PAPER No. 292.

M. A. RAHIM, I. A. ZAFAR, S. M. NIAZ :—
Flood Control Investigations in West Pakistan.

Mr. M. A. Rahim :—It falls to my lot as one of the 3 collaboraters to introduce our joint paper on "Flood Control Investigations in West Pakistan". Due to certain limitations, lack of data and time, it has not been possible to make it less academic and more practical. However, we consider that even in this form, the paper will be of certain practicability to the authorities tackling flood control problems. We have tried to include most of the aspects of the floods and their control, with their special application to conditions in West Pakistan. For example, causes of floods, their magnitude and frequency, various protection measures and their relative utility, economic analysis of flood control projects and their benefits, are some of the headings dealt with.

It appears to be a problem with various departments whether to choose 1950 flood magnitude for designing various works connected with floods. With this in view, we have made studies for various rivers at different localities with whatever data was available with us and have established equations based on statistical grounds which can be utilised to determine the exceedence interval for floods As for instance, it would be found from these that 1950 flood in Ravi at Shahdara was a 54 year flood while that at Sidhnai a 75 year flood. It will be noted that this method is more reliable than the usual probability method. Comparison of results by the two methods has been made on Page 95 of the Paper.

It may be noted that flood in Ravi during 1947 was actually higher than that in the last flood ; in fact, more than a 100 year flood. It was a partition flood. When I call it a partition flood, it reminds one of a coincidence which must have been noted by everyone that the rivers near the border were those mostly in spate during September, 1947, that is, Ravi, Sutlej, Chenab, Jhelum and Sind were comparatively quiet. No wonder that this elicited the remarks from somebody that the land of the five rivers was in fury at this unnatural vivisection of the motherland.

Results of additional investigations which could not be published in the paper originally, will be handed over now for incorporation along with the discussion. It may however be pointed out that further details of probability studies could not be made due to lack of time, data and on account of limitations imposed to make the paper brief.

It always requires a rare flood of wide spread damaging nature to arouse the public and the authorities to consider problems of flood control seriously. The energies of the Engineers should not slacken and investigation for all the possible flood control projects for various sites should be carried out. As far as possible, multipurposes projects should be taken up first as these promise immediate tangible benefits besides flood control advantages.

Importance of co-ordination by various Departments for flood control measures has been stressed in the paper and it can hardly be overemphasized, otherwise, a particular project proposed by one Department at a point may create problems for another Department at some other point. Such a co-ordination will naturally result in an economical solution for the joint problems.

Various recommendations in the paper have been made, bearing in mind the needs of various Departments and based on difficulties which were felt while writing this paper. Setting up of a river control authority is of paramount importance. Some of its functions can be undertaking snow surveys, fixing catchment areas for various rivers and their tributaries, studying regime fluctuations of rivers and flood frequency. A central waterways laboratory should also be set up to undertake all model investigations for river structures. A right step has been taken in this direction with the setting up of the Punjab Flood Commission

There is hardly any systematic manner of collecting data relating to characteristics of floods. We have prepared a proforma for the purpose, which has just been placed in your hands. This is rather comprehensive because it is meant to cater for requirements of various Departments who will fill up the respective portions pertaining to them. It is expected that such a standard proforma, when completed will be of immense use to the proposed river control authority for basing design of any works connected with floods. Various annexures and this proforma could not be embodied in the paper in the first instance due to some limitation which could have afforded a chance for the members to appreciate and offer their constructive criticism.

At the end, the authors would like to express their sincere gratitude to Khan Bahadur Sheikh Abdul Hamid, Chief Engineer, Irrigation and M. J. Chughtai, Esquire, Chief Engineer, N. W. R. for their valuable suggestions.

APPENDIX TO PAPER No. 292

Proforma (A) for collection of information during floods

Place of observation..... ....

Dates

I.—Meteorological Data	1	2	3	4	5	6	7
(1) Intensity of rainfall during previous 24 hours to be obtained from Meteorological Department							
(2) *Type of rainfall in column 1.*—(continuous, intermittent, light drizzle or cloud-burst type with approximate duration of each.							
(3) Duration of the storm and approximate wind velocity.							
(4) Area covered by the storm in sq. miles as deduced from the rainfall map.							
(5) Name of the important tributaries of the river affected by the storm.							
(6) Direction of the storm.							
(7) Maximum and minimum temperature variation.							
II.—Hydraulic observations.							
(1) Gauge readings or defining the H. F. L. with respect to a fixed point where no gauges exist.							
(2) Velocity by float system or any other method.							
(3) Afflux-variation in upstream, centre line and downstream water flow depths.							
(4) Discharge by observation or computation.							

