RUFFORD PARK
RAINFALL STUDY

E J Stewart
A Report to Elliott and Brown
Consulting Engineers

Institute of Hydrology
March 1988

Rufford Park Rainfall Study

1. Background

The objective of the study was to assess the rarity of the storm that led to flooding near Rufford Park on 1 June 1983. The boundary of the Rufford Park catchment is shown in Figure 1 and the site of Maylodge Drive is indicated. It can be seen from Figure 1 that the main catchment incorporates the two subcatchments of Rainworth Water and Gallow Hole Dyke. The catchment area is approximately 70 sq km.

2. Availability of Data

Daily rainfall data were extracted from the rainfall library at the Institute of Hydrology for a 25 km x 25 km square study area approximately co-centred with the Rufford Park catchment. Twenty-three gauges were found to have data for the day of the storm, ie. the 24 hours ending at 0900 h on 1 June 1983. (Of these, seven were situated within or close to the catchment boundary - see Figure 1). In addition, three gauges with daily records of between 45 and 81 years in length were found to lie within the study area. Hourly data in the form of recording rain gauge charts were provided by Severn Trent Water for three gauges within the study area for the day of the event.

3. Analysis of Storm

The analysis focused on the storm which occurred over the study area in the early hours of 1 June 1983. The period from 1800 GMT on 31 May to 1200 GMT on 1 June was dominated by thunderstorms over the British Isles, with associated heavy rainfall occurring over large areas. Waves developed in an eastward-moving cold front, one of which caused particularly heavy rainfall over the eastern Midland counties. Rainfall accumulations were typically 10-15mm over a 6-hour period, with a small region in the range 20-25mm (Hand, 1984). Some of the daily gauges in the vicinity of Rufford Park recorded their highest 1-day rainfalls of the year on 31 May 1983.

The aim of the analysis was to attach a return period to the average areal rainfall estimated to have fallen on the catchment over the duration of the storm. Since the hourly gauges were not situated within the catchment boundary, the areal rainfall for the storm was estimated by applying the storm "profile" judged from two of the hourly gauges (122769 and 123376) to a best estimate of the catchment daily rainfall. The average rainfall profile expressed as a percentage of daily rainfall is given in Figure 2. The rainfall profile at gauge number 123712 was not used in the analysis since its shape was found to be inconsistent with the others, possibly indicating that it was affected by a different rainfall event. The catchment daily rainfall was calculated as a weighted mean of the daily rainfall totals recorded at the seven gauges shown in Figure 1, the weights being obtained by a method of reciprocal distances.

The catchment rainfall was thus calculated to be 28.9mm. Applying the storm profile from Figure 2, the storm duration was estimated to be 5 hours, with a corresponding catchment rainfall of 28.7mm.

4. Assessment of Rarity

4.1 INTRODUCTION

The standard technique for determining the return period of a given areal rainfall involves the derivation of point rainfall frequency curves, to which a relevant areal reduction factor (ARF) is applied (NERC,1975) to produce catchment rainfall frequencies. This methodology was adopted in the present study, and the analysis presented is concerned with both 1-day and 5-hour rainfalls.

4.2 POINT RAINFALL FREQUENCY

The Flood Studies Report (FSR) method (NERC, 1975) was used to derive curves of point rainfall frequency for 1-day and 5-hour durations applicable to the Rufford Park catchment. The values of M5 1-day and 5-hour point rainfalls were calculated to be 41.8 mm and 32.1 mm, respectively. The FSR growth curves for 1-day and 5-hour durations are given in Figure 3.

In order to verify the results, the 1-day FSR point rainfall frequency curve was plotted against two regional curves (Figure 4). In Figure 4, standardised rainfall refers to rainfall depth in mm divided by the mean of 1-day annual maximum point rainfalls. The curve labelled "GEV" was produced in the following way. Data from the three long-term gauges were analysed to produce time series of annual maximum daily rainfalls in the area of study (Annex 1). Following the procedure adopted in a recent study of regional storm hazard assessment (Dales and Reed, 1988) the three sets of annual maxima were combined into one. A General Extreme Value (GEV) distribution was fitted to the data using the method of probability weighted moments. The North East curve was derived by Dales and Reed (1988) in the same way using data from a number of gauges in North East England. From Figure 4 it can be seen that the forms of the two GEV-fitted curves are very similar. They also reflect closely the form of the FSR curve for return periods of less than 50 years.

