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1983/008

Estimation of return period of December 1979 flood peak on Tawe catchment

A) ANALYSIS OF YNYS TANGLWS RECORD

1) A list of annual maximum flows (Table 1) was presented by the client. The origin of these values has not been discussed with Welsh WA but it is understood that they conform to latest views on rating curves for the station.

2) From comparison with data already held at IH, it appears that Table 1 relates to calendar year flow maxima rather than water year data. This divergence from normal practice is thought to be fairly trivial in the context of the present study.

3) Examination of river level charts held on microfilm at IH revealed that flood events prior to 1973 were not well recorded. Hydrographs were truncated, or otherwise unnatural, above a level of about 3 metres. Contemporary notes on the station indicate that bypassing occurred upstream of the gauging station, floodwater passing into the Fendrod system.

4) Subsequent discussion with Welsh WA indicates that the problem was rectified by raising of banks carried out in about 1972/73. The river level hydrograph for the December 1979 event (Fig. 1) shows little evidence of truncation. It is possible that the change of gradient at about 3.4 metres was influenced by hydraulic conditions upstream or downstream of the gauging station; however, comparison with the corresponding hydrograph recorded on the well gauged Rhondda catchment (approx. 30 km ESE) suggests that the overall shape of the Tawe hydrograph is not unreasonable.

5) The precise origin of the flows in Table 1 has not been verified with Welsh WA. They appear to conform to a rating equation of the approximate form:

$$q = 17.5\ h^{2.2} \qquad (1)$$

where q is flow in cumecs and h is river level in metres. When

compared to the "Table K" rating used by the Water Data Unit to process Tawe river level data in the period from November 1977:

$$q = 14.378\ h^{2.367} \qquad (2)$$

Equation 1 yields higher flows for the commoner flood peaks ($h < 3.25$m) but lower flows for extreme river levels such as the 4.328 m recorded in the December 1979 event. It is understood that the rating equations are based on current meter measurements up to a stage of 1.88 m. Thus the validity of either equation to estimate extreme flood flows is very much dependent on extrapolation.

6) From 3 and 4 above it is concluded that the flow record prior to 1973 should be discarded and a statistical analysis made of the remainder of the record. With such a short period of record a peaks over threshold (POT) analysis is to be preferred to an annual maximum analysis. However, this would have taken considerable time and required close inspection of the river level charts.

7) Analysis of the nine annual maxima (Table 1) for the period 1973 to 1981 yields a mean annual flood, $\bar{Q}$, of:

$\bar{Q}$ = 238 cumecs

This provides only a very rough estimate (coefficient of variation 0.35). The presence of the 1979 event in such a small sample is likely to bias the estimate. If, for example, the highest and lowest annual maxima (1979 and 1978 respectively) are excluded, a somewhat lower estimate results:

$\tilde{Q}$ = 223 cumecs

8) Using the $\bar{Q}$ estimates derived above, the flood growth factor for the December 1979 flow of 432 cumecs is variously:

432/238 = 1.82 or 432/223 = 1.94

Comparison with the region 9 (Welsh) growth curve given in the Flood Studies Report (see page 14 of the guide) indicates that these

factors correspond to return periods of:

35 years and 50 years

respectively.

B) INDEPENDENT ASSESSMENT FROM RAINFALL

Flood studies Supplementary Report No. 12 (FSSR 12) provides a means of assessing the return period of a notable event largely from rainfall information. It is primarily intended for use where no flow data are available but, in the circumstances faced here, provides a useful "second opinion". The method is, of course, only approximate.

Following the procedure described in FSSR 12, an estimate of the return period of the December 1979 event on the Tawe is about 25 years. (See Appendix for details).

C) SUMMARY OF CONCLUSIONS

From the above assessments it is concluded that a reasonable estimate of the return period of the December 1979 event on the Tawe is 35 years. It is suggested that the true return period of the December 1979 flood peak is more likely to be within the range 25 to 50 years than without; however, this belief is intuitive and the range quoted should be taken only as a guide to the considerable uncertainty inherent in assigning return periods to particular extreme events in the absence of a long term flow record.

D) RECOMMENDATIONS

If desired, a more thorough assessment could be made by:

(i) visiting the site

(ii) discussing the Ynys Tanglwys flow record with Welsh WA (especially with regard to rating curves).

