PAPER No. 295

Analysis of Heavy Rainfall in Short Periods at Lahore

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ABSTRACT :

1. The data of heavy rainfall in short periods for intensities above 0.5 in./hr have been collected from the hyetograph records of Lahore for 6 years from 1945 to 1950. The monthly and annual frequencies of falls of different intensities for intervals of .25 in/hr. have been worked out for the whole range of intensities above 0·5 in./hr. recorded during the period, and the probability of occurance of falls of different intensities calculated with the help of the mean annual values.

2. An effort has been made to establish a relationship between amounts and durations of falls and it is found that the equation satisfying the observed values for Lahore is of the form

$$R = \alpha t - \beta t^2$$

where R is amount of rainfall in cents, t is duration of fall in minutes and α and β are constants.

The equation giving the maximum amounts in different durations in the most copious spells at Lahore is as follows :—

$$R = 7.2t - .08t^2$$

3. From the above equations it has been inferred that for maximum intensity in cents/min. the general equation is of the form

$$\frac{\partial R}{\partial t} = I = \alpha - 2\beta t$$

The intensity-duration relationship for maximum intensity I, in cents/min. at Lahore is given by the equation

$$I = 7.2 - .16\, t$$

4. Basis for classifying various spells of intense rainfalls at Lahore has been discussed and tentative lower limits for different classes suggested. The observed intense falls of Lahore have been classified according to these limits and their monthly distribution discussed.

5. At the end, the validity of the Lahore results for other places in the plains of north Punjab (P) has been discussed

1. INTRODUCTION

1·1. Statistics of heavy rainfall in 24 hours have been published by the late India Meteorological Department in several Memoirs, Scientific notes and yearly volumes of the India Weather Review. The problem of heavy rainfall in short periods and its intensities does not seem to have been studied for any place in Pakistan so far. The subject, however, is of great interest to the Engineers, particularly those engaged in works connected with storm water drainage, etc.

1·2. S. N. Naqvi and Jalil Tahir in a recent paper have worked out on the basis of data from 1945-50 the averages and frequencies of hourly rainfall at Lahore. Average intensities and frequencies for spells of rainfall which are continuous or with breaks of duration less than an hour, as also the frequencies of different durations of these spells, have been examined in that paper In the present paper the characteristics and frequencies of heavy falls in short periods have been examined for Lahore for the same period of 6 years from 1945 to 1950.

2. DATA USED :

2·1. An examination of intensities of rainfall has shown that the intensities vary directly with the normal rainfall at a station. Lahore being situated in a drier region, the lowest limit for noteworthy falls had to be fixed at a much lower level than in countries like Britain. Tabulated data of heavy falls of rain with intensities of 0.5 in./hr. or more were available for Lahore from January to July 1946 and from July 1947 to December 1948. In these tabulations some continuous falls of 0.5 in./hr. or more had been split up into shorter periods and shown as more than one fall. The available tabulations have therefore been thoroughly scrutinized to eleminate discrepancies, and fresh data have been tabulated for all intense falls from January 1945 to December 1950. Only that portion of a fall has been taken into account where the intensity was 0.5"/hr or more. This means that even a continuous fall with varying intensity appears as more than one heavy fall in the tabulation, leaving gaps for those durations when the intensity was less than 0·5 in/hr. The structure of each intense fall has been further analysed by finding out the total rainfall after every five minutes from the beginning of each heavy spell. The data so obtained are given at the end of this paper as appendix. In this list besides the date, time, total amount of rainfall and its progressive totals at 5 minutes intervals, the average intensity of each intense fall has been worked out. The intensity data so obtained have been analysed in tables I and II.

TABLE I—MONTHLY FREQUENCY OF HEAVY RAINFALL OF DIFFERENT INTENSITIES AT LAHORE

(TOTAL No. OF OCCURRANCES FROM 1945-50)

MONTH	No. of cases of rainfall with intensities in inches of													Total
	.48 to .74	.75 to .99	1.00 to 1.24	1.25 to 1.49	1.50 to 1.74	1.75 to 1.99	2.00 to 2.24	2.25 to 2.49	2.50 to 2.74	2.75 to 2.99	3.00 to 3.24	3.25 to 3.49	3.50 to 3.74	
January	4	...	...	...	1	...	—	...	...	...	...	...	..	5
February	7	1	1	2	...	...	...	...	...	...	..	..	..	11
March	9	6	5	2	...	...	...	2	...	...	..	..	1	25
April	...	1	..	2	...	...	...	...	...	...	...	...		3
May	2	1	1	1	...	...	...	...	...	...	...	...		5
June	9	6	2	1	...	...	1	..	...	...	...	...	...	19
July	28	15	11	5	3	6	3	1	1	..	...	...	...	73
August	16	15	10	15	1	5	1	1	1	...	...	2	...	67
September	12	9	4	3	...	1	...	...	...	...	...	...	...	29
October	1	1	...	...	...	...	...	...	...	...	...	...	...	2
November	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	1	...	...	...	...	...	..	...	...	..	...	...	...	1
TOTAL	89	55	34	31	5	12	5	4	2	...	...	2	1	240

2·2—Table I gives for each month the total number of occasions of falls of different intensitites in different intervals of 25 cents/hours covering the entire range of intensities actually observed at Lahore during the period *i.e.*, from 0·5″/hour to 3·74″/hour. Higher intensities are most frequent during the monsoon months, 60% of the total number of intense falls being recorded in July and August and about 21% in June and September. Next in the matter of heavy intensities come February and March in which about 12% of the intense falls were recorded. The remaining 7% of the intense falls are recorded in January, April, May, October and December. October and November are really free from intense falls ; 0·9% of the falls rccorded in October were of an intensity less than 1″/hour.

TABLE II :—ANNUAL FREQUENCY OF HEAVY RAINFALLS OF DIFFERENT INTENSITIES AT LAHORE—1945-1950

YEAR	No. of cases of rainfall with intensity in inches of													Total
	.48 to .74	.75 to .99	1.00 to 1.24	1.25 to 1.49	1.50 to 1.74	1.75 to 1.99	2.00 to 2.24	2.25 to 2.49	2.50 to 2.74	2.75 to 2.99	3.00 to 3.24	3.25 to 3.49	3.50 to 3.74	
1945 ...	18	9	4	6	...	1	...			...		...	1	39
1946	8	9	4	2	...	1	2	1		..	..		...	27
1947 ...	12	10	4	5	.	1	1	..	..	..		1	...	34
1948 ...	26	12	13	8	1	5	3	..	..	...	...	...	...	68
1949 ...	11	8	3	3	2	2	...	..	1	...	...	1	...	31
1950 ...	15	7	5	7	2	1	...	3	1	...	...	..	...	41
Total ...	90	55	33	31	5	11	6	4	2	...	..	2	1	240
Mean ..	15.0	9.2	5.5	5.2	.83	1.9	1	.67	.33	...	...	.33	.17	...
Smoothed Mean-actual	15.5	11.0	8.0	5.2	3.3	2.1	1.5	1.1	.8	.55	.40	.33	.27	50.1
% Frequency from smooth curve	31	22	16	10.4	6.6	4.2	3.0	2.2	1.6	1.1	.7	.66	.54	100.1
% probability of occurrence	31	22	15	11	6	4	3	2	1.5	1.1	.8	.7	.6	98.7

2·3—In table II the annual frequency of intense rainfalls of different intensities for each year from 1945 to 1950 has been worked out for the same ranges of intensities as in table I and the mean annual frequency for each range of intensity has been calculated. These mean frequencies of different intensities have been plotted on a graph (fig 1) and a frequency curve drawn. The frequency curve obtained is not a smooth one, evidently because the data of 6 years, though quite sufficient to indicate the trends and characteristics of heavy rainfalls in short periods at Lahore, are not large enough to cover all possible cases of intense falls. A smooth frequency curve has therefore been drawn touching the highest frequencies and it has been extrapolated to meet the intensity axis of the graph. The probability of occurrance of falls of different intensities has been worked out by dividing the area below the frequency curve for each range of intensity by the total area below the whole curve from 0·5 in/hour to higher limits, the probalility of occurrance of falls upto 3·74″/hr. which were actually observed, have been given in the last line of table II. In table II-A are given the percentage probabilities of occurrence for all the intensities likely to occur at Lahore.

2·4—On the basis of the data examined in the present paper it can be inferred that at Lahore it is well nigh impossible to have a fall of intensity greater than 5·50 in/hr. The probability for a fall with intensity above 5″ in/hr. is about 7 in 10,000 ; that for fall above 4·75″/hr. about 16 in 10,000 ; for all rainfalls of intensity above 3·75 in/hr. the probability is 15 in 1,000.