4.3 AREAL RAINFALL FREQUENCY

Areal reduction factors for 1-day and 5-hour rainfalls relating to a catchment size of 70 sq km were taken from FSRII. The ARF for 1-day rainfalls was found to be 0.95, and that for 5-hour rainfalls to be 0.90. Thus, M5 catchment rainfalls were calculated for each duration as follows:

M5 1-day catchment rainfall = 41.8 x 0.95 = 39.7mm

M5 5-hour catchment rainfall = 32.1 x 0.90 = 28.9mm.

For each duration, expressing the actual catchment rainfall on 31 May 1983 as a proportion of the FSR M5 areal value gives the growth factor, and the corresponding return period can be read from the graph in Figure 3. In this way, the return periods of the catchment rainfalls of 1-day and 5-hour durations on 31 May 1983 were found to be 2 years and 5 years, respectively. A summary of the results is given in Table 1.

5. Additional Comments

Although the return period of the 5-hour storm has been calculated to be 5 years, this does not necessarily represent the return period of the flooding which occurred at Rufford Park as a result. It seems likely that the effect of the storm was exacerbated by the wet spring which preceded it. The 5-day antecedent precipitation index for the catchment was calculated using the FSR method to be 4.4mm. Also, the timing of the centroids of the hourly rainfall profiles gives an indication of the most likely direction of storm movement. It seems probable that the storm tracked down the main catchment, passing over the Gallow Hole Dyke tributary last, and this may have contributed to the extent of the flood in the area.

The significance of the contribution of the Gallow Hole Dyke subcatchment to the flooding at Rufford Park is unclear. It is possible that the peak response of Gallow Hole Dyke to a 5-hour storm would normally have passed ahead of that from the main Rainworth Water catchment. This aspect of the problem would require further investigation.

6. Summary

The return period of the 5-hour storm which occurred on 31 May 1983 is estimated to be 5 years.

7. References

Dales, M.Y., Reed, D.W. (1988) Regional flood and storm hazard assessment. Report No.102, Institute of Hydrology, Wallingford.

Hand, W.H. (1984) The severe weather during 31 May and 1 June 1983 - a case study using a numerical model. Met. Mag. 113, 1345:217-238.

Natural Environment Research Council (1975) Flood Studies Report. NERC, London.

TABLE 1. Summary of results

Duration	Estimated catchment rainfall (mm)	FSR M5 point rainfall (mm)	ARF	FSR M5 catchment rainfall (mm)	Return period of catchment rainfall (years)
1 day	28.9	41.8	0.95	39.7	2
5 hour	28.7	32.1	0.90	28.9	5

Figure 1 Map of the Rufford Park catchment showing the positions of the daily rain gauges used in the analysis.

