Indian Journal of
METEOROLOGY & GEOPHYSICS

January 1965
Vol. 16 No. 1

551·577·627·

A brief study of Rainfall and flood producing Rain Storms in the Beas Catchment (upto Pong)

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(*Received 6 December 1963*)

ABSTRACT. Mean monthly and annual rainfall for the Beas Catchment based on 1950 rainfall normals have been worked out by isohyetal method. Frequencies of heavy falls of rain of 3 inches and above at eight selected raingauge stations inside the catchment whose data are available for the last 60 years have been worked out. The highest 24-hour rainfall amounts recorded during the four months (July to October) at 17 raingauge stations within the catchment have also been presented after examining their available daily rainfall data. Peak discharge data at Pong dam site for years from 1935 to 1960 were also examined and rain spells corresponding to major floods have been analysed by depth-duration method. On the basis of this analysis design storm rainfall depths have been worked out which have also been maximised for moisture charge.

1. Introduction

River Beas rises on the southern slopes of the Rohtang pass (13,050 ft) in the Pirpanjal range of the Western Himalayas. Its Himalayan catchment of 5600 sq. miles is bounded by the catchments of three main rivers of the Punjab, *viz.*, Chenab, Ravi and Sutlej. In the north and northeast high mountain ranges whose elevation varies from 12,000 to 16,000 ft separate it from Ravi and Chenab basins. In the south and southeast it is separated from Sutlej valley by comparatively lower ranges. On the basis of the Himalayan area drained by this river, it ranks fourth among the major rivers of the Punjab and fifteenth among the twentytwo principal Himalayan rivers from Indus in the west to Brahmaputra in the east (Burrard 1934).

From its source in the Rohtang pass, Beas river flows in a southerly direction upto Larji for about 75 miles and gathers three important tributaries from the east, *viz.*, Parbati, Sainj and Tirthan. The eastern-most part of the catchment is dotted with a number of glaciers whose total area is about 280 sq. miles and whose mean elevation is about 19,000 ft a.s.l. (Kanwar Sain 1946). Parbati, Sainj and Tirthan collect the drainage of these glaciers and feed the main river. In this reach, the gradient of Beas river is of the order of 125 ft per mile.

Beas pierces the Dhola Dhar range of the outer Himalayas near about Larji and thereafter flows in a westerly direction. It enters the Kangra valley after leaving Mandi and maintains its course till it debouches upon plains of the Punjab near Andaura. In this reach its gradient decreases gradually and is hardly 10 ft in a mile. As it flows through the valley of Kangra it is joined by several tributaries from the north. These rivers drain the southern slopes of the Dhola Dhar range before their confluence with the main river. Immediately after its confluence with the Gaj Khad, a dam is proposed to be built across the river near Pong. Beas finally joins Sutlej river near Harike after a total course of about 280 river-miles from its source.