TABLE II-A.—PERCENTAGE PROBABILITY OF HEAVY FALLS OF DIFFERENT INTENSITIES AT LAHORE.

Range of intensity in inches/hr.	Area below the probability curve (small squares on graph)	Percentage probability of occurrance of falls with intensity	
		within range	Above the lower limit of each range
5.50 to 5.74	0.0	0.00	0.00
5.25 to 5.49	0.5	0.02	0.02
5.00 to 5.24	1	0.05	0.07
4.75 to 4.99	2	0.09	0.16
4.50 to 4.74	4	0.18	0.34
4.25 to 4.49	6	0.28	0.62
4.00 to 4.24	8	0.37	0.99
3.75 to 3.99	11	0.5	1.5
3.50 to 3.74	13	0.6	2
3.25 to 3.49	15	0.7	3
3.00 to 3.24	18	0.8	4
2.75 to 2.99	24	1.1	5
2.50 to 2.74	33	1.5	6
2.25 to 2.49	47	2.2	8
2.00 to 2.24	65	3.0	12
1.75 to 1.99	90	4.1	16
1.50 to 1.74	135	6.2	22
1.25 to 1.49	232	10.7	33
1.00 to 1.24	330	15.2	48
.75 to .99	475	21.9	70
.50 to .74	662	30.5	100



3. AMOUNT—DURATION AND INTENSITY—DURATION RELATIONSHIP.

3·1—Several workers have found out intensity — duration relationships for different countries. Prof. H. N. Walsh [2] on the basis of analysis of hyetograph records of Cork for 13 years indicates that a curve approximating closely to that drawn through the plotted values of the maximum recorded intensities for showers lasting less than 120 minutes is represented by the formula

$$i = 9{\cdot}2/\sqrt{t}$$

where i is intensity in inches per hour and t is duration in minutes. He also suggested the formula

$$i = 78/(t + 30)$$

for values which may be exceeded about once in five years.

3·2—D. H. Lloyed Devies [3] suggested an equation

$$i = 40/(t + 20)$$

as applicable to Birmingham for design of sewers

3·3—K. Tutuni [4] suggested a general equation

$$i\sqrt{(t - K_1)} = K_2$$

Where K_1 and K_2 are constants. He found that for Nagano (Japan) $i\sqrt{t}$ is very nearly equal to $\sqrt{5}$. Wussow[5] gives $i\sqrt{t} = \sqrt{5}$, while Fasseg [6] gives larger values.

3·4—Dr. John Glasspoole [7] after describing the above works in his analysis of heavy rainfall in short periods in Britain for 1921-27, derives an equations of the form

$$i = 63{\cdot}1/(t + 14{\cdot}8)$$

for mean values of heaviest falls and shows that lowest limits for classification of heavy rainfall in short periods used in volumes of British Rainfall since 1908 could be very well represented by equations of the form

$$i = 100/(t + 40) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$i = 135/(t + 20) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

& $$i = 180/(t + 15) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

He has also used an other form

$$1 = K_1/t^{k\,2}$$

for representing these limits and mentioned in the passing that equations (1) to (3) correspond closely to equations of the form

$$R^2 = Kt$$

where R is the amount of rainfall.

3·5—All the above workers have actually dealt with average intensities in the total duration of a particular heavy spell. An examination of most of the spells of heavy rain at Lahore, however, showed that intensity is very seldom uniform through out the duration of a fall. To determine the intensity — duration or amount — duration relationship for Lahore, the structure of each individual fall was examined by finding out the progressive amounts at 5 minutes intervals in each fall.

TABLE III :—PROGRESSIVE TOTAL AMOUNTS AT 5 MINUTES INTERVALS IN FALLS OF 25 MINUTES OR MORE

(Arranged according ascending average intensity in in./hr.)
AT LAHORE 1945—1950

Date	5	10	15	20	25	30	35	40	45	50	55	60	65	Average intensity
2-8-46	5	10	15	19	23	20	33	40	...	..	...	...	...	.60
22-7-45	5	10	16	21	26	31	3›	42	48	...			...	.64
8-8-45	8	14	19	24	30	35	40	44	48					.64
19-9-50	5	10	15	20	25	30	38	43	48	53	58	65	70	.65
19-9-50	6	11	16	22	27	36	42	47	52	50	64	70	...	.70
25-7-49	5	11	17	23	30			...		...			..	.72
18-6-45	6	14	20	24	30	36	42			...			...	.72
1-8-45	5	10	16	22	28	34	40	50	58	63	...		...	.76
3-2-49	4	9	10	25	33	38		...			..		...	.76
14-9-50	6	12	17	27	34	...				...			...	.78
22-7-45	8	18	26	32	38		..						...	.91
4-10-47	8	16	34	34	46	51	56	64	72	76	83		...	.91
2-8-46	10	18	24	29	34	39	45	51	69		...		...	.92
2-8-46	5	12	18	28	40		...					..	...	.96
17-7-50	8	16	24	31	40	...	..	...	...	..		...	..	.96
7-6-46	7	19	29	37	41	...	..			...			...	.98
17-9-50	6	16	36	46	56	68	73		...	...		...	..	.98
14-9-45	9	14	19	28	35	45	55	65	74	...			...	.99
10-9-46	6	12	22	34	46	58	64	76	86	96	126	134	..	1.12
3-9-49	10	20	30	40	58	64	70	..		..	...		...	1.20
4-8-48	7	17	23	30	57	63	68	84	92	...	..	...	...	1.32
12-8-40	5	12	22	33	47	63	72	...				..	...	1.20
11-8-50	5	17	23	30	53	...		...	...	...		...	...	1.26
31-7-43	20	40	48	54	60	66				...		...	...	1.32
29-9-47	8	20	30	56	68	76	85	90	...	...				1.35
10-7-40	7	15	26	46	58			...	...	..		...	...	1.39
8-8-46	10	22	34	46	56	70	..	..	...			...	..	1.40
3-7-46	19	37	51	61	70			...				...	...	1.44
10-8-47	6	23	40	50	61	72	...	...	...	...		...	...	1.44
15-8-48	16	30	44	72	82	92		...	...		...	...	...	1 84
14-7-48	6	20	28	66	77	...	..					...	..	1.85
6-7-45	8	26	46	66	86	106	124	146	154	160				1.92
14-7-48	16	36	54	72	92		...		...	...		...	...	2 21
13-8-50	26	46	76	98	116	130	...	...			...	...	...	2.60

3·6—The analysis for falls of 25 minutes or more is given in table III. A fall of 30 minutes duration on 13-8-50 has highest total amounts in 15, 20, 25 & 30 minutes as follows :—

Minutes	5	10	15	20	25	30
Amount in cents. — R			76	98	116	130
Rate of change of R per 5 min. ∂ R (first differential).			22	18	14	
Rate of change of ∂ R *i e.* ∂^2R (2nd differential)			—4	—4		

3·7—Thus we find that in the curve of highest amounts at Lahore $\frac{\partial^2 R}{\partial t^2}$ = Const. Such a curve is represented by an equation of the form

$$R = Kt^2$$

This is the equation of a parabola. It is therefore evident that the curve of highest amounts and corresponding durations at Lahore is represented by a parabola. If we extrapolate this curve backwards and forwards with the help of the extrapolated values of ∂^2 R and keep in a view the highest amount that has been recorded at Lahore in the first 5 minutes, we get the maximum amount — duration series which is given in table IV. A composite series obtained by selecting highest amounts in different durations from actual observations is also given in the table.

TABLE IV.—Maximum amount — duration series as calculated and as actually observed at Lahore.

	Duration of fall in minutes	5	10	15	20	25	30	35	40	45
1.	Rate of change of R, (∂ R)	(a) 30	(a) 26	22	18	14	(a) 10	(a) 6	(a) 2	
2.	Calculated maximum amount-duration series in cents.	(b) 30	60	86	108	126	140	150	156	158
3.	Actual maximum amount-duration series in cents.	30	46	76	98	116	130		146	154
4.	Actual maximum amount received on	8/1/45			13-8-50				6-7-45	

NOTE—(a) Extrapolated values of ∂ R.

(b) The series has been calculated with the help of R beginning with 30 cents as base the highest amount received in any 5 minutes.

3·8—The calculated progressive totals evidently agree as best as could be expected when comparing them with progressive totals of different dates based on a short series of data covering 6 years only. In the case of the probablity curve in section 3· we had found the need of smoothing the curve for the same reason and in the same direction It will be noticed that the calculated series for the rainfall amount-duration relationship is giving slightly higher values.