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Proforma (A) for collection of information during floods

Place of observation ....

	Dates						
	1	2	3	4	5	6	7
(5) Any scours detected and scour depths below fixed points.							
(6) Duration of the peak flood with time and date.							
III.—Watershed characteristics							
(1) Brief description about the watershed ; like shape, physical and geological features. Lay out of the main stream and important tributaries with a view to determine their concentration.							
IV.—Configuration of the flood plain and interferences to its natural topography.							
(1) Whether road, railway, canal or any embankments, cut across natural drainage lines on upstream or the downstream side and their behaviour during the flood indicating dispersion factor.							
(2) Relative life of these structures.							
(3) Vegetation and humus growth and any other interferences to the flood flow.							
(4) Whether approach of flood flow radial or at a bend (nominal medium or severe).							
(5) Adverse effects caused by failure of canals or any other protection lines.							
(6) Nature of the soil and position of the subsoil water.							

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Proforma (A) for collection of information during floods.

Place of observation.....

Dates

	1	2	3	4	5	6	7
(7) Any intentional cuts made by government authorities or public to avert thereat at certain other points.							
(8) In the event of previous flood attacks in the same locality whether these features repeated themselves.							
(9) Any known proposals which are going to cause further interferences in the flood plain and bring about adverse effects.							
V.— Cause of the flood.							
(1) Whether due to local rain over a water shed.							
(2) Whether due to spilling from some river or a Nallah or a combined attack from various sources.							
V.—Duration of flood flow							
(1) Approximate location of points of spilling with probable route adopted by the flood flow to be given on an index plan, scale 1" =1 mile. Scale may be adjusted if area to be shown so demands.							
(2) Any idea about discharge spilt over, at various points.							

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Proforma (A) for collection of information during floods.

Place of observation ....

	Dates						
	1	2	3	4	5	6	7
VII. Behaviour of embankments against headed up flood water.							
(1) Nature of soil composing the bank and condition of compaction.							
(2) Saturation period.							
(3) Weeping action on the down stream face.							
(4) Sand blowing and oozing out of the seepage water on dry face.							
(5) Wind erosion.							
(6) Whether crown width, free board and slopes adequate considering hydraulic gradiant.							
(7) Any suggestions for strengthening of the embankment.							
VIII. Behaviour of control points on rivers and important Nullahs :—							
Bridges, canal headworks syphons, aqueducts etc :—							
(1) Whether full waterway functions.							
(2) Whether free board adequate or not.							
(3) Whether abnormal afflux due to high velocity head.							
(4) Whether any severe scouring or undermining action noticed.							

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Proforma (A) for collection of information during floods.

Place of observation ....

	Dates						
	1	2	3	4	5	6	7
(5) Whether the guide bund system functioned successfully.							
(6) Approximate idea about discharge spilt over on the upstream approach.							
(7) Any visible development of creeks on upstream or the down stream direction with possible reasons.							
(8) Behaviour of the retired bund system like marginal bunds etc.							
(9) Possible adverse effects of any schemes to construct new control points on upstream or the downstream directions.							
(10) Any emergency measures adopted to protect the structures which had an adverse flood attack at some other points during course of the flood.							
(11) Any suggestions based on observations during the flood.							
IX. Local information gathered to draw comparison of the flood intensity with past floods with a detailed justification							
(1) Area under sweep of the flood.							
(2) Flood heights attained.							
(3) General idea about the damage							

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Proforma (A) for collection of information during floods.

Place of observation..... ....

	Dates						
	1	2	3	4	5	6	7
X.—Damage observed during course of the flood.							
(1) Undermining of any structures.							
(2) Uplifting of any foundations.							
(3) Damage by uneven settlement of founds especially in case of buildings.							
(4) Development of the breaches.							
(5) Scouring action around protection works.							
(6) Subsidence of railway lines, road surfacing etc. by water saturation of the banks.							
XI.—Detail of the indirect losses.							
(1) Every effort should be made to collect as much of damage figures during the floods as possible especially the indirect losses like dislocation and longer routing of communication system, and temporary remedicl measures adopted to minimise the flood attack, emergency evacuation of civil population etc. Otherwise the detailed damage figures can best be collected after the floods, as detailed in proforma (B).							
XII.—Remedial measures.							
(1) Any measures adopted before the anticipated flood attack, like temporary dips, openings, breaching sites, provision of stone pitching, laying gunny bags, etc :							

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Proforma (A) for collection of information during floods.

Place of observation ....