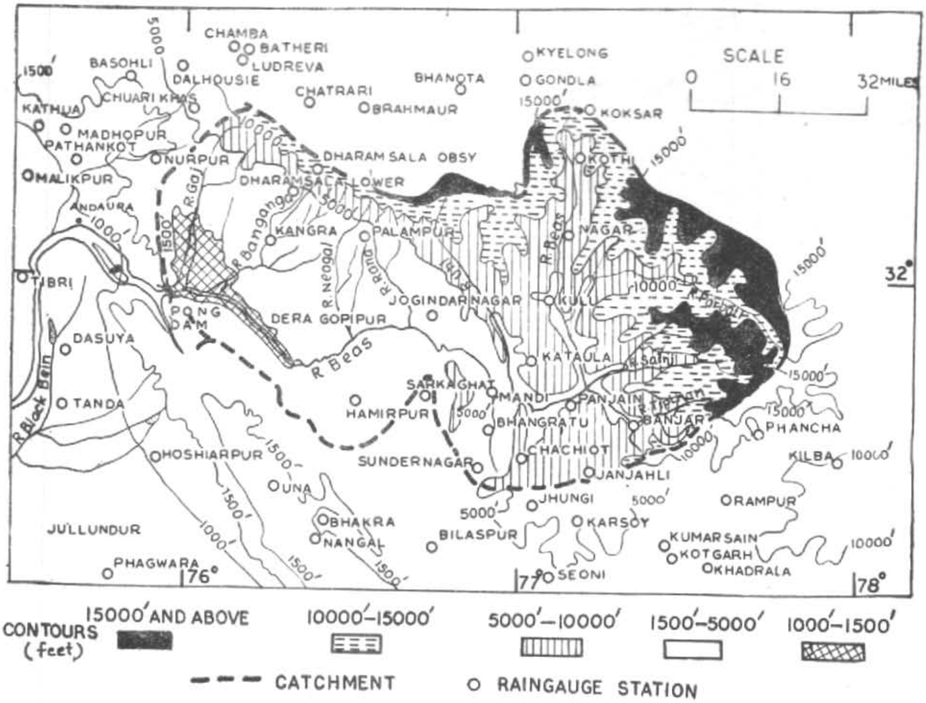

Fig. 1. Raingauge stations in Beas Catchment

2. Raingauge network

The catchment map of Beas river showing the existing raingauge network in and near the catchment is given in Fig. 1. A statement indicating the names of raingauge stations and the period, for which their published data are available, is given in Table 1. At present there are 17 raingauges within the catchment upto Pong dam site. The total catchment area upto Pong dam site is about 5000 sq. miles. Thus the area of the catchment represented by each raingauge is about 300 sq. miles. This network of raingauges is fairly satisfactory when compared with the neighbouring Himalayan catchments of Chenab, Ravi and Sutlej. However, there are several wide gaps in this network specially in the eastern half of the catchment where the distribution of raingauges is not uniform. Uptil 1950, there were only eight raingauges inside the catchment (upto Pong). Their daily rainfall data are available since 1891

TABLE 1

Ordinary raingauges within Beas Catchment (upto Pong)

Name of raingauge station	Year from which data available	Name of raingauge station	Year from which data available
Banjar	1891	Kangra	1891
Bhangrotu Farm	1952	Kataula	1955
Chachiot	1951	Kothi	1950
Dharamsala* (Lower)	1891	Kulu	1891
Dehra Gopipur	1891	Mandi	1951
Ham'rpur	1891	Nagar	1891
Janjhali	1955	Palampur	1891
Jogindernagar	1951	Panjain	1955
		Sundernagar	1951

*There is also a raingauge station at Dharamsala (Upper) which has been functioning since 1931

TABLE 2

Comparison of mean* monthly and annual rainfall amounts (in inches) at stations in the western and the eastern parts of Beas Catchment

Raingauge stations in western part of the catchment					Raingauge stations in eastern part of the catchment				
Station	Jul	Aug	Sep	Annual	Station	Jul	Aug	Sep	Annual
Palampur	31·9	34·2	10·1	105·6	Nagar	7·4	7·6	4·1	48·0
Dehra Gopipur	15·2	16·1	6·4	52·8	Kulu	5.0	5·8	3·0	38·6
Hamirpur	16·1	16·6	6·1	54·0	Banjar	9·3	9·1	4·2	43·9

* Means are based on data upto 1950

in the printed rainfall tables of the Punjab. Rainfall data of nine additional raingauges within the catchment have become available from 1951 with the formation of Himachal Pradesh.

Two class-II meteorological observatories located within the catchment at Dharamsala and Mandi are functioning from April 1950 and May 1954 respectively. Around the catchment there is a class-I meteorological observatory at Pathankot and three class-II observatories at Dalhousie, Bilaspur and Simla. Recently nine self-recording rain-gauges have been installed in the eastern part of the catchment at Kulu, Manali, Sainj, Dhara, Hamirpur, Shahpur, Palampur, Gopalpur and Garwana.

3. Onset and withdrawal of monsoon

Monsoon sets in over the catchment towards the middle of last week of June. Monsoon normally withdraws from this region by the middle of September.

It has been observed that the eastern part of the catchment (*i.e.*, the part of catchment roughly to the east of Long. 77°E) receives comparatively less rainfall than the western part during the monsoon months. This may be due to the fact that the western part is more exposed to the monsoon currents than the eastern part which is located in the interior of the Himalayas. This difference in rainfall has been brought out clearly in Table 2 where mean monthly monsoon/annual rainfall amounts of stations located more or less on the same latitudes have been compared in these two parts of the catchment. Although the altitude of these stations may not be the same, Table 2 gives a general picture of rainfall distribution in the eastern and the western parts of the catchment. The east-west orientation of the Dhola Dhar range, which forms the northern boundary of the western part of the catchment, helps monsoon currents to shed most of their moisture in the western part of the catchment. Dharamsala, which is located on the southern slopes of the Dhola Dhar range, has the highest mean annual rainfall for any station in the western Himalayas—Dharamsala (Upper) 126 inches and Dharamsala (Lower) 116 inches.

4. Frequencies of heavy falls of rain

Frequencies of heavy falls of rain during the months July to October at selected raingauge stations inside the catchment whose rainfall data are available from 1901-1960 were examined. Table 3 gives the frequency of heavy falls of rain of 3 inches and above in 24-hours at 8 raingauge stations. It can be seen from Table 3 that Dharamsala has the highest frequency of heavy falls of rain during the months of July, August and September. Of the remaining stations, Palampur and Kangra have the next higher frequencies. Table 3 also shows that stations in the eastern half of the catchment have the lowest frequencies of heavy rain.