3·8—Taking R in cents and t in minutes in this series the R—t relationship will be represented by an equation of the form

$$12{\cdot}5\ (158-R) = (45-t)^2$$

There is however reason to believe that the equation for max-amount-duration relationship will be

$$12{\cdot}5\ (164-R) = (45-t)^2 \text{ or } R = 7{\cdot}2\ t - {\cdot}08t^2$$

3·10—The above equation means that an intense fall af the maximum copioucity at Lahore can not last longer than 45 minutes and cannot exceed 164 cents in that duration. In fact in none of the falls recorded at Lahore the amount has exceed 160 cent. There have, however, been falls of longer durations, the maximum being of 65 minutes. In all the falls of longer duration the amount of rainfall upto 45 minutes has been much less. In a fall of 160 cents in 50 minutes the amount received in 45 minutes was 154 cents and this is the 2nd most rare fall on record. In the third fall of 134 cents in 60 minutes, the amount received in the first 45 minutes was 96 cents only.

3·11—The falls of longer durations mentioned above apparently belong to some family of curves other than those given by the equations for the most intense falls. While examining the problem from this angle it will be noted that in the case of the maximum amount duration curve the second differential, $\partial^2 R = 4$. This fixes a family of amount — duration parabolas in which each parabola is determined by the amount received in the first 5 minutes.

3·12—If the amount in the first 5 minutes were 30 cents and the second differential of the series of progressive totals were 3, the amount — duration series would be as follows :—

Duration t in minutes	0	5	10	15	20	25	30	35	40	45	50	55
Amount R in cents.	0	30	57	81	102	120	135	147	156	162	165	165
First differential in cents.		30	27	24	21	18	15	12	9	6	3	0

Again, suppose the amount in the first 5 minutes were 20 cents, and the 2nd differential were 2, the amount-duration series would be

Duration t in minutes	0	5	10	15	20	25	30	35	40	45	50	55
Amount R in cents.	0	20	38	54	68	80	90	98	104	108	110	110
First differential in cents.	20	18	16	14	12	10	8	6	4	2	0	

If the amount in the first 5 minutes were 20 and the 2nd differential were 1, the amount — duration series would continue to 95 minutes with a maximum amount of 193 cents.

3·13. It is thus evident that the maximum amount and duration of a spell of heavy rainfall will be determined by the amount received in the first five minutes and the subsequent variations depending upon the 2nd differential.

3·14—We have thus seen that the amount-duration relationship is represented by a general equation of the form

$$R = \alpha t - \beta t^2 \qquad \ldots\ldots\ldots\ldots A$$

in which α and β are determined by the R & T coordinates of the appex of the parabola and are constant for each family of the curves,

Intensity in cents per minute will be given by $\frac{\delta R}{\delta t}$

$\therefore$ by differentiating A we find that

$$\frac{\delta R}{\delta t} = I = \alpha - 2\beta t$$

This is a straight line which for the maximum amount-duration curve at Lahore will be given by

$$I = 7{\cdot}2 - {\cdot}16\ T$$

3·15 In the case of a warm front the slope being generally uniform, $\delta^2 R$ will also be uniform and the R-T relationship of heavy falls will be represented by parabolas of one family only in each case and the intensity-duration relationship by a straight line of constant slope.

3·16. In the case of cold front thundershowers the matter will be rather complicated, because the size of drops in a shower, or in its various parts, depends upon the up-currents in different parts of the cloud. This may result into various families of parabolas being superposed upon the basic parabola depending upon virtual and potential temperatures of the airmasses in juxtaposition. The resultant amount-duration curve in thundershowers will therefore be of the form given in fig 2. Examples of this type of curves are not lacking in the data given in appendix.

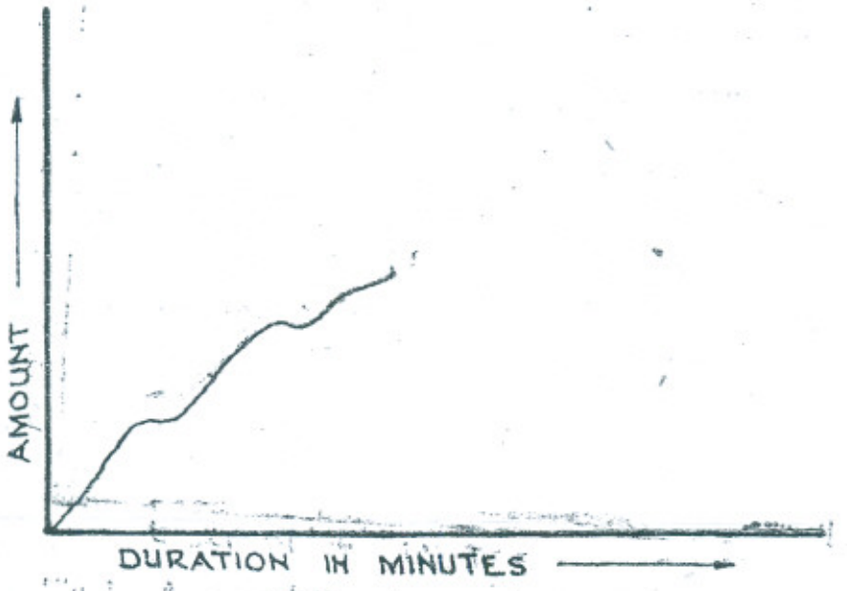


Fig 2. Amount-Duration curve in a thundershower

3·17 The relationship between the values of 2nd differential and the thermodynamic properties of air masses will, however, be dealt with in a separate paper. It is proposed to examine in that paper all the spells in their entirety without imposing any arbitrary limit on intensity as has been done in the present paper because it deals with intense falls only.

4. CLASSIFICATION OF INTENSE RAINFALLS.

4·1 To utilize the data of intense rainfalls in Engineering practice at a places, it is necessary to classify the falls into different categories. In the yearly volumes of British Rainfall the intense falls are classified into "Noteworthy", "Remarkable" and "Very Rare" categories since 1868. The lower limits of amounts and intensities of falls of different durations have been specified, but continued to vary considerably from year to year until 1907. From 1908 this classification has remained unchanged. As already mentioned, the lower limits for each class in British Rainfall can be represented approximately by the following equations.

for Noteworthy falls $i = \frac{100}{t+40}$

,, Remarkable ,, $i = \frac{135}{t+20}$

,, Very rare ,, $i = \frac{180}{t+15}$

4·2 We have found in section 3 that our intense falls are represented by equations of the form.

$$R = \alpha t - \beta t^2$$

But in this equation there is a limit of maximum duration for every class of fall, which makes it unsuitable for being used as a basis for general classification. Keeping however the equations for British classification and our own equation in view, I have tentatively accepted the lower limits for each class indicated in table V. These limits are shown in fig. 3.

TABLE V :—LOWER LIMITS OF INTENSE FALLS OF RAIN AT LAHORE.

Time	Noteworthy			Remarkable			Very Rare		
	Amount		Rate	Amount		Rate	Amount		Rate
mns.	in.	mm.	in/hr	in.	mm.	in/hr	in.	mm.	in/hr
5 or less	.05	1.27	0 60	.12	3.05	1.44	.24	6 10	2 88
10 ,,	.10	2.54	0 60	.24	6.10	1.44	.41	10 41	2.46
15 ,,	.15	3.81	0.60	.34	8.64	1.36	.57	14.48	2.28
20 ,,	.20	5.08	0 60	.43	10.92	1.29	.71	18 03	2.13
25 ,,	25	6.35	0.60	.51	12.95	1.22	.82	20.83	1.97
30 ,,	.30	7.62	0.60	58	14.73	1.16	.92	23 37	1.84
35 ,,	.34	8.64	0.58	.64	16.26	1.10	1.01	25.65	1.73
40 ,,	.39	9.91	0.58	.69	17.53	1.03	1.09	27.69	1.59
45 ,,	.43	10.92	0.57	.74	18.80	0.98	116	29.46	1.55
50 ,,	.47	11.94	0.56	.79	20.07	0.95	1.22	30.99	1.46
55 ,,	.50	12.70	0 55	.84	21.34	0.92	1.29	32.77	1.41
60 ,,	.54	13.72	0.54	.88	22 35	0.88	1.36	34.54	1.36
65 ,,	.57	14.48	0.53	.93	23 62	0.86	1.43	36.32	1.32
70 ,,	.60	15.24	0 51	.97	24.64	0.83	1.48	37.59	1.27
75 ,,	.63	16.00	0 50	1.01	25.65	0.81	1.54	39.12	1.23
80 ,,	.65	16.51	0.49	1.05	26.67	0.79	1 60	40.64	1.20
85 ,,	.67	17.02	0.47	1.08	27.43	0.76	1.66	42.16	1.17
90 ,,	.69	17.53	0.46	1.11	28.19	0 74	1.71	43 43	1.14
95 ,,	.71	18.03	0.45	1.14	28.96	0.72	1.77	44.96	..12

FIG 3.