(iii) extracting independent flow peaks over a threshold (eg. greater than 2.5 metres river level) for the valid period of record.

(iv) carrying out a peaks over threshold (POT) statistical analysis

to arrive at a broader based estimate of $\bar{Q}$.

(v) comparing the Tawe POT analysis with that of a nearby gauging station with a longer and higher quality record (eg. The Rhondda at Trehafod).

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TAWE @ YNYSTANGLWS (1957 - 1981)

ANNUAL	MAXIMA
1957	207.70
1958	286.54
1959	215.74
1960	273.31
1961	186.11
1962	255.03
1963	183.14
1964	256.83
1965	273.31
1966	215.74
1967	302.11
1968	222.30
1969	160.34
1970	278.94
1971	267.75
1972	232.36
1973	235.77
1974	196.73
1975	230.66
1976	157.40
1977	225.63
1978	148.28
1979	432.40
1980	272.00
1981	245.64

cubic metres per second

$\bar{Q}$ = 238 cumecs.

TABLE 1 CALENDAR YEAR ANNUAL MAXIMUM FLOWS

Punched Tape reading O. Ras RIVER — Tawe 26th-28th December 79

1:123 GAUGING STATION:— Ynystanglws

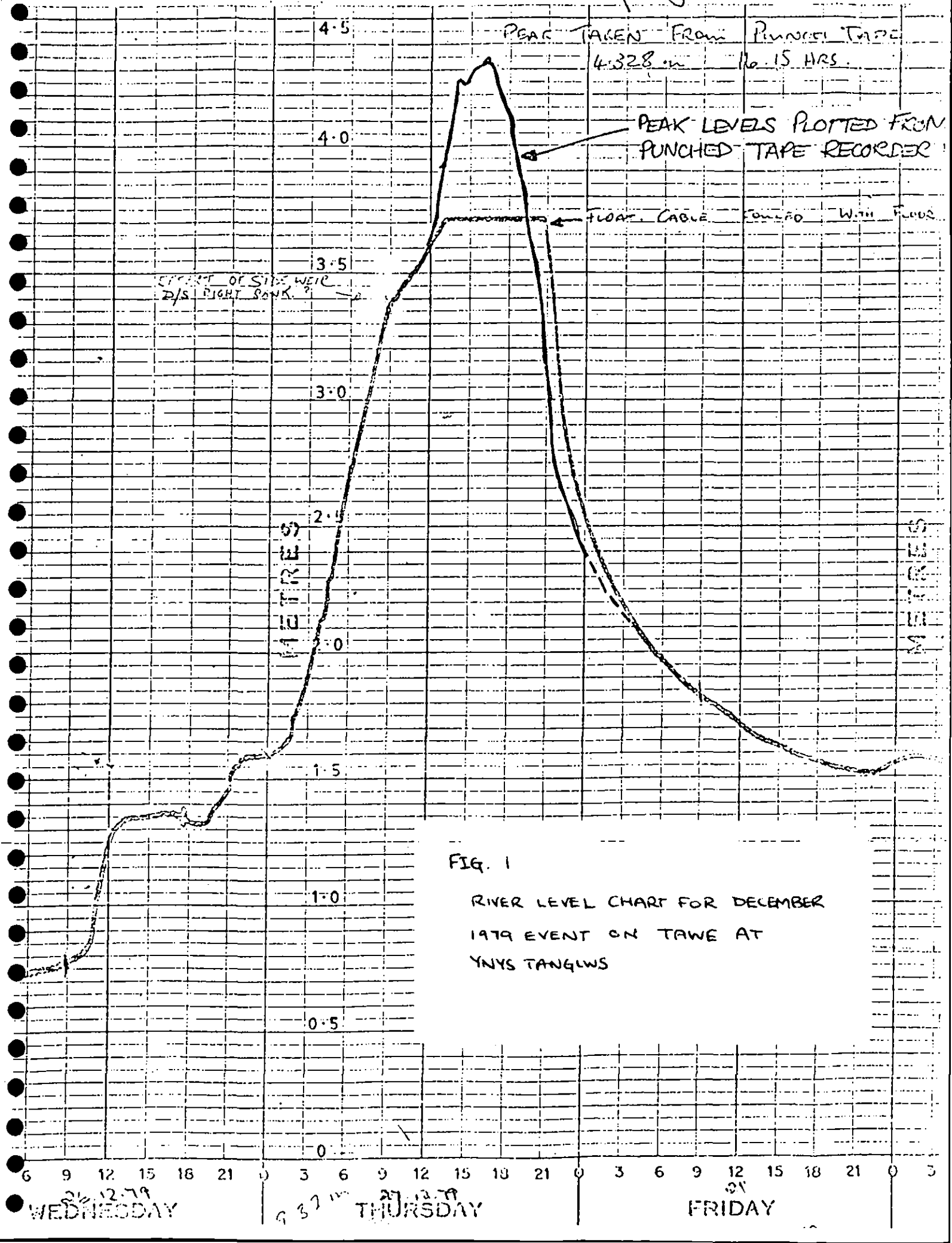

FIG. 1

RIVER LEVEL CHART FOR DECEMBER 1979 EVENT ON TAWE AT YNYS TANGLWS

APPENDIX

Assessment of return period using FSSR12 approach for December 1979 event on Tawe at Ynys Tanglws.

Stage 1 (i) Catchment characteristics (from maps):

AREA 227.5 km^2 ; MSL 36.2 km

S1085 9.6 m/km

SAAR 1840 mm

M5-2D 98.6 mm

r 0.22

SOIL 0.47 (30% type 3, 70% type 5)

URBAN 0.025

(ii) Calculation of RSMD

M5-24hr / M5-2D = 0.803

M5-24hr = 79.2 mm

M5-1D / M5-24hr = 1/1.11

M5-1D = 71.3 mm

SMDBAR = 2.4 mm

ARF = 0.925

RSMD = ARF M5-1D − SMDBAR

= 0.925 × 71.3 − 2.4

= 63.6 mm

(iii) Evaluation of Tp and design storm duration D

$$Tp = 4.66\, MSL^{0.14}\, S1085^{-0.38}\, (1+URBAN)^{1.99}\, RSMD^{-0.4}$$

= 5.90 hr