Table 4 gives the highest 24-hour rainfall amounts recorded at each of the 17 raingauge

TABLE 3

Frequencies of rainfall of 3" and above during the months of July to October recorded at raingauge stations in Beas Catchment whose data are available from 1901–1960

Station	3·00–4·99	5·00–6·99	7·00–8·99	9·00–12·99	13·00–16·99	Total for all occasions
			JULY			
Banjar	7	..	..	..	..	7
Dharamsala (Lower)	143	51	13	3	2	212
Dehra Gopipur	34	10	1	..	..	45
Hamirpur	33	14	..	1	..	48
Kangra	73	27	7	2	..	109
Kulu	1	..	..	..	..	1
Nagar	1	..	..	..	..	1
Palampur	116	32	14	2	..	164
			AUGUST			
Banjar	6	..	..	..	..	6
Dharamsala (Lower)	156	53	16	3	..	228
Dehra Gopipur	52	13	2	1	..	68
Hamirpur	53	7	..	1	..	61
Kangra	112	32	13	1	..	158
Kulu	2	..	..	..	..	2
Nagar	4	..	..	..	..	4
Palampur	108	41	15	7	1	172
			SEPTEMBER			
Banjar	9	..	..	..	..	9
Dharamsala (Lower)	44	8	4	1	1	58
Dehra Gopipur	20	2	..	1	..	23
Hamirpur	13	2	1	..	..	16
Kangra	40	6	2	..	..	48
Kulu	2	..	..	..	..	2
Nagar	6	..	..	..	..	6
Palampur	28	6		..	..	36
			OCTOBER			
Banjar	2	..	..	..	..	2
Dharamsala (Lower)	3	1	1	..	..	5
Dehra Gopipur	5	1	1	..	..	7
Hamirpur	3	1	..	..	..	4
Kangra	1	1	1	..	..	3
Kulu	3	..	..	..	..	3
Nagar	1	..	..	..	..	1
Palampur	7	..	..	..	..	7

TABLE 4

Highest 24-hour rainfall (in inches) recorded at raingauge stations in Beas Catchment in the months July to October during 1901-1960*

Station	July		August		September		October	
	Highest amount	Date	Highest amount	Date	Highest amount	Date	Highest amount	Date
Banjar	4·5	18-7-55	4·1	22-8-51	4·9	22-9-24	3·3	27-10-17
Bhangrotu Farm	4·2	19-7-57	7·5	31-8-60	4·4	25-9-54	3·5	4-10-55
Chachiot	4·5	5-7-53	9·0	21-8-51	3·3	25-9-54	3·1	3-10-55
Dharamsala (Lower)	15·3	16-7-34	11·8	19-8-23	14·0	21-9-17	7·2	3-10-55
Dehra Gopipur	8·2	23-7-13	9·3	12-8-32	9·3	26-9-47	7·2	4-10-55
Hamirpur	9·7	19-7-09	9·5	14-8-03	7·0	27-9-54	6·0	4-10-55
Janjhali	3·9	15-7-58	3·2	6-8-58	2·8	26-9-55	3·8	3-10-55
Jogindernagar	7·6	25-7-59	6·9	21-8-51	6·5	16-9-59	4·0	3-10-55
Kangra	12·1	31-7-26	9·3	24-8-22	7·6	12-9-43	7·2	4-10-55
Kataula	8·3	30-7-58	4·5	31-8-60	5·5	1-9-60	2·3	4-10-55
Kothi	4·1	16-7-58	3·1	3-8-53	3·9	14-9-57	3·9	4-10-55
Kulu	3·4	31-7-15	3·3	23-8-36	3·5	27-9-54	4·9	27-10-17
Mandi	5·5	31-7-54	10·0	31-8-60	4·1	1-9-60	3·2	3-10-55
Nagar	3·2	29-7-51	4·1	13-8-10	4·1	14-9-06	3·5	27-10-17
Palampur	9·5	15-7-44	13·5	21-8-30	7·7	5-9-39	4·9	6-10-59
Panjain	5·0	17-7-55	6·7	19-8-59	2·2	25-9-55	3·1	4-10-55
Sundernagar	5·2	29-7-51	9·7	31-8-60	4·8	26-9-54	3·0	3-10-55

*For stations which have come into existence after 1901 their data have been considered from the year of publication of their data

stations inside the catchment during their respective periods of availability of daily rainfall data. From this table it can be seen that highest 24-hour rainfall of 15·25 inches was recorded at Dharamsala on 16 July 1934. The next higher rainfall amounts are 14·30 and 13·55 inches which were recorded at Dharamsala and Palampur on 21 September 1917 and 21 August 1930 respectively.

5. Mean monthly and annual catchment rainfall

Mean monthly and annual values of rainfall for each raingauge station in and around the catchment based on 1950 rainfall normals were plotted. Isohyets were drawn on individual monthly and annual maps keeping in view the general topography of the catchment and the broad principles summarized by Satakopan (1951) regarding preparation of isohyetal maps. In drawing these isohyetal maps help was also taken of the short period average rainfall data of the remaining nine raingauge stations after converting these into long period averages by the usual ratio method. Fig. 2 shows the mean annual isohyetal map of the catchment based on 1950 normals of rainfall. Table 5 gives the mean monthly and annual rainfall of the catchment upto Pong. The mean rainfall values given in this table may be taken as tentative till rainfall normals based on a uniform period for all the raingauge stations in and near the catchment become available.

It may be seen from Table 5 that the annual rainfall of the catchment is about 58 inches. Monsoon rainfall (*i.e.*, July to September) is about 62 per cent of the annual rainfall. Fig. 3 shows the histogram and mass curve of mean monthly rainfall for the catchment.