4·3 Remarkable and very Rare falls have been given in Table VI

TABLE VI.—REMARKABLE AND VERY RARE FALLS AT LAHORE.

Year	Remarkable falls				Intensity.	Very rare falls				
	Date.	Time of comm	Duration.	Amount.		Date.	Time of comm	Duration	Amount.	Intensity.
		hrs 1st	Min.	In	In/hr.					
1945 ...	31/7	0120	30	0·66	1·32	2/3	0·45	5	·30	3·60
	14/8	2015	15	0·34	1·36	6/7	11·45	50	1·60	19.2
	14/2	1410	45	0·74	0·99					
1946	29/6	0635	20	·70	2·10					
	3/7	0325	15	·46	1·84					
	,,	0615	25	·70	1·68					
	10/7	1950	25	·58	1·39					
	11/7	0013	5	·18	2·16					
	15/7	0455	10	·38	2·28					
	10/8	1015	60	1·34	1·34					
1947	10/8	0800	30	·72	1·44	27/8	1252	5	·28	3·36
	12/8	0618	15	·44	1·76					
	27/8	1708	15	·37	1·48					
	29/8	0915	5	·18	2·16					
	20/9	0320	40	·90	1·35					
1948	10/7	0240	10	·36	2·16	14/7	0610	25	·92	2·21
	14/7	0255	25	·77	1·85	15/8	1330	25	·92	2·21
	,,	0415	15	·48	1·92					
	18/7	2325	5	·12	1·44					
	4/8	1145	45	·92	1·23					
	8/8	1245	30	·70	1·40					
	11/8	1300	15	·46	1·84					
	,,	1330	15	·44	1·76					
	,,	1637	15	·35	1·40					
	,,	2155	5	·16	1·92					
	12/8	1157	35	·72	1·23					
1949 ..	11/7	0730	10	·28	1·68	25/8	0342	5	·29	3·48
	19/7	0748	5	·22	2·64					
	20/7	0355	5	·15	1·80					
	2/8	0415	10	·25	1·50					
	3/9	0250	10	·33	1·98					
	,;	0700	25	·70	1·20					
	28/9	2105	30	·47	1 41					
1950	26/1	0137	15	·40	1 60	13/8	1630	30	1·30	2·60
	22/3	0135	10	·39	2·34					
	26/3	1540	10	·40	2·40					
	5/7	0530	15	·38	1·52					
	13/7	0553	10	·33	1·98					
	17/7	1116	25	·40	·96					
	2/8	0710	5	·20	2·40					
	5/8	0945	5	·12	1·44					
	14/9	0910	10	·24	1·44					
	17/9	0330	35	·73	1·25					

The number of occurrances of each class of fall in different years from 1945 to 1950 were as follows :-

	1945	1946	1947	1948	1949	1950	Total	Mean
Unclassed though 1/2"/hr or more	2	1	2	8	1	1	15	3
Noteworthy	32	19	26	47	22	28	174	29
Remarkable	4	7	5	11	7	11	45	8
Very Rare	2	0	1	2	1	1	7	1

The analysis of remarkable and very rare falls according to months is as follows :—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.
Remarkable	1	—	2	--	—	1	16	18	7	—	—	—
Very rare	—	—	—	—	—	—	2	4	—	—	—	—

4·4 It will be seen that falls of very rare class are confined to July and August and those of the Remarkable variety to Jany, March and from June to Sept. The remarkable fall in June is really associated with the advance of the monsoon.

5. GENERAL CONSIDERATIONS.

5·1 Due to the scarcity of observatories provided with Hyetographs, it has been possible to examine the data of heavy rainfall in short periods for Lahore alone. It is, however, seen from the monthly and annual normals of rainfall for different districts in the Punjab that the order of rainfall and its variation from month to month is similar in Lahore, Gujranwala, Sheikhupura, Shahpur, Jhelum, and Attock districts.

5·2 The variability of the annual rainfall of India worked out by A. V. Williamson and K. G. T. Clark[8] and the co-efficient of variability of the monsoon rainfall worked out by S. N. Naqvi[9] also show that the character of rainfall in the north Punjab is practically uniform, the co-efficient of variability being within $\pm$ 20% to $\pm$ 30% of the normal. In view of this it can be assumed that the Lahore results will be valid for the submontane region of the Indus plane to the south of Sialkot Rawalpindi and Attock and to the north of Montgomery, Lyallpur, Sargodha & D. I. Khan. The probability of occurrence of falls of different intensities will be slightly lower in places to the south of Lahore Mianwali line and slightly more to the north. The normal rainfall at Sialkot and Rawalpindi being higher, it is likely that even higher intensities than those recorded at Lahore may be met with.

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APPEN

INTENSE FALLS OF RAIN IN SHORT

Lat. 31°.35 N—Long. 74° 20′ E.

Year	Date	Time of commence-ment	Duration in minutes	Amount in inches	Intensity in/hr.
1945	8/1	18.35	10	.08	.48
	2/3	10.45	5	.30	3.60
	,,	11.30	5	.05	.60
	7/4	10.45	10	.21	1.26
	18/5	7.10	5	.05	.60
	20/5	8.05	10	.23	1.38
	18/6	5.05	35	.42	.72
	,,	8.20	5	.05	.60
	,,	8.35	10	.15	.90
	,,	8.50	5	.09	1.08
	,,	9.05	10	.12	.72
	,,	11.45	5	.06	.72
	,,	12.35	5	.06	.72
	,,	13.40	5	.06	.72
	19/6	0.45	5	.07	.84
	2/7	22.35	10	.09	.54
	,,	22.55	5	.06	.72
	2-3/7	23.50	15	.22	.88
	5/7	10.55	10	.23	1.38
	6/7	11.30	10	.14	.84
	,,	11.45	50	1.60	1 92
	13/7	04.50	5	.10	1.20
	20/7	12.45	10	.12	.72
	22/7	04.13	5	.05	.72
	,;	04.35	25	.38	.91
	31/7	01.20	30	.66	1.32
	1/8	00.30	50	.63	.76
	1/8	19.20	45	.48	.64
	14/8	05.45	5	.06	.72
	,,	20.15	15	.34	1.36
	26/8	13.45	20	.42	1.26
	7/9	15.25	5	.05	.60
	14/9	14.10	45	.74	.91
	,,	16.00	5	.05	.60
	,,	17.10	5	.06	.72
	26/9	22.35	10	.19	1.15
	27/9	02.20	20	.39	1.17
	,,	03.45	5	.08	.96
	,,	04.35	5	.08	.96

DIX

PERIODS AT LAHORE—1945-1950

Height of rain gauge above mean sea level—602' above M.S.L.

FALL IN MINUTES												
5	10	15	20	25	30	35	40	45	50	55	60	65
4	8	...	...	...	...	...	...	..	...	...	...	...
30	...	...	...	..	...	..	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...	..	...	...	...
10	21	...	...	..	..	...	...	..	...	...	...	...
5	...	...	...	..	...	...	...	..	...	...	...	..
15	23			...	...		...	..	...	...	...	...
6	14	20	24	30	36	42	...	...	...	...	..	...
5	...	...	...	...	...	...	...	...	...	...	...	...
5	15	...	...	...	...	...	...	..	...	...	...	...
9				...	...	..	..	...	...	...	...	...
6	12	...	...	...	...	...	...	...	...	...	...	...
6	...		...	...		...	...	...	...	...	...	...
6	...	...	...		...	...	...	...	...	...	...	...
6	...	...	...	..	...	...	...	...	...	...	..	...
7	...	...	..	...	...	...	...	...	...	..	...	...
5	9	...	...	...		...	...	...	...	...	...	...
6		...			...	...		...	...	...	...	...
5	11	22	..	...	...	...	...		...	...	...	...
17	23	...	...	...	...	...	...	...	...	...	..	...
6	14		...		...	...	...	...			...	...
8	26	46	66	86	1.06	1.26	1.46	1.54	1.60	...	...	...
10	...	...			...	..	...	...		...	...	...
6	12	...		...	...	...	...	...	..	...	...	...
5	...		...	...		...	...	...	...	...	...	...
8	18	26	32	38	...	...	...	..	...	...	...	..
20	40	48	54	60	66	...	..	...		...	...	...
5	10	16	22	28	34	40	50	58	63	...	...	...
8	14	19	24	30	35	40	44	48		...	...	...
6		...		...	...	...	...	...	...	...	...	...
12	24	34	...	...	...	...	...	...	...	...	...	...
16	28	36	42	...	...		...	..	...	...	..	...
5	...		...	...	...	...			...	...	...	...
9	14	19	28	35	45	55	65	74	...	...	...	...
5	...		...	...	...	...	...	..	..	...	...	..
6	...	...	...	...	...	...	...	...	...	..	...	...
13	19	...			...	...	...			...	...	...
12	20	30	45	...	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...		...	...	...