Dates

	1	2	3	4	5	6	7
(2) Measures adopted during the actual flood attack like filling the scour holes, checking erosion or undermining action, filling rat holes, checking wind erosion, strengthening of banks, intentional cuts or breaching sites made, construction of protection bunds and feeding the aprons etc :							
(3) Proposals for future long range remedial measures based on experience during course of the flood.							

XIII.—Any recommendations or special remarks.

Generally, recommendations can best be based on actual difficulties experienced during the flood attack and they should be brought on record to be useful for subsequent proposals. Local factors having special bearing on subsequent investigations should be given in detail against various items of this proforma.

I.—Proforma (B) for collection of information after floods :—

(1) Whether H. F. L. if above the previous record marked on bridges or other masonary structures.							
(2) What is its R. L. both on the upstream and the downstream faces.							

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Proforma (B) for collection of information after floods.

Place of observation..... ....

Dates

	1	2	3	4	5	6	7
II.—Modifications in configuration of the water shed or the flood plain :—							
(1) Any changes in the local ground slope because of deposit of the sediment.							
(2) Any change in the natural drainage lines with possible reasons.							
(3) Changes in the subsoil water level.							
(4) Any obstructions in the passage of flood flows created or cleared.							
(5) Effect on vegetation growth and other physical features.							
(6) Gulley formation.							
II. Regime changes of rivers and the important Nullahs as visible to the naked eye in anticipation of survey work :—							
(1) Apparant fluctuations in course of Rivers or Nullahs.							
(2) Tendency for creeks and bye-pass channels to develop.							
(3) Behaviour of bed levels, phenomanon of accretion etc :							
(4) Undermining, side erosion etc :							
(5) Behaviour of water ways in the flood openings.							

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Proforma (B) for collection of information after floods.

Place of observation ....

	Dates						
	1	2	3	4	5	6	7
(6) Development of cut offs.							
(7) Embayment behind any structures.							
IV.—Detail of the direct damage :—							
(1) Dimensions of the breaches.							
(2) Damage to the banks, roads, Railway track, canals etc :							
(3) Damage to masonary structures of bridges or canal headworks, like piers, abutments, curtain walls, loose apron etc :							
(4) Damage to training works like guide bund system, retired bund system, apron etc :							
(5) Damage to buildings.							
(6) Damage by deposition of sediment.							
(7) Damage to community services like electric and water supplies sewerage system telegraph installations, etc :							
(8) Damage to flood control and drainage works.							
(9) Damage to public property and miscellaneous.							

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Proforma (B) for collection of information after floods.

Place of observation ....

Dates

	1	2	3	4	5	6	7
(10) Damage to agricultural property like grain, crops fertility of lands etc.							

NOTE :—

Figures of damages should be collected river-wise or Nullah-wise especially for civil losses and before such estimation exact flood routing should be determined. In case there is a combined attack every effort should be made to split up the figures proportionate to approximate discharge spilling from various sources.

V.—Causes of damages.

(1) Every possible cause should be given against various items in the preceding para.

VI.--Detail of indirect damages

(1) Loss of human life.

(2) Cost on relief, evacuation and rehabilitation of flood viticms.

(3) Interruption to industry and commerce.

(4) Interruption to transport system.

(5) Rise in price index of commodities, shortage of food, famine conditions.

(6) Spreading of epidemics.

APPENDIX TO PAPER No. 292

Proforma (B) for collection of information after floods.

Place of observation ....

	Dates						
	1	2	3	4	5	6	7
(7) Adverse effects on qualities of the drinking water like increased salinity, bacteroleogical contamination etc.							
(8) Cost of temporary arrangements like diversions, protection bunds, transhipments etc.							
(9) Reduction in value of land or urban property because of being vulnerable to flood attack.							
Note. – Every effort should be made to calculate the indirect damages in terms of monetary loss by standardising value of various assets or fixing scales of earning capacities of various services or by detailing the benefits which could have been expected without the floods. Rebate should be given for any advantages achieved because of flooding of certain areas. The concerned departments should supply figures against various items of indirect damages pertaining to them.							
VII. Emergency repair work							
(1) Time taken to restore temporary working of various systems.							
(2) Brief description of the method adopted.							
(3) Any likelihood of the emergency repair work interfering with the permanent work. Any special remarks for subsequent guidance.							

APPENDIX TO PAPER No. 292

Proforma (B) for collection of information after floods.

Place of observation .....