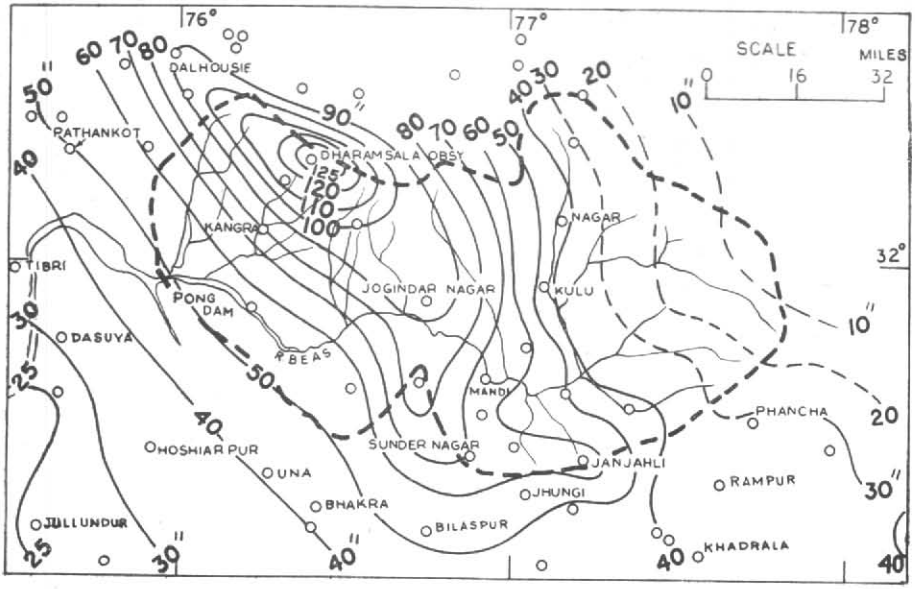

Fig. 2. Beas Catchment showing mean annual isohyets (1950 Normals)

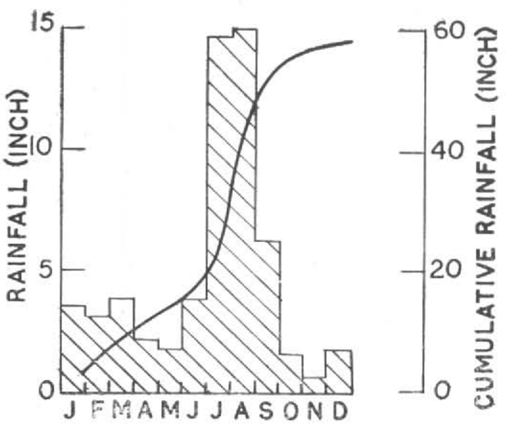

Fig. 3. Histogram and mass curve of monthly normal rainfall for Beas Catchment upto Pong

TABLE 5

Mean monthly and annual rainfall (in inches) over Beas Catchment (upto Pong)

Month	Mean rainfall	Per cent of annual	Month	Mean rainfall	Per cent of annual
Jan	3·47	6	Aug	14·95	26
Feb	3·21	6	Sep	6·29	11
Mar	3·93	7	Oct	1·48	3
Apr	2·15	4	Nov	0·49	1
May	1·72	3	Dec	1·69	3
Jun	3·80	7	Annual	57·81	—
Jul	14·63	25	Monsoon months (Jul to Sep)	35·87	62

TABLE 6

Peak discharge dates and rainfall amounts received during storm spells over Beas Catchment (upto Pong)

S. No.	Storm period	Peak discharge at Pong (Lakh cusecs)	Date	Daily depth of storm rainfall (inches)					Total storm rainfall (inches)
				1st day	2nd day	3rd day	4th day	5th day	
1	7—10 Aug 1935	4·08	10 Aug	0·5	0·6	0·2	2·0	..	4·4
2	23—26 Jul 1936	3·43	26 Jul	0·5	1·0	1·0	1·0	..	3·5
3	6—10 Aug 1942	4·13	9 Aug	0·6	0·6	1·3	2·0	0·6	5·1
4	11—14 Aug 1943	5·29	14 Aug	1·4	2·0	1·6	2·2	..	7·2
5	3—5 Aug 1944	4·55	5 Aug	0·3	1·1	1·7	..	..	3·1
6	1—3 Aug 1946	4·42	2 Aug	1·3	1·9	0·2	..	..	3·4
7	24—27 Sep 1947	6·00	26 Sep	0·4	0·8	3·9	1·7	..	6·8
8	2—5 Sep 1950	2·41	5 Sep	0·5	1·7	2·3	1·0	..	5·5
9	20—22 Aug 1951	4·82	22 Aug	1·3	2·1	2·2	..	..	5·6
10	2—4 Aug 1952	2·25	3 Aug	1·7	2·1	1·1	..	..	4·9
11	31 Jul—4 Aug 1953	2·65	3 Aug	1·1	0·8	1·1	1·4	1·6	6·0
12	25—28 Sep 1954	3·17	26 Sep	2·1	1·5	2·1	1·1	..	6·8
13	3—6 Oct 1955	3·72	5 Oct	1·9	4·4	3·6	1·4	..	11·3
14	11—13 Aug 1956	1·96	12 Aug	0·9	1·7	0·8	..	..	3·4
15	1—4 Sep 1957	2·91	3 Sep	1·3	1·4	2·8	1·5	..	7·0
16	18—20 Sep 1959	1·98	21 Sep	0·7	0·5	1·2	..	..	2·4
17	29 Aug—1 Sep 1960	3·26	31 Aug	0·7	0·7	1·3	1·7	..	4·4