APPEN

INTENSE FALLS OF RAIN IN SHORT PERIODS

Year	Date	Time of commence-ment	Duration in minutes	Amount in inches	Intensity in/hr.
1946	23/2	22.25	10	0.21	1.26
	3/3	02 55	20	0.20	0.60
	,,	04 35	5	0.06	0.72
	,,	13.25	5	0.09	1 08
	26/4	21 20	10	0.14	0.84
	18/5	05.00	10	0.14	0.84
	19/5	06.20	10	0.18	1.08
	,,	06.40	5	0.05	0.60
	7/6	15.30	25	0.41	0.98
	,,	16 10	5	0.06	0.72
	13/6	05 45	10	0.09	0.54
	19/6	14.50	20	0.30	0.90
	29/6	06 35	20	0.70	2.10
	,,	10.00	10	0.10	0.60
	3/7	03 25	15	0.46	1.84
	,,	06.15	25	0.70	1.44
	,,	06.50	5	0.08	0.96
	10/7	19.50	25	0.58	1.39
	,,	21.55	5	0.05	0.60
	11/7	00.13	5	0.18	2.16
	15/7	04 55	10	0 38	2.28
	2/8	10.40	5	0.08	0 96
	,,	11.00	45	0 69	0.92
	,,	11.50	40	0.40	0.60
	,,	12 35	25	0.40	0.96
	8/8	15.35	10	0.19	1.14
	10/8	10.15	60	1.34	1.12

DIX

AT LAHORE—DURING 1945—1950 (*contd.*)

FALL IN MINUTES

5	10	15	20	25	30	35	40	45	50	55	60	65
0.12	0.21		..	...	...	...	...	...	...	...	...	...
0.05	0 10	0.15	0.20	...	...	...	...	...	..	...	...	...
0.06	...	...	..	...	...	...	..	..	...	...	...	...
0.09		...	...	...	.	...	...	...	...	...	...	..
0.07	0.14	...	.	..	...	..	...	...	...	...	...	...
0.06	0.14		...	...	...	...	...	..	..	...	...	...
0.07	0.18	.	..	...	...	...	...	...	...	...	...	...
0.05	..	...	..	...	...	...	...	...	...	...	...	...
0.07	0.19	0.29	0.37	0.41	...	...	...	...	...	...	...	...
0.06	...	...	...	...	...	...	...	...	...	...	...	...
0.05	0.09	..		..	...	...	...	...	...	...	...	...
0.05	0.17	0.25	0.30	..	...	...	...	...	...	...	...	...
0.10	0.28	0.46	0 70	...	...	...	...	...	...	...	...	...
0.04	0.10	...	...	..	...	...	...		..	...	...	...
0.08	0.40	0.46	...		...	...	...	.	...	...	...	...
0.19	0.37	0.51	0.61	0.70	...	...	..	...	.	...	...	...
0.08	...	..	...		...	...	...	.	...	...	...	...
0.07	0.15	0.26	0.46	0.58	...	...	...	...	...	.	...	...
0.05	...	...	....	...	...	..		...	...	...	...	...
0.18	...		..	..	...	...	...	...	...	...	...	...
0.08	0.38	...	..	...	...	...	...	...	...	...	...	...
0.08	...		...	...	...	...	...	..	...	.	...	...
0.10	0.18	0.24	0.29	0.34	0.39	0.45	0.51	0.69	...	...	...	...
0.05	0.10	0.15	0.20	0.23	0.28	0.33	0.40		...	...	...	...
0.06	0.12	0.18	0.28	0.40	0.40	...	...	...	...	...	...	...
0.06	0.19		...	...	.	...	...	...	...	...	...	...
0.06	0.12	0.22	0.34	0.46	0.58	0.64	0.76	0.86	0.96	1.26	1.34	...

APPEN

INTENSE FALLS OF RAIN IN SHORT PERIODS

Year	Date	Time of commence-ment	Duration in minutes	Amount in inches	Intensity in/hr
1947	4/1	22.35	5	0.04	0.48
	5/2	02.25	5	0.05	0.60
	,,	05.44	5	0.04	0 48
	3/3	11 25	5	0.07	0.84
	,,	15.30	5	0.06	0 72
	4/3	02.00	5	0 08	0.96
	,,	02.10	5	0.07	0.84
	22/3	18.50	5	0 10	1.20
	10/8	08.00	30	0.72	1.44
	11/8	05.05	5	0.11	1.32
	12/8	01.55	5	0.05	0 60
	,,	05.50	10	0.12	0.72
	,,	06.15	15	0.44	1,76
	,,	07.40	5	0 10	1.20
	,,	07.55	10	0.12	0.72
	15/8	01.25	5	0.10	1.20
	,,	01.40	5	0.09	1.08
	16/8	08.10	5	0 07	0.84
	,,	09.35	5	0.07	0.84
	23/8	02.12	5	0 05	0,60
	27/8	12.52	5	0.28	3.36
	27/8	17 08	15	0 37	1.48
	,,	17.57	5	0.05	0.60
	,,	18.25	20	0.31	0.93
	28/8	11.50	5	0.08	0.96
	29/8	09.15	5	0,18	2.16
	30/8	07.00	15	0.23	0.92
	,,	09.57	5	0 05	0.60
	,,	10.43	10	0.21	1.26
	5/9	15.50	10	0.13	0.78
	16/9	08.00	5	0.06	0.72
	20/9	03.20	40	0.90	1.35
	4/10	10.30	55	0.83	0.91
	22/12	07.13	5	0.05	0.60

DIX

AT LAHORE—1945—1950 (*contd.*)

FALL IN MINUTES

5	10	15	20	25	30	35	40	45	50	55	60	65
0.04	...	...	...	...	...	...	...	...	...	...	...	...
0.05	...	...	...	...	...	...	...	...	...	...	...	...
0.04	...	...	...	...	...	...	...	...	...	...	...	...
0.07	...	...	.	...	...	...	...	...	...	...	...	...
0.06	...	...	...	...	...	...	...	...	...	...	...	...
0.08		...	...	...	...	...	...	...	...	...	...	...
0.07	...	...	...	...	...	...	...	...	...	...	...	...
0.10	...	...	...	..	...	...	...	...	...	...	...	...
0.06	0.23	0.40	0.50	0.61	0.72	...	...	...	...	..	...	...
0.11	...	...	...	...	...	...	...	...	...	...	...	...
0.05		...	...	...	...	...	...	...	...	...	...	...
0 06	0.12	...	...	...	...	...	...	...	...	...	...	...
0.20	0.34	0.44	...	...	...	...	...	...	...	...	...	...
0.10		...	...	...	...	...	...	...	...	...	...	...
0.06	0.12	...	...	...	...	...	...	...	...	...	...	...
0.10	...	...	...	...	...	...	...	...	.	...	...	...
0.09	...	...	...	...	...	...	...	...	...	...	...	...
0.07	...	...	...	..	...	...	...	...	...	...	...	...
0.07	...	...	..	...	...	...		...	...	...	...	...
0.05	...	...	...	...	...	...	...	...	...	...	...	...
0.28		...	...	...	...	...	...	...	...	...	...	...
0.20	0.26	0.37	...	...	...	...	...	...	...	...	...	...
0.05	...	...	...	...	..	...	...	...	...	...	...	...
0.09	0.19	0.25	0.31	...	...	...	...	..	...	...	...	...
0.08	...	...	...	...	...	...	...	...	...	...	...	...
0.18	...	...	...	...	...		...	...	...	...	...	...
0.10	0.16	0.23	...	.	...	...	...	...	.	...	...	...
0.05	...	...	...	...	...	...	...	...	..	...	...	...
0 05	0.21	...	...	...	...	...	...	...	...	...	...	...
0.05	0.13	...	...		...	...	...	...	...	...	...	...
0.06	...	...	...	...	..	...	...	...	...	...	...	...
0.08	0.20	0.30	0.56	0.68	0.76	0.86	0.90	...	...		...	...
0.08	0.16	0.24	0.34	0.46	0.51	0.56	0.64	0.72	0.76	0.83	...	...
0 05	...	...	..	...	...	...	...	...	...	...	...	...