D = (1 + SAAR/1000) Tp = 2.84 × 5.9 = 16.8

say, D = 17 hr (A data interval of 1 hour is then adequate)

(iv) Calculation of storm rainfall depths, P

r = 0.22 and M5-2D = 98.6 ⇒

M5-17hr / M5-2D = 0.71

M5-17 hr = 70.0 mm

D = 17 and AREA = 227.5 ⇒ ARF = 0.915

Flood peak return period	Rainfall* return period	MT/MS growth factor	MT	P (= MT.ARF)
2.33	2	0.805	56.4	51.6
5	8	1.105	77.4	70.8
10	17	1.26	88.2	80.7
25	43	1.46	102.2	93.5
50	81	1.62	113.4	103.8
100	140	1.77	123.9	113.4

(v.) Calculation of percentage runoffs, PR

SPR = 95.5 SOIL + 12 URBAN = 45.2

For SAAR = 1840, design CWI = 125

PR = SPR + 0.22(CWI − 125) + 0.1(P − 10)

= 45.2 + 0.1 (P − 10)

Flood peak return period	P	0.1(P−10)	PR
2.33	51.6	4.2	49.4
5	70.8	6.1	51.3
10	80.7	7.1	52.3
25	93.5	8.3	53.5
50	103.8	9.4	54.6
100	113.4	10.3	55.5

(vi.) Calculation of flood peaks using shortcut described in FSSR 9.

D/Tp = 17/5.90 = 2.88 ⇒ RC = 0.418

D = 17, AREA = 227.5

$$q = RC\left(\frac{PR}{100}\right)\left(\frac{P}{D}\right)AREA = 5.594\,\frac{PR}{100}\,P$$

Baseflow allowance: ANSF = (0.00074 RSMD + 0.00033(CWI − 125) + 0.003) AREA

= 11.4 cumecs

FOOTNOTE: * Adoption of a disparate rainfall return period is part of the design package being used, not a general rule

Flood peak return period	PR	P	q	q + ANSF
	100			
2·33	·494	51·6	142·6	154
5	513	70·8	203·2	215
10	523	80·7	236·1	247
25	535	93·5	279·8	291
50	·546	103·8	317·0	328
100	·555	113·4	352·1	364

Stage 2 (i) API5 at 09.00 on 26 December 1979 = 4·7
(Ynys Cedwyn House raingauge)

API5 at start of heavy rainfall (02.00 on 27/12/79)
= 18·4

SMD = 0 CWI = 125 − SMD + API5 = 143·4

(ii) Duration of heavy rainfall taken from Glyntawe raingauge as 17 hr (02.00 – 19.00). Thus duration is as for design case (Stage 1).