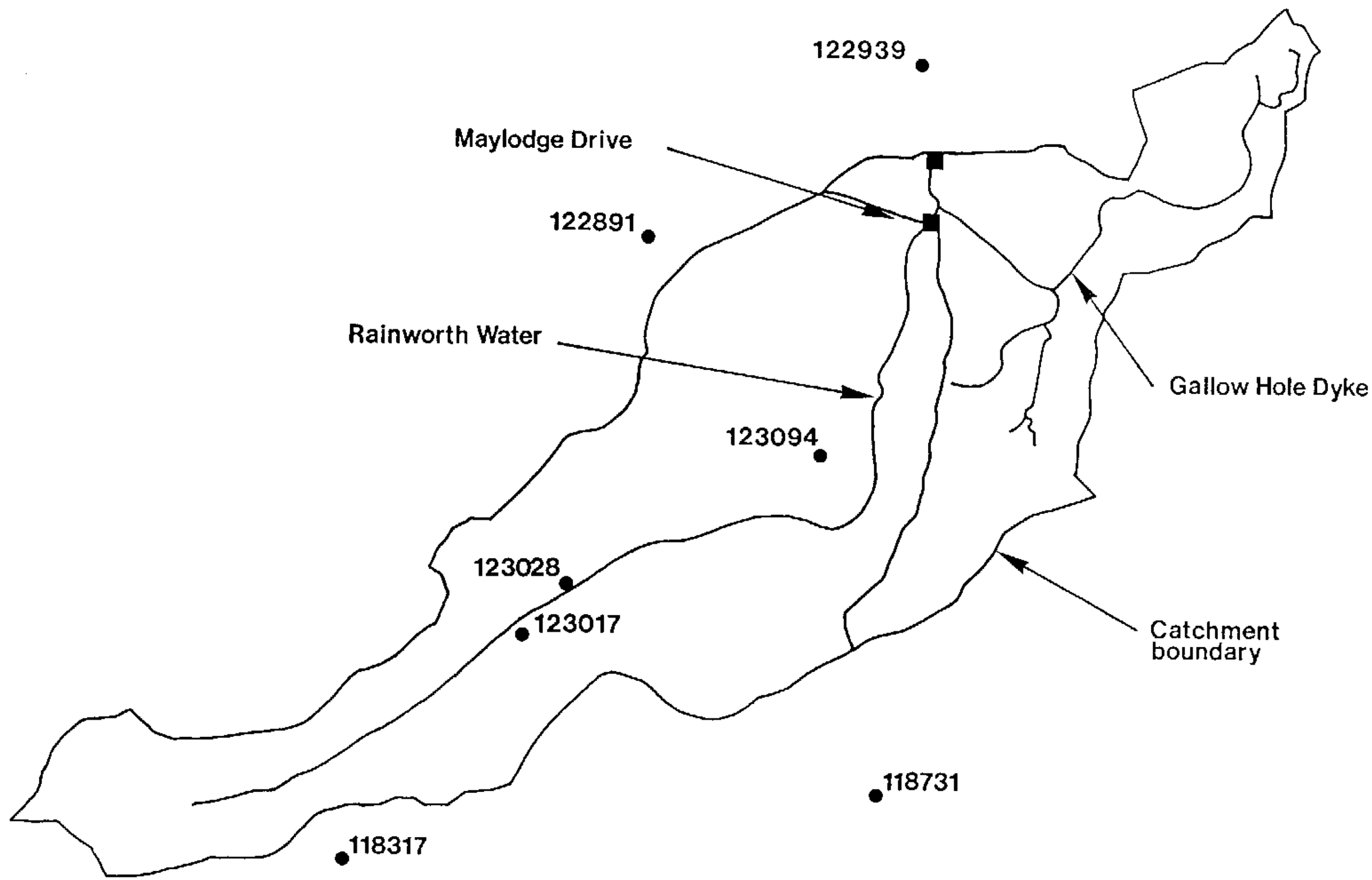


Figure 2 Average storm profile

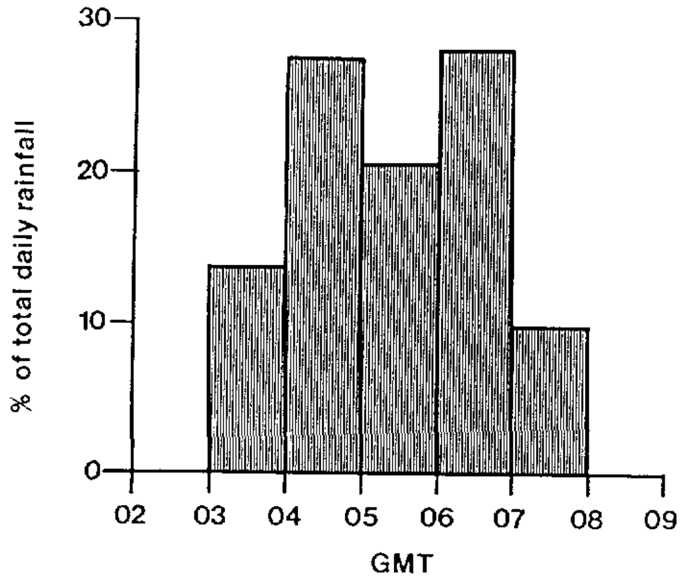