APPEN

INTENSE FALLS OF RAIN IN SHORT PERIODS

Year	Date	Time of commencement	Duration in minutes	Amount in inches	Intensity in hour
1948	3/2	14·20	5	0·09	1·08
	,,	14·50	5	0·04	0·48
	,,	15·10	10	0·08	0·48
	,,	16·32	5	0·04	0·48
	7/3	06·25	5	0·04	0·48
	8/3	08·05	5	0·06	0·72
	,,	08·15	5	0·04	0·48
	10/3	07·10	5	0·06	0·72
	12/3	02·45	5	0·04	0·48
	,,	0?·10	5	0·08	0·96
	,,	11·10	5	0·07	0·84
	,,	11·37	10	0·19	1·14
	3/4	01·03	10	0·21	1·26
	10/6	03·33	5	0 04	0 48
	21/6	10·17	5	0·08	0·96
	10/7	02·40	10	0·36	2·16
	,,	02·55	10	0·19	1·14
	,,	03·35	5	0·10	1·20
	,,	05·20	10	0·12	0·72
	14/7	02·55	25	0·77	1·85
	,,	04·15	15	0·48	1·92
	,,	05·25	10	0·16	0·96
	,,	05 50	5	0 04	0·48
	,,	06·10	25	0 92	2·21
	,,	06·55	5	0·06	0·72
	,,	07 38	15	0·25	1·00
	,,	08·00	10	0 22	0·72
	,,	08·30	5	0·06	0·72
	,,	08·40	5	0·06	0·72
	18/7	23·05	10	0·19	1·14
	,,	23·25	5	0·12	1·44
	19/7	04·35	5	0 07	0·84
	22/7	01·50	10	0·12	0·72
	,,	04·15	45	0·48	0·64
	,,	05·45	5	0·07	0·84
	,,	06·10	5	0·08	0·96
	,,	07·20	15	0·28	1·12
	,,	07·37	10	0·16	0·96
	,,	07·55	10	0·12	0·72
	,,	09·43	5	0·06	0·72
	,,	09 53	10	0·18	1·08
	,,	10·15	15	0·30	1·20
	,,	11·07	15	0·32	1·28
	,,	12·40	20	0·42	1·56
	,,	13·38	10	0·10	0·60
	,,	13·50	5	0·05	0·60
	28/7	06·12	5	0·06	0·72
	,,	06·25	10	0·11	0·66
	4/8	11·45	45	0·92	1·23
	7/8	14·25	15	0·33	1·32
	8/8	12·45	30	0·70	1·40
	11/8	13·00	15	0·46	1·84
	,,	13·30	15	0·44	1·76
	,,	16·37	15	0·35	1·40
	,,	21·48	5	0·08	0 96
	,,	21·55	5	0·16	1·92
	,,	22 25	15	0·32	1·28
	,,	23·32	5	0·10	1 20
	12/8	09·50	15	0·13	0·52
	,,	11·57	35	0·72	1 23
	,,	13·15	5	0·09	1·08
	,,	17·15	10	0·23	1·38
	,,	17·28	20	0·26	0·78
	13/8	04·35	5	0·08	0 96

DIX

AT LAHORE DURING 1945-1950—(Contd.)

FALL IN MINUTES

5	10	15	20	25	30	35	40	45	50	55	60	65
0·09	...	...	...	...	...	...	...	...	...	...	...	...
0·04	...	...	...	...	...	...	...	...	...	...	...	...
0·04	0·08	...	...	...	...	...	...	...	...	...	...	...
0·04	...	...	...	...	...	...	...	...	...	...	...	...
0·04	...	...	...	...	...	...	...	...	...	...	..	...
0·06	...	...	...	...	...	...	...	...	...	...	...	...
0·04	...	...	...	...	...	...	...	...	...	...	...	...
0·06	...	...	...	...	..	...	..	...	...	...	...	...
0·04	...	...	...	...	...	...	...	...	...	...	...	...
0·08	...	...	...	...	...	...	...	...	...	...	...	...
0·07	0·19	...	...	...	...	...	...	...	...	...	...	...
0 08	0·21	...	...	...	...	...	...	...	...	...	...	...
0·14	...	...	...	...	...	...	...	...	...	...	...	...
0·04	...	...	...	...	...	...	...	...	...	...	...	...
0·08	...	...	...	...	..	...	...	...	...	...	...	...
0·12	0·36	...	...	...	...	...	...	...	...	...	...	...
0·07	0·19	...	...	...	...	...	...	...	...	...	...	...
0·10	...	...	...	...	...	...	...	...	...	...	...	...
0·08	0·12	...	..	...	...	...	...	...	...	...	...	...
0·06	0·20	0·28	0·66	0·77	...	...	...	...	...	...	...	...
0·06	0·24	0·48	...	...	...	..	...	...	...	...	...	...
0·10	0·16	...	...	...	...	...	...	...	..	...	...	...
0·04	...	...	...	...	...	...	...	...	...	...	...	...
0·16	0·36	0·54	0·74	0·92	...	...	...	...	...	...	...	...
0·06	...	...	...	...	...	...	...	...	...	...	...	...
0 10	0·21	0·25	...	...	...	...	...	...	...	...	...	...
0·18	0·22	...	...	...	...	...	...	...	...	...	...	...
0·06	...	...	...	...	...	...	...	...	...	...	...	...
0·06	...	...	...	...	...	...	...	...	...	...	...	...
0 09	0·19	...	...	...	...	...	...	...	...	...	...	...
0·12	...	...	...	...	...	...	...	...	...	...	...	...
0·07	...	...	...	...	...	...	...	...	...	...	...	...
0·05	0·12	...	...	...	...	...	...	...	...	...	...	...
0·05	0·10	0·16	0·21	0·26	0·31	0·36	0·42	0·48	...	...	...	...
0·07	...	...	...	...	...	...	...	...	...	...	...	...
0·08	...	...	...	...	...	...	...	...	...	..	...	...
0·12	0·20	0·28	...	...	...	...	...	...	...	...	...	...
0·08	0·16	...	...	...	..	...	...	...	...	...	...	...
0·05	0·12	...	...	...	...	...	...	...	...	..	...	...
0 06	...	...	...	...	...	...	...	...	...	...	...	...
0·06	0·18	...	...	...	...	...	...	...	...	...	...	...
0·07	0·18	0·30	...	...	...	...	..	...	...	...	...	...
0·12	0·22	0·32	...	...	...	...	...	...	...	..	...	...
0·16	0·25	0·37	0·42	...	...	...	...	...	...	...	...	...
0·05	0·10	...	...	...	...	...	...	...	...	...	...	...
0·05	...	...	...	...	...	...	...	...	...	...	...	...
0·06	...	...	...	...	...	...	...	...	...	...	...	...
0·06	0·11	...	...	...	...	...	...	...	...	...	...	...
0 07	0·17	0·23	0·39	0·57	0·63	0.68	0·84	0·92	...	...	...	...
0·11	0·23	0·33	...	...	...	...	...	...	...	...	...	...
0·10	0·22	0·34	0·46	0·56	0·70	...	...	...	...	...	...	...
0·18	0 33	0·46	...	...	...	...	...	...	...	...	...	...
0·19	0·30	0·44	...	...	...	...	...	...	...	...	...	...
0·08	0·22	0·35	...	...	...	...	...	...	..	...	...	...
0 08	...	...	...	...	...	...	...	...	...	...	...	...
0·16	...	..	...	...	...	...	...	...	...	...	...	...
0·05	0·26	0·32	...	...	...	...	...	...	...	...	...	...
0·10	...	..	...	...	...	...	...	...	...	...	...	...
0 05	0·09	0·13	...	...	..	...	...	...	...	...	...	...
0·05	0·12	0·22	0·33	0·47	0·63	0·72	...	...	...	...	...	...
0·09	...	...	...	...	...	...	...	...	...	...	...	...
0·10	0·23	...	...	...	...	...	...	...	...	...	...	...
0·08	0·12	0·20	0.26	...	...	...	...	...	...	...	...	...
0·08	...	...	...	...	...	...	...	...	...	...	...	...

