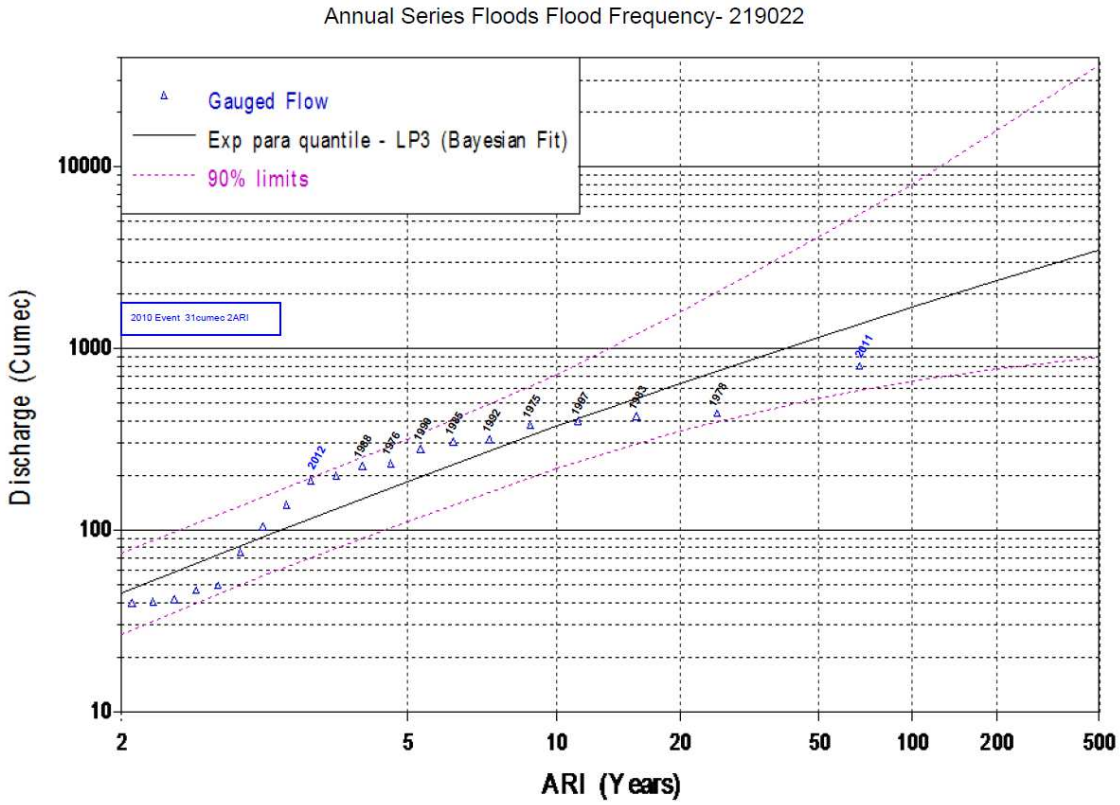


Figure 11.7: Flood Frequency Curve at Station 219006 – Tantawangalo Creek @ Tantawangalo*



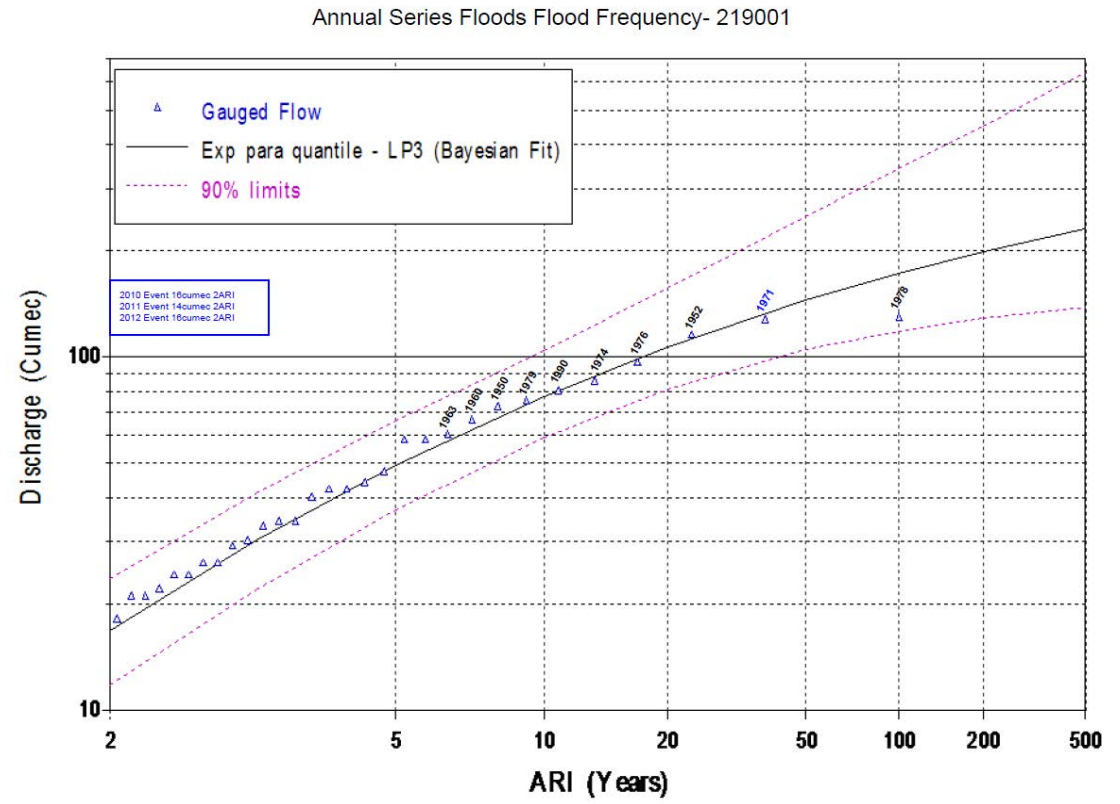
** February event used for 2010*

Figure 11.8: Flood Frequency Curve at Station 219022 – Tantawangalo Creek @ Candelo Dam Site*



** February event used for 2010*

Figure 11.9: Flood Frequency Curve at Station 219001 – Rutherford Creek @ Brown Mountain*



** February event used for 2010*

The ranking of the top 10 historic events from the partial series analysis at Bega (North Bye) is shown in Table 11.5 in order of decreasing peak water level. Also shown are the Feb 2010, Mar 2012, and Mar 1983 events.

Table 11.5: Top Ranked Historic Events Recorded at Station 219900 – Bega River at Bega (North Bye)

Rank	Event	Peak Gauged Height (m)	Peak Corresponding Water Level (mAHD)	Approximate ARI (by plotting position)	Approximate ARI (by fitted curve)
1	Feb 1971	9.78	15.48	139	94
2	May 1851	9.75	15.45	52	90
3	May 1870	9.10	14.80	32	36
4	Feb 1898	8.90	14.60	23	27
5	Jan 1934	8.80	14.50	18	23
6	Feb 1919	8.69	14.39	15	20
7	Feb 1873	8.68	14.38	13	20
8	Mar 2011	8.47	14.18	11	15
9	Mar 1893	8.30	14.00	10	11
10	May 1963	8.10	13.80	9	9
22	Feb 2010	6.84	12.54	4	1
29	Mar 2012	6.58	12.28	3	1
32	Mar 1983	6.50	12.20	3	1