6. Analysis of flood producing rain spells during the period 1935-60

Data of peak discharges recorded at Pong during the period 1935—60 were examined and eleven occasions when the peak discharge exceeded 3 lakh cusecs were selected for rainfall analysis. Besides these eleven occasions of major floods, all other occasions of peak floods during the period 1951-60 were also selected for detailed analysis as rainfall data of more number of raingauge stations are available from 1951 onwards. Table 6 gives 17 peak flood dates and the corresponding rain storm periods. As the discharge data are not available for the year 1958, rainfall study for this year was not undertaken.

From an examination of peak discharge data, it has been observed that major floods generally occur in Beas river during the months of August and September although July is one of the principal rainy months of this region. During the period 1935—60, it has been noticed that a major flood occurred only once in July and once in October.

7. Analysis of rain spells associated with major floods

Corresponding to each major flood daily rainfall data of all raingauge stations in and around the catchment were first examined to fix the rain spell. The daily and total rainfall maps of each rain spell listed under Table 6 were prepared and isohyets drawn, care being taken to give due weight to orography. The total storm maps were also checked with daily storm maps and adjustment of isohyets was done wherever required. Figs. 4—7 show some typical total storm isohyetal maps which were analysed for depth-duration analysis. Daily and total storm isohyetals were planimetered and mean rainfall depths over the catchment (upto Pong) were calculated, for individual storm days as well as for the total storm period. The weighted depths of rainfall on individual storm days thus obtained have also been given in Table 6.