APPEN

INTENSE FALLS OF RAIN IN SHORT PERIODS

Year	Date	Time of commence-ment	Duration in minutes	Amount in inches	Intensity in/hr.
1949	2/2	00.40	5	0 05	0.60
	3/2	20.15	30	0.38	0.76
	23/3	02 25	5	0.11	1.32
	6/6	00.00	10	0.15	0.90
	27/6	03.43	5	0.11	1.32
	11/7	05.30	5	0.07	0.84
	,,	07.30	10	0.28	1.68
	14/7	09.50	20	0.33	0 99
	19/7	07.48	5	0.22	2.64
	,,	08 00	5	0.08	0.96
	20/7	03.40	5	0.06	0.72
	,,	03.55	5	0.15	1.80
	21/7	03.00	10	0.19	1.14
	22/7	05.10	5	0.08	0.96
	,,	05.28	5	0.06	0.72
	25/7	01.00	10	0.10	0.60
	,,	03.10	20	0.24	0.72
	,,	12.00	25	0.30	0.72
	30/7	11.00	15	0.29	1.16
	2/8	04.15	10	0.25	1.50
	,,	04.30	15	0.14	0.56
	,,	15.25	5	0.06	0.72
	,,	16.28	5	0.06	0.72
	3/8	05.32	5	0.05	0.60
	9/8	09.52	10	0.12	0.72
	24/8	22.37	5	0.08	0.96
	25/8	03.42	5	0.29	3.48
	3/9	02.50	10	0.33	1.98
	,,	07.00	35	0.70	1.20
	28/9	21.05	20	0.47	1.41
	30/9	22.25	10	0.16	0.96

DIX

AT LAHORE—DURING 1945—1950 (*concld.*)

FALL IN MINUTES

5	10	15	20	25	30	35	40	45	50	55	60	65
0.05	...	...	...	...	...	...	...	...	...	...	...	...
0.04	0.09	0.19	0.25	0.33	0.38	...	...	...	...	...	...	...
0.11	...	...	...	...	...	...	...	...	...	...	...	...
0.09	0.15	...	...	...	...	...	...	...	...	...	...	...
0.11	...	...	...	...	...	...	...	..	...	...	...	...
0.07	...	...	...	...	...	...	...	...	...	...	...	..
0.20	0.28	...	...	...	...	...	...	...	...	...	...	...
0.09	0.19	0.25	0.33	...	...	...	...	...	..	...	...	...
0.22	...	...	..	...	...	...	...	...	...	...	...	...
0.08	...	...	...	...	...	...	...	...	...	...	...	...
0.06	...	...	...	...	...	...	...	...	...	...	...	...
0.15	...	...	...	...	...	...	...	...	...	...	...	...
0.14	0.19	...	...	...	...	...	...	...	...	...	...	...
0.08	...	...	...	...	...	...	...	...	...	...	...	...
0.06	...	...	...	..	...	...	...	...	...	...	...	...
0.05	0 10	...	...	...	...	...	...	...	...	...	...	...
0.05	0.10	0.18	0.24	...	...	...	...	..	...	...	...	...
0.05	0.11	0.17	0.23	0.30	...	...	..	...	...	...	...	...
0.10	0.20	0.29	...	...	...	...	...	..	...	...	...	...
0.17	0.25		...	..	...	...	...	...	...	...	...	...
0.04	0.08	0.14	...	...	...	...	..	.	...	...	...	...
0.06	...	...	...	...	...	...	...	...	...	...	...	...
0.06	...	..	...	...	...	...	...	...	...	...	...	...
0.05	...	...		...	...	...	...	...	...	..	...	...
0 06	0.12	...	...	...	...	...	...	...	...	...	...	...
0.08	...	...	.	...	...	...	...	...	...	...	...	...
0.29	...	...	...	...	...	...	...	...	...	...	...	...
0.18	0.33	...	..	...	...	...	...	...	...	...	...	...
0.10	0.20	0.30	0.40	0.58	0.64	0.70	...	...	..	...	...	...
0.10	0.22	0.40	0.47	...	...	...	...	...	...	...	...	...
0.08	0.16	...	...	...	...	...	...	...	...	...	...	...

APPEN

INTENSE FALLS OF RAIN IN SHORT

Year	Date	Time of commence-ment	Duration in minutes	Amount in inches	Intensity in/hr.
1950	18/1	06.15	10	0.10	0.60
	19/1	12.40	5	0.05	0.60
	26/1	01.37	15	0.40	1.60
	8/2	15.30	5	0 05	0.60
	,,	18.37	10	0.21	1.26
	21/3	04.00	5	0.09	1.08
	22/3	01.35	10	0.39	2.34
	,,	17.05	5	0.10	1.20
	,,	23.05	10	0.13	0.78
	23/3	16.15	15	0.32	1.28
	26/3	15.40	10	0.40	2.40
	5/7	05.30	15	0.38	1.52
	,,	07.00	5	0.09	1.08
	9/7	15.00	5	0.05	0.60
	11/7	11.30	5	0.04	0.48
	13/7	05.53	10	0.33	1.98
	17/7	11.16	25	0.40	0.96
	24/7	13.45	5	0.06	0.72
	28/7	12.55	5	0.05	0.60
	1/8	13.28	15	0.35	1.40
	2/8	06.55	5	0.07	0.84
	,;	07.10	5	0.20	2.40
	5/8	08.15	15	0.32	1.28
	,,	09.45	5	0.12	1.44
	7/8	18.10	10	0.19	1.14
	11/8	12.40	25	0.53	1.26
	13/8	16.30	30	1.30	2.60
	3/9	06.30	5	0.06	0.72
	4/9	02.25	5	0.08	0.96
	,,	04.40	5	0.09	1.08
	14/9	09.10	10	0.24	1.44
	,,	10.40	25	0.34	0.78
	17/9	03.30	35	0.73	0.98
	,,	11.45	15	0.20	0.80
	19/9	11.40	10	0.10	0.60
	,,	12.00	10	0.10	0.60
	,,	12.45	65	0.70	0.65
	,,	14.40	5	0.06	0.72
	,,	16.20	5	0.06	0.72
	,,	16.45	60	0.70	0.70
	,,	20.20	10	0.12	0.72

Total =

Total No. of occasions =

Mean =

DIX

PERIODS AT LAHORE—1945-1950 (*concld.*)