(iii) Profile of storm taken from Glyntawe raingauge (see computer listing)
P = 86·7

(iv) Depth of storm deduced from Glyntawe raingauge profile and Ynys Cedwyn House 2-daily total for 26/27 December 1979. This assumes that catchment average 2-day rainfall was 110 mm (as per Ynys Cedwyn House); Fig 2 attached suggests that this is a reasonable estimate given that the Tawe raingauges are located in the valley.

(v) Construction of the triangular unit hydrograph (Tp = 5.90 hr, AREA = 227·5 km²) as per computer listing.

(vi) Percentage runoff synthesised as
PR = SPR + 0·22(CWI − 125) + 0·1(P − 10)
= 45·2 + 4·0 + 7·7 = 56·9

(vii) Convolution of rain and unit hydrograph as per computer listing. Percentage runoff applied afterwards.

(viii) Addition of antecedent flow (baseflow) at beginning of heavy rainfall : 43·7 cumecs yields a peak flow of:

253 + 44 = 297 cumecs *

Stage 3 Comparison of peak flow synthesised for December 1979 event (Stage 2) with the design peak flows synthesised for various return periods (Stage 1) indicates a return period of about 25 years. *

DISCUSSION

The rainfall experienced on the Tawe catchment (86·7 mm in 17 hr.) was not all that extreme. The above method allows for the fact that this heavy rainfall occurred at a time when the catchment was already very wet.

A close study of the attached 2 day rainfall values (Fig. 2) indicates that rainfall totals were up to 50% higher on some catchments to the NE and SE, notably in the Rhondda, Cynon and some of the headwaters of the Usk. Thus the above calculation does not indicate that the December 1979 storm was generally a 25 year return period event in SE Wales.

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* FOOTNOTE:

Close reading of FSSR 12 is required to understand the basis of this return period assessment. That the rainfall/runoff method yields a flow estimate (297 cumecs) significantly lower than the gauged value (432 cumecs) is immaterial. The FSSR 12 procedure provides a return period assessment that is independent of the Ynys Tanglwst flow record.

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04/Jul/83 13:36 dwr LPT

```
*OLD /UFPROGS/CONVOL
*RUN

HOW MANY NET RAINFALL VALUES ?
=17

ENTER NET RAINFALL VALUES IN MM/HR
=2.8 2.2 3.1 3.1 5.9 9.6 7.9 7.5 9.9
=9.7 7.8 5.2 2.7 2.1 2.8 2.5
=1.9

HOW MANY NON-ZERO U.H. ORDINATES ?
=14

ENTER NON-ZERO U.H. ORDINATES AS PROPORTIONS
=14.4 28.7 43.1 57.5 71.9 83.9 74.4 65.0 55.6 46.2 36.7 27.3 17.9 8.5
```

INDEX	RAIN MM/HR	U.H.	RUNOFF cumecs
1	2.800	14.400	40
2	2.200	28.700	112
3	3.100	43.100	226
4	3.100	57.500	389
5	5.900	71.900	635
6	9.600	83.900	1012
7	7.900	74.400	1437
8	7.500	65.000	1916
9	9.900	55.600	2463
10	9.700	46.200	3070
11	7.800	36.700	3639
12	5.200	27.300	4058
13	2.700	17.900	4330
14	2.100	8.500	4447
15	2.800	0.	4372
16	2.500	0.	4132
17	1.900	0.	3762
18	0.	0.	3304
19	0.	0.	2814
20	0.	0.	2332
21	0.	0.	1878
22	0.	0.	1480
23	0.	0.	1019
24	0.	0.	702
25	0.	0.	473
26	0.	0.	316
27	0.	0.	205
28	0.	0.	120
29	0.	0.	55
30	0.	0.	16

56.9% of 4447
= 253 cumecs

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HOW MANY NET RAINFALL VALUES ?
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