Figure 3 Rainfall growth curves for Rufford Park

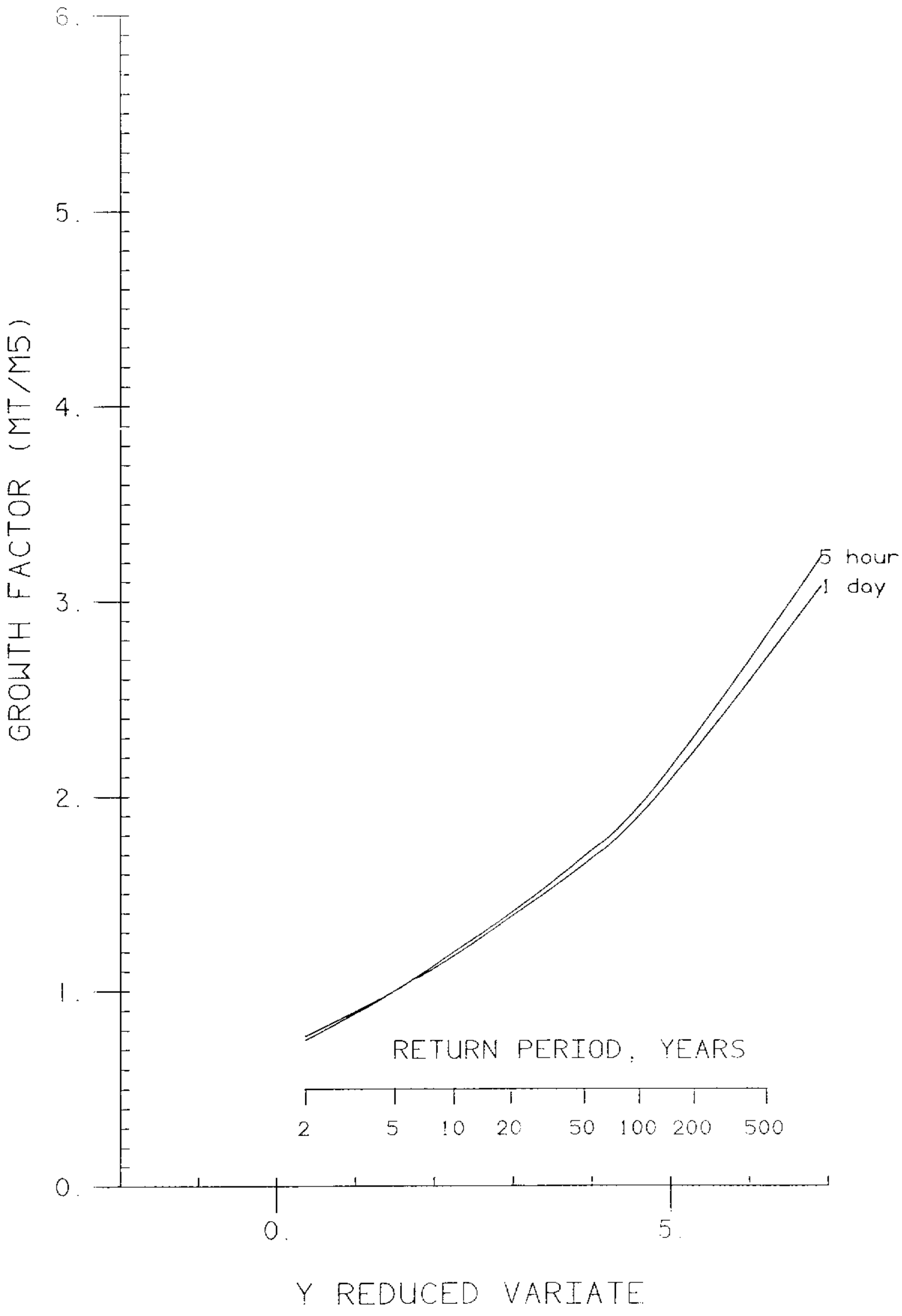
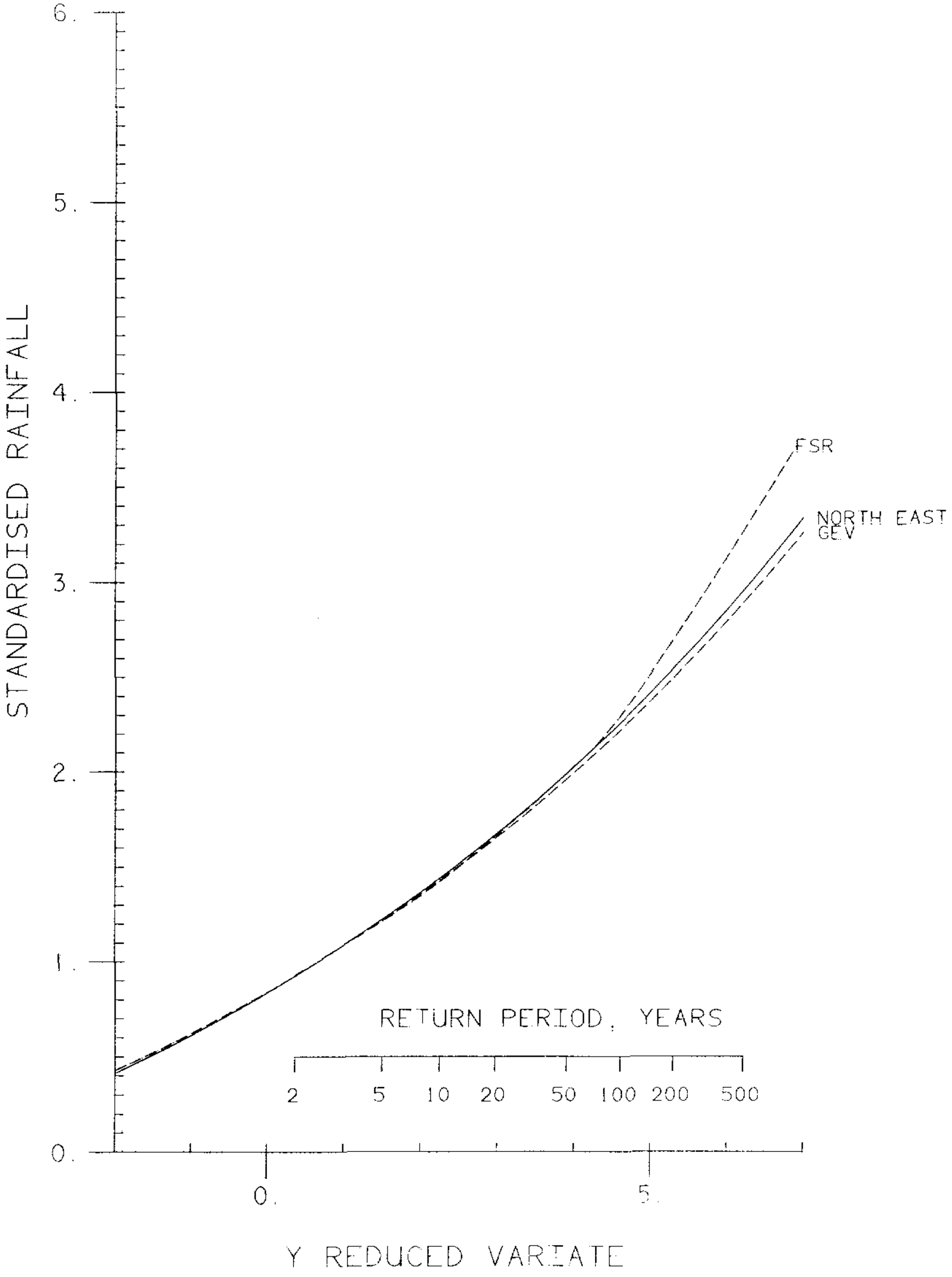