FALL IN MINUTES

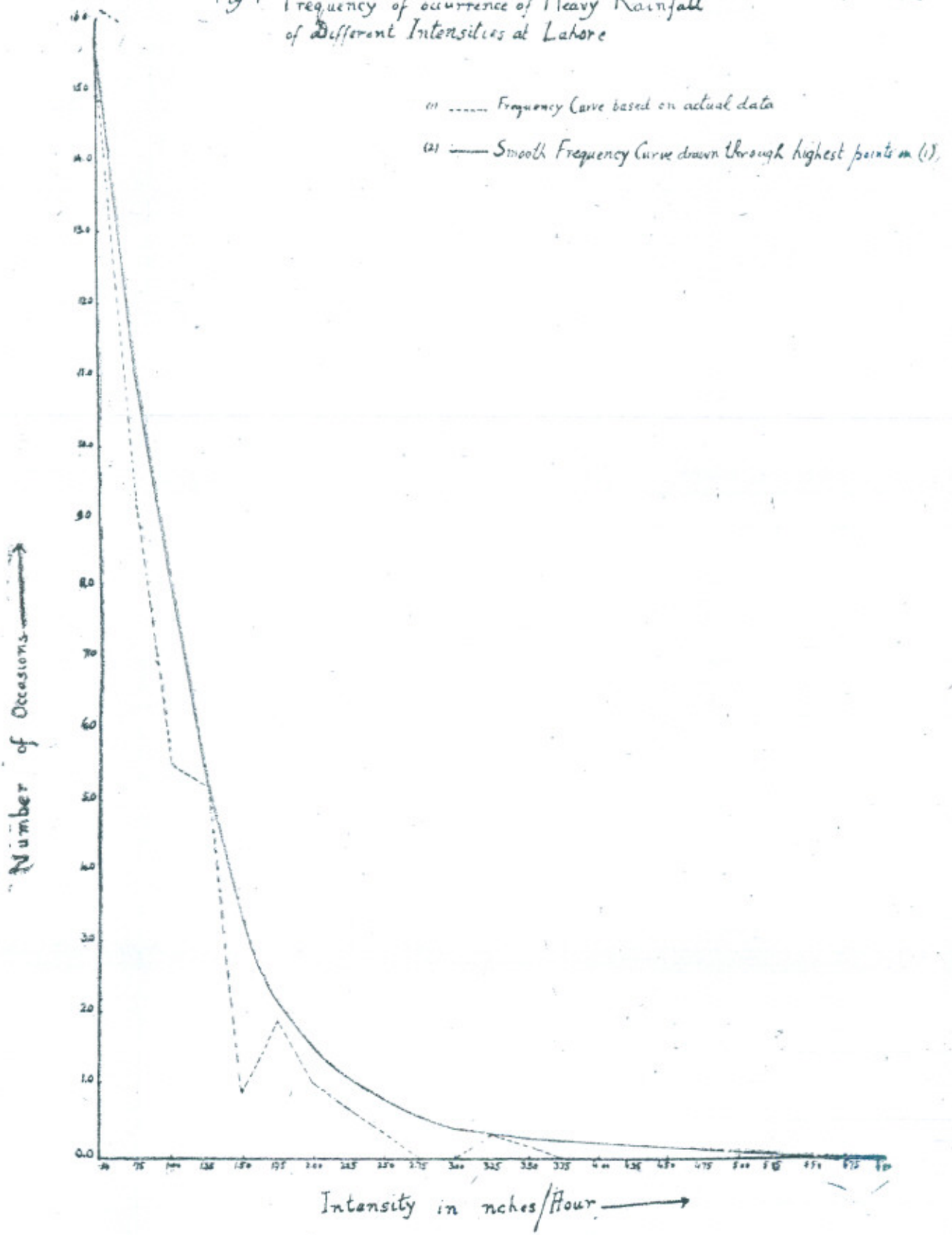
5	10	15	20	25	30	35	40	45	50	55	60	65
0.05	0.10	...	...	...	...	...	..	...	...	...	...	...
0.05	...	...	...	..	...	...	...	...	...	...	...	...
0.16	0.28	0.40	...	...	...	...	...	...	..	...	...	...
0.05	...	...	...	...	..	...	...	...	...	...	...	...
0.10	0.21	...	...	..	...	...	...	...	...	...	...	..
0.09	...	...	...	...	...	...	...	...	...	...	...	...
0.13	0.39	...	...	...	...	...	...	...	...	...	..	...
0.10	...	...	...	...	...	...	...	...	...	...	...	...
0.06	0.13	...	...	...	...	...	...	..	...	...	...	...
0.08	0.22	0.32	...	...	...	...	...	...	...	...	...	...
0.12	0.40	...	...	...	...	...	...	...	...	...	...	...
0.10	0.20	0 38	...	...	...	...	...	...	...	...	...	...
0.09	..	...	...	...	...	...	...	...	...	...	...	...
0.05	...		...	...	...	...	...	...	...	...	...	...
0.04	...	...	...	...	...	...	...	...	...	...	...	...
0.13	0.33	...	...	...		...	...	...	...	...	...	...
0.08	0.16	0.24	0.31	0.40	...	...	...	...	...	...	...	...
0.06	...	...	...	...	...	...	...	...	...	...	...	...
0.05	...	...	...	...	...	...	...	...	...	...	..	...
0.07	0.23	0.35	...	...	...	...	...	...	...	...	...	...
0.07	...	...	...	...	...	...	...	...	...	...	...	...
0.20	...	...	...	...	...	..	...	...	...	...	...	...
0.09	0,24	0.32	...	...	...	...	...	...	...	...	...	...
0.12	...		...	...		...	...	..	...	...	...	...
0.14	0.19	...	...		...	...	...	...	...	...	...	..
0.05	0.17	0.33	0.45	0.53	...	...	...	...	...	...	...	...
0.26	0.46	0.76	0.98	1.16	1.30	.	...	...	...	...	...	...
0.06	...	...	...	...	...	...	...	...	...	...	...	...
0.08	...	...	...	...	...	...	..	..	...	...	...	...
0.09	...	...	...	...	...	...	...	..	..	..	...	...
0.14	0.24			...	...	...	...	...	...	...	..	...
0.06	0.12	0.17	0.27	0.34	...	...	...	...	...	...	...	...
0.06	0.16	0.36	0.46	0.56	0.68	0.73	...	...	...	...	...	...
0.06	0.14	0.20	...	...	...	...	...	...	...	...	...	...
0.05	0.10	...	...	...	...	...	...	..	...	...	...	...
0.05	0.10	...		...		..	..	...	...	...		...
0.05	0.10	0.15	0·20	0.25	0.30	0.38	0.43	0.48	0.53	0.58	0.65	0.70
0.06	...	...	...	...	...	...	...		...	...	...	...
0.06		...	...		...	..	...	..	...	...		...
0.06	0.11	0.16	0.22	0.27	0.36	0.42	0.47	0.52	0.58	0.64	0.70	...
0.06	0.12	..	...		...	...	...	...	...	...	...	...
19.21	28.75	21.26	17.77	17.03	13.41	9.84	8.45	8.00	5.08	2.48	2.69	0.70
240	130	71	45	34	24	17	13	11	6	3	3	1
0.08	0.22	0.30	0.39	0.50	0.56	0.58	0.65	0.73	0.85	0.83	0.90	0.70

PAPER NO: 33

Fig 1 Frequency of occurrence of Heavy Rainfall of Different Intensities at Lahore

(1) ..... Frequency Curve based on actual data

(2) —— Smooth Frequency Curve drawn through highest points in (1).



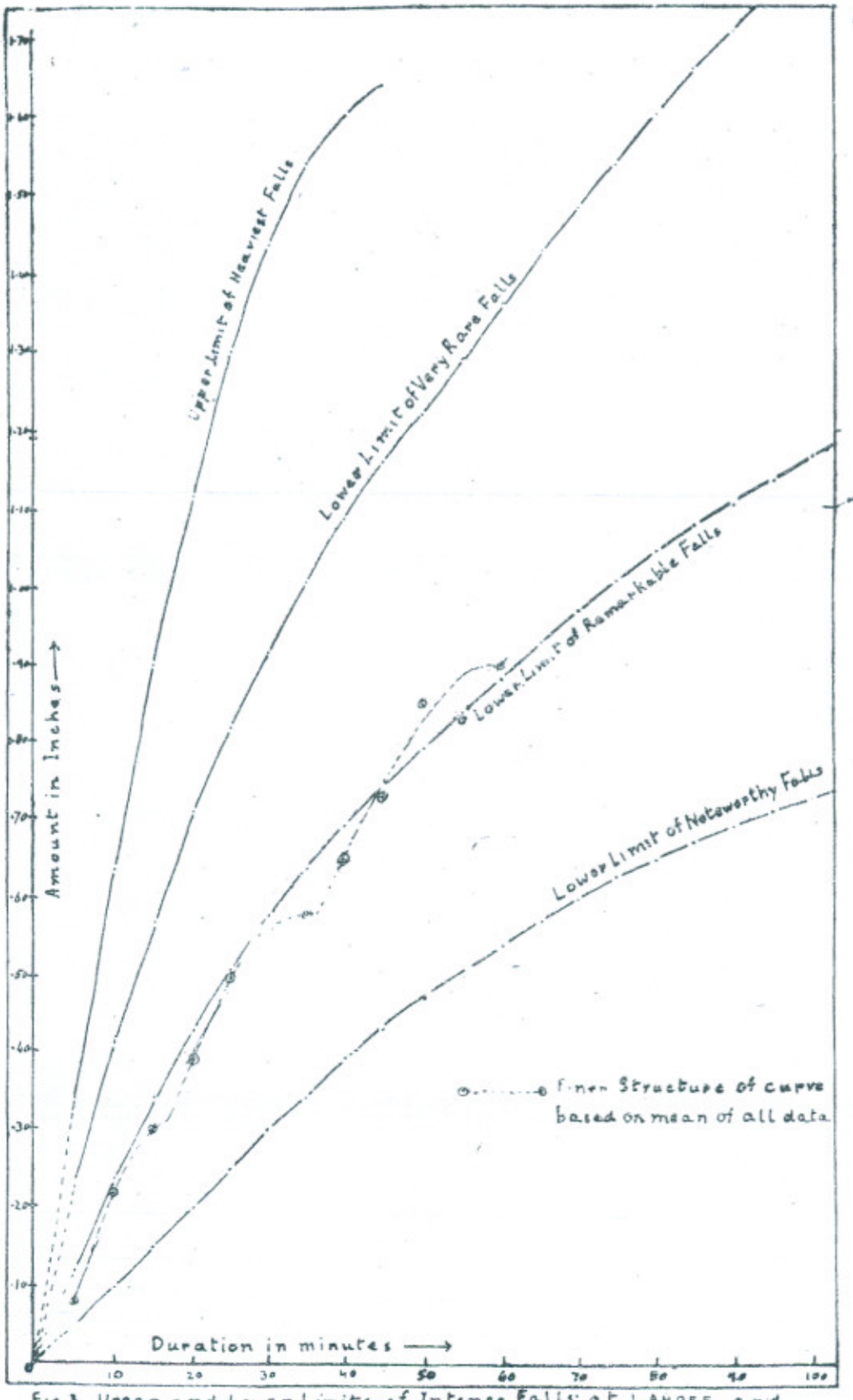


Fig. 3. Upper and Lower Limits of Intense Falls at LAHORE and curve based on mean of all data