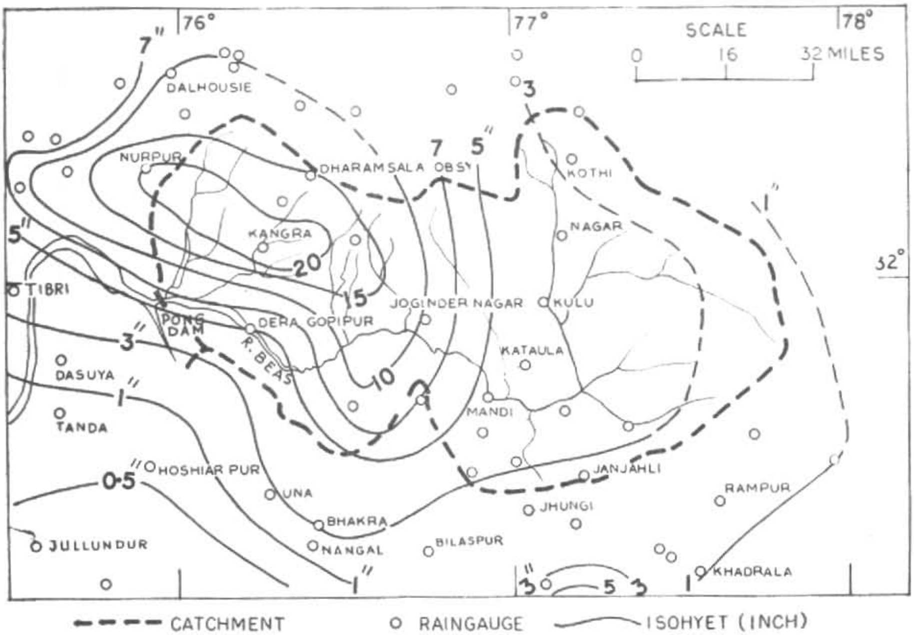

Fig. 4. Beas Catchment showing total storm isohyets, 11 to 14 August 1943

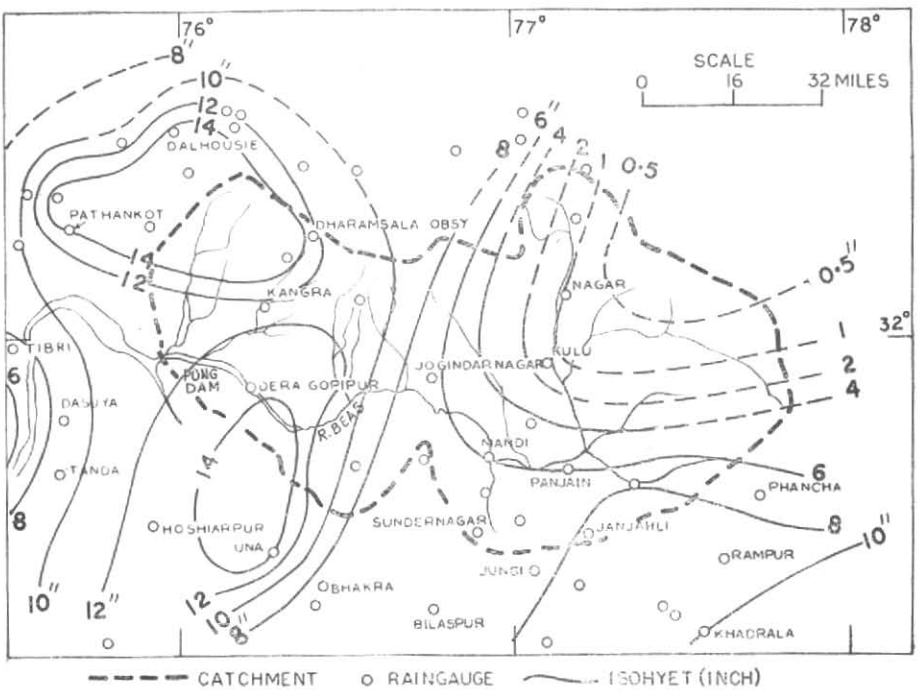

Fig. 5. Beas Catchment showing total storm isohyets, 24 to 27 September 1947

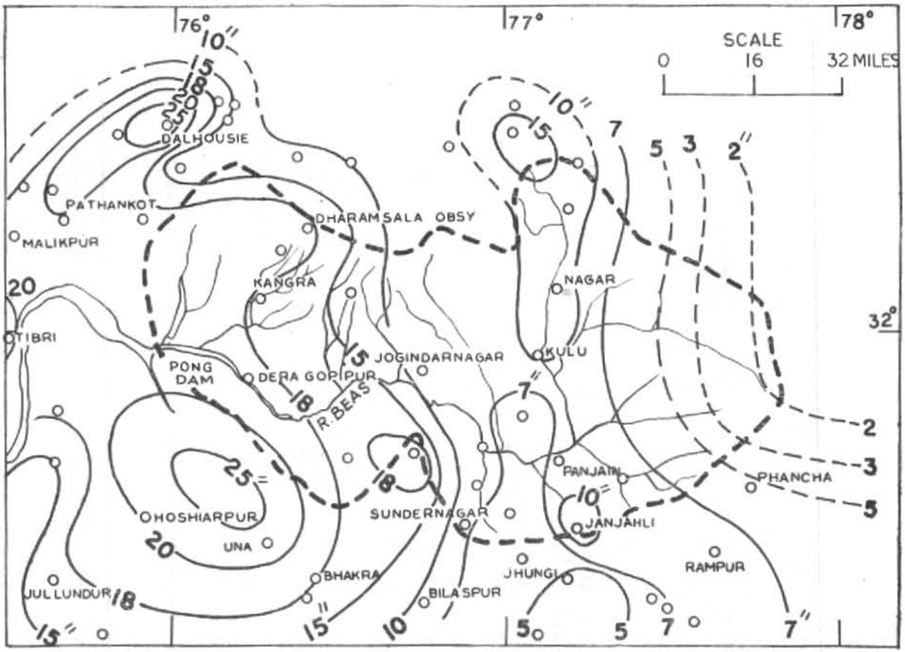

Fig. 6. Beas Catchment showing total storm isohyets, 3 to 6 October 1955

From this table it may be seen that maximum depths of rainfall over the catchment were obtained during the October 1955 rain spell when the catchment received about 11·3 inches of rain during a period of 4 days. In other words, during the 4-day storm period, the catchment received a total rainfall which is about 8 times its mean monthly rainfall for that month. The heavy concentration of rain took place on 2nd and 3rd day and a peak discharge of 3·72 lakh cusecs occurred on the 3rd day of the storm. Rain storms of August 1943, September 1947, September 1954 and September 1957 are also important as the catchment received concentrated rainfall during these rain spells. The September 1947 rain storm produced a record peak discharge of 6·0 lakh cusecs at Pong. In this storm the heaviest concentration of rain was on the 3rd day of the storm which was also the day of record peak discharge. It is seen that the majority of flood producing rain storms affecting Beas catchment have been of 4-day duration.

8. Synoptic situations leading to heavy rainfall

On an examination of the meteorological situations responsible for heavy spells of rainfall and consequent floods in Beas river, it has been observed that floods are generally caused by either of the following two meteorological situations—

(*i*) Breaking up of monsoon depressions over the Punjab Himalayas after traversing the central parts of the country. If the breaking up of a depression coincides with the passage of an active western disturbance moving eastwards across the Punjab-Kashmir Himalayas, exceptionally heavy rain is received. The severe floods in Beas in September 1947, September 1954, October 1955 and August 1960 were caused by meteorological situations similar to the above. The track of these depressions is shown in Fig. 8.