Figure 4 Comparison of 1 - day rainfall growth curves for Rufford Park



ANNEX 1

Time series of annual maximum 1-day rainfalls for the long-term gauges.

Year	Gauge Number 117430	122769	123017
1898	22.9(19 Oct)	-	-
1899	28.4(02 Oct)	-	-
1900	43.7(11 Jun)	-	-
1901	43.7(12 Dec)	-	-
1902	23.1(01 Dec)	-	-
1903	43.7(24 Aug)	-	-
1904	33.0(17 Aug)	-	-
1905	26.4(17 Jun)	-	-
1906	36.3(18 Oct)	-	-
1907	39.6(14 Aug)	-	-
1908	32.8(01 Jun)	-	-
1909	32.5(17 Aug)	-	-
1910	40.6(01 Dec)	-	38.6(01 Dec)
1911	28.4(24 Jun)	-	-
1912	51.3(21 Jul)	-	54.1(30 May)
1913	46.7(05 Oct)	-	47.2(05 Oct)
1914	25.9(09 Jun)	-	-
1915	-	-	51.8(16 Jul)
1916	30.5(18 Nov)	-	33.5(24 Feb)
1917	25.9(08 Aug)	-	38.9(08 Aug)
1918	21.3(04 Sep)	-	24.1(04 Sep)
1919	52.1(19 Mar)	-	34.3(19 Mar)
1920	37.6(03 Jul)	-	41.7(19 Feb)
1921	47.0(03 Oct)	-	49.5(03 Oct)
1922	69.1(06 Aug)	-	64.0(06 Aug)
1923	32.0(05 May)	-	25.4(05 May)
1924	28.4(21 Oct)	-	29.2(21 Oct)
1925	30.2(19 Sep)	-	30.5(19 Sep)
1926	18.5(01 Nov)	-	21.6(01 Nov)
1927	34.3(22 Oct)	31.2(14 Sep)	30.5(23 Oct)
1928	26.2(10 Oct)	28.2(27 Oct)	34.8(10 Oct)
1929	30.7(11 Nov)	34.8(05 Oct)	32.5(11 Nov)
1930	30.5(20 Jul)	49.3(20 Jul)	39.6(20 Jul)
1931	59.7(03 Sep)	64.5(03 Sep)	72.1(03 Sep)
1932	57.9(13 Jul)	61.7(21 May)	58.4(21 May)
1933	35.8(10 Oct)	48.3(10 Oct)	55.6(10 Oct)
1934	21.3(13 Jul)	18.0(09 Nov)	18.5(09 Nov)
1935	56.4(14 Jul)	24.9(23 Aug)	30.2(15 Nov)
1936	29.2(07 Jul)	27.2(07 Jul)	25.4(07 Jul)
1937	32.0(23 Oct)	36.3(02 Dec)	31.8(15 Jul)
1938	28.4(11 Aug)	27.7(03 Oct)	30.0(03 Oct)
1939	22.1(25 Jan)	23.4(25 Jan)	27.4(17 Jul)
1940	34.0(16 Oct)	32.5(31 Oct)	30.5(16 Oct)