(*ii*) Due to strong monsoon conditions prevailing over the region thereby causing a

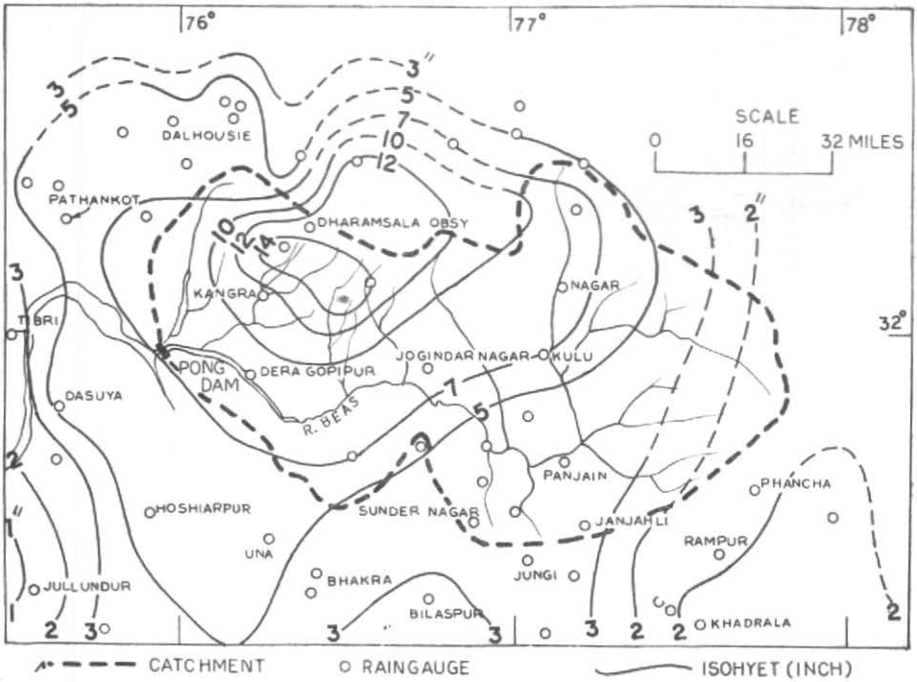

Fig. 7. Beas Catchment showing total storm isohyets, 1 to 4 September 1957

prolonged spell of heavy rainfall over the Punjab Himalayas and bringing floods in Beas.

It has, however, been observed that none of the 17 peak flood situations, mentioned earlier, were caused by the setting in of "Breaks" in the monsoon.

9. Design storm depths

On the basis of analysis of 17 rainstorms over Beas catchment, an attempt has been made to find out the design storm depths for different durations by depth-duration method. This data may be useful to the project engineers for the estimation of design flood.

From the daily depths of storm rainfall given in Table 6, maximum depths of rainfall over the catchment for durations of one-day, two-day etc were derived for each storm. Maximum values of rainfall thus obtained were then plotted against different durations and for each storm a depth-duration curve was drawn. The 17 depth-duration curves are presented in Fig. 9. It is evident from Fig. 9 that 1955 depth-duration curve represents the maximum depths of rainfall for different durations over the catchment as this curve envelopes all the other sixteen curves. The maximum depths of rainfall for durations of one-day, two-day etc have been read off from the 1955 curve and are given below—One-day 4·4 inches, Two-day 8·0 inches, Three-day 9·9 inches and Four-day 11·3 inches.

The above values give the design depths of rainfall for Beas catchment upto Pong and are based on the analysis of rain spells corresponding to peak discharge data for the period 1935—60. It is likely that higher depths may be obtained if major rain storms of earlier years are also analysed.

10. Maximisation of design depths of rainfall

The design depths of rainfall obtained earlier have been maximised for moisture charge

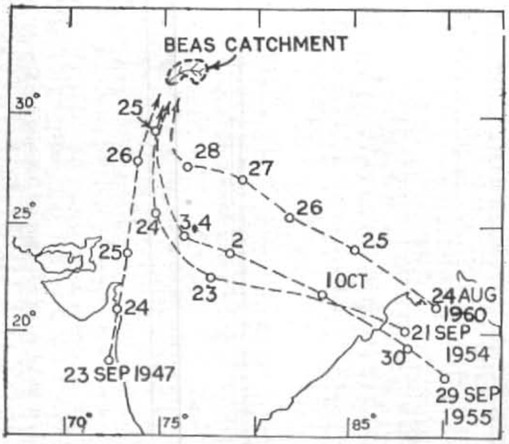

Fig. 6. Tracks of some important depressions responsible for floods in Beas river

for obtaining maximum probable depths over the catchment by using the technique followed in U. S. A. (Lovett 1955). Briefly stated, the technique consists in finding out an upward adjustment factor taking into consideration the 'persisting' dew point recorded during the storm period and the maximum dew point ever recorded within the catchment. Under the assumption of saturation with pseudo-adiabatic lapse rate, the precipitable water content in the atmosphere from 1000 to 200 mb corresponding to the maximum dew point and the "persisting" dew point are obtained from the U. S. Weather Bureau diagram (dew point temperatures being reduced to 1000 mb). The ratio of the depths of precipitable water corresponding to the maximum dew point to that of the 'persisting' dew point, thus obtained, gives the upward adjustment factor for moisture charge.

The available dew point data of Dharamsala and Mandi observatories were examined for maximising the design depths obtained earlier. Using the technique mentioned above the upward adjustment factors were calculated to be 1·22 and 1·66 for Dharamsala and Mandi respectively. A mean value of 1·44 was taken as the adjustment factor for the catchment as a whole. The design depths of rainfall multiplied by this adjustment factor gives the maximum probable depths for different

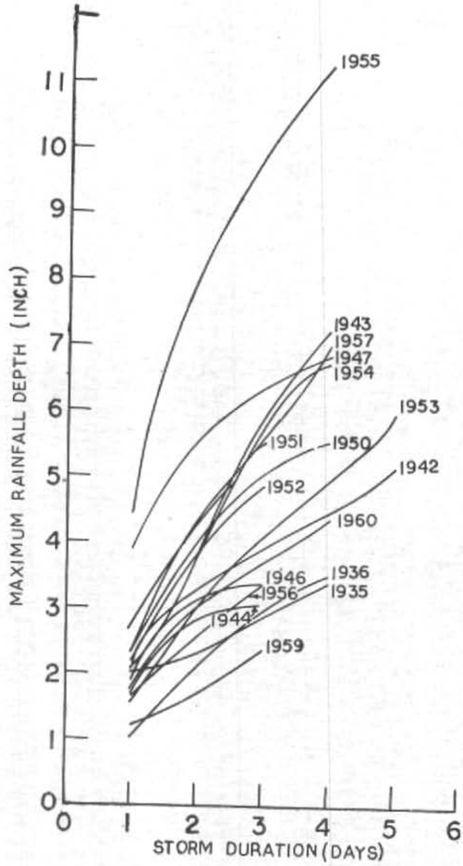

Fig. 9. Depth-Duration curves for Beas Catchment (upto Pong), 1935-1960

durations. The maximum probable depths of rainfall for Beas catchment are given below—One-day 6·3 inches, Two-day 11·5 inches, Three-day 14·3 inches and Four-day 16·3 inches.

11. Application of depth-area-duration statistics for obtaining design storm

In the present study design depths for the catchment have been calculated by depth-duration method in which the catchment and not the storm is taken as a unit. Taking the storm as a unit, Parthasarathy (1959) analysed the October 1955 Punjab storm and found its heavy rain centre near Batala, which is about 40 to 45 miles westsouthwest of Pong dam site in the Punjab plains. On picking up the rainfall depths corresponding to the area of Beas catchment (upto Pong) from the depth-area-duration curves prepared by Parthasarathy for this storm, we get the following design depths —

Maximum depth for

One-day	12·7 inches
Two-day	19·0 inches
Three-day	20·0 inches

On comparing the above depths of rainfall with the actual depths obtained over the catchment for this very storm, it is seen that the rainfall depths obtained by the depth-area-duration method give very exaggerated values of rainfall which are, perhaps, not likely to occur over the catchment. In fact, the actual depths of rainfall obtained earlier for the October 1955 storm (by depth-duration method) are the maximum depths over the catchment after analysing 17 major rain storms. It, therefore, appears that application of D.A.D. statistics will not be applicable to this catchment as this method gives uneconomical design depths of rainfall because of the highly hilly terrain of the catchment. Therefore, for design purposes, we may adopt actual maximum depths obtained by depth-duration analysis after maximization for moisture charge etc.

12. Conclusion

From the foregoing, the following conclusions may be drawn —

(1) Mean annual rainfall of Beas catchment upto Pong dam site is about 58 inches. Monsoon (July to September) rainfall of the catchment is about 62 per cent of the annual.

(2) Eastern part of the catchment receives comparatively less rainfall than the western part during the monsoon months. Being in the interior of the Himalayan ranges, the eastern part does not get as much rain as the western part.

(3) The chief flood producing months are August and September. Very rarely floods have occurred in July or October. Normally, floods occur in this catchment by monsoon depressions breaking up over the Punjab Himalayas or by strong monsoon conditions prevailing over the region.

(4) Rainfall analysis of 17 flood producing storms during the years 1935—60 has shown that October 1955 storm caused the maximum depths of rainfall over the catchment. These depths after maximization may be taken as design depths of rainfall for this catchment for estimation of design flood.

13. Acknowledgements

Our thanks are due to Shri P. K. Datta Roy for his help in the preparation of the diagrams.

REFERENCES

Burrard, S. G. *et al.* 1934 *Geography and Geology of the Himalayan Mountain and Tibet*, pt. III, pp. 175-179.

Kanwar Sain 1946 *The role of glaciers and snow on Hydrology of Punjab Rivers*, p. 1.

Lovett, N. B. 1955 *J. Instn. Engrs Aust.*, **26**, 9-11, pp. 39-46.

Parthasarathy, K. 1959 Proc. symp. met. hydrol. aspects of floods and draughts in India, pp. 15-19.

Satakopan, V. 1951 *Indian J. Met. Geophys.*, **2**, 1, pp. 9-24.