Year	Gauge Number 117430	122769	123017
1941	29.7(23 Aug)	25.7(07 Mar)	29.5(09 Oct)
1942	28.4(04 Mar)	25.4(10 May)	26.2(04 Mar)
1943	24.9(29 May)	29.2(29 May)	23.4(29 May)
1944	46.7(19 Aug)	22.9(19 Aug)	29.2(27 Feb)
1945	20.8(14 Jul)	20.6(11 Oct)	-
1946	23.9(10 Aug)	34.5(19 Aug)	31.2(19 Aug)
1947	30.5(12 Mar)	21.8(10 May)	22.9(10 May)
1948	39.1(30 Dec)	23.6(12 Sep)	42.7(30 Dec)
1949	37.8(15 Jul)	35.1(15 Jul)	40.1(15 Jul)
1950	22.4(24 Feb)	20.8(30 Sep)	21.8(15 Jul)
1951	44.7(06 Aug)	37.3(06 Aug)	69.6(06 Aug)
1952	29.7(01 Jul)	24.6(13 Oct)	31.5(05 Jun)
1953	28.4(12 Oct)	23.6(12 Oct)	24.1(12 Oct)
1954	30.2(20 Aug)	25.4(05 Nov)	35.8(07 Jun)
1955	34.0(17 May)	31.0(17 May)	25.4(25 Mar)
1956	26.4(08 Jun)	25.9(02 Sep)	24.1(08 Jun)
1957	37.1(25 Sep)	38.1(08 Aug)	42.4(08 Aug)
1958	31.2(10 Aug)	50.5(01 Jul)	38.4(01 Jul)
1959	24.1(16 Apr)	31.7(16 Apr)	24.9(16 Apr)
1960	49.0(04 Oct)	40.1(03 Dec)	42.4(03 Dec)
1961	26.2(12 Jul)	23.1(29 Dec)	30.5(26 Apr)
1962	28.4(06 Aug)	33.3(06 Aug)	16.4(06 Aug)
1963	53.3(06 Jul)	20.8(03 Jul)	26.2(01 Sep)
1964	45.5(14 Mar)	39.4(14 Mar)	45.2(14 Mar)
1965	26.4(22 Dec)	28.4(21 Jun)	31.2(21 Jun)
1966	28.2(21 Aug)	22.6(21 Aug)	26.7(21 Aug)
1967	42.7(16 Oct)	43.9(16 Oct)	41.4(14 May)
1968	42.7(10 Jul)	61.0(14 Jul)	45.5(14 Jul)
1969	47.5(16 Nov)	49.3(28 Jul)	-
1970	28.4(12 Apr)	36.3(19 Aug)	-
1971	68.4(04 Jul)	41.0(23 Apr)	-
1972	46.4(08 Sep)	-	-
1973	40.0(15 Jul)	-	39.7(19 Jun)
1974	22.9(04 Jul)	-	23.1(20 Nov)
1975	36.4(01 Dec)	-	38.1(01 Dec)
1976	-	-	35.2(24 Sep)
1977	33.5(01 Nov)	-	28.0(01 Nov)
1978	36.4(15 Jun)	-	40.7(16 Jun)
1979	37.7(13 Aug)	-	33.0(25 Oct)
1980	25.5(16 Oct)	-	28.8(07 Aug)
1981	-	-	29.7(24 Apr)
1982	-	-	45.1(22 Jun)
1983	-	-	28.1(31 May)