	Dates						
	1	2	3	4	5	6	7
(1) Position of the damaged structures and possibility of their interference to the restoration work.							
(2) Exact depths of scour holes by probing in stagnant water.							
(3) Position of subsoil water flow and arrangements for dewatering to facilitate any construction.							
(4) Chances of any emergency measures adopted during floods to interfere with the repair work like filling up the scours with pitching stone etc.							
IX. Survey Work.							
(1) Whether proper survey work to record regime changes in Nullahs and rivers, characteristics of flood plain, flood routing etc. taken in hand.							
(2) Any practical difficulties in commencing the survey work.							
(3) Whether complete information required to do investigations for adequate flood control proposals collected during the floods or certain data lacking because of practical difficulties.							
VIII. Investigation for permanent repair work.							
For immediate repairs to the damages, detailed study of the site soon after cessation of the flood attack is necessary.							

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Proforma (B) for collection of information after floods.

Place of observation ....

	Dates						
	1	2	3	4	5	6	7
Give detail of any important hydraulic observations which could not be collected witn reasons and which have to be deduced by indirect method of calculations based on the survey work.							
X. Co-ordination between various departments.							
(1) Whether hydraulic observations like gauge readings, discharge, velocity etc. correspond to observations recorded by other departments in close vicinity of the site.							
(2) Whether the contemplated proposals will affect any other department or the public adversely.							
(3) Whether the problems calling for a joint action by various authorities, have been referred to them for proper co-ordination.							
(4) What is the best solution of problems in your opinion.							

APPENDIX No. 5 (a)

RAVI AT SHAHDARA.

(Probability Method)

Sr. No.	Year	Maximum flood cusecs	Maximum discharge in order of magnitude (cusecs)	Number of times peak was equalled or exceeded (n)	Total No : of years for which record is available $=21=y$. $P=100\times n/y$
1	1930	60,000	39,250	21	100
2	1931	80,000	39,400	20	95·2
3	1932	70,200	46,300	19	90·5
4	1933	67,300	50,432	18	95·8
5	1934	39,250	51,600	17	81·0
6	1935	54,050	51,799	16	76·1
7	1936	1,06,870	54,050	15	71·4
8	1937	62,000	55,500	14	66·7
9	1938	51,600	60,000	13	62·0
10	1939	50,432	60,500	12	57·2
11	1940	55,500	62,000	11	52·3
12	1941	39,400	67,300	10	47·6
13	1942	1,29,838	70,200	9	42·9
14	1943	1,00,900	76,900	8	38·1
15	1944	46,300	80,000	7	33·4
16	1945	60,500	86,200	6	28·6
17	1946	76,900	1,00,900	5	23·9

APPENDIX No. 5 (b)

RAVI AT ABDUL HAKIM.

(Probability Method)

Sr No.	Year	Maximum flood cusecs	Maximum discharge in order of magnitude (cusecs)	Number of times peak was equalled or exceeded (n)	Total No. of years for which record is available $=21=years$. $P=100\times n/y$
1	1930	25,426	12,303	21	100
2	1931	12,303	12,981	20	95·2
3	1932	37,104	13,871	19	90·5
4	1933	48,400	13,982	18	85·8
5	1934	25,534	16,061	17	81·0
6	1935	24,512	17,179	16	76·1
7	1936	48,511	22,519	15	71·4
8	1937	17,179	24,512	14	66·7
9	1938	22,519	25,426	13	62·0
10	1939	16,061	25,534	12	57·2
11	1940	13,871	29,524	11	52·3
12	1941	13,982	33,200	10	47·6
13	1942	62,200	37,104	9	42·9
14	1943	50,566	46,233	8	38·1
15	1944	29,524	48,400	7	33·4
16	1945	33,200	48,511	6	28·6
17	1946	12,981	50,566	5	23·9

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APPENDIX No. 5 (c)

CHENAB AT WAZIRABAD.

(Probability Method)

Sr. No.	Year	Maximum flood cusecs	Maximum discharge in order of magnitude (cusecs)	Number of times peak was equalled or exceeded (n)	Total No : of years for which record is available $=19=y$. $P=100\times n/y$
1	1932	269,000	99,516	19	100
2	1933	2,42,926	1,24,310	18	94·9
3	1934	1,44,576	1,44,576	17	89·5
4	1935	2,56,754	1,52,264	16	84·5
5	1936	1,52,264	1,60,000	15	79·1
6	1937	99,516	1,64,819	14	73·7
7	1938	2,55,716	1,66,948	13	68·5
8	1939	1,66,948	1,74,795	12	63·3
9	1940	1,24,310	2,03,644	11	58·0
10	1941	1,64,819	2,12,000	10	52·7
11	1942	2,03,644	2,33,000	9	47·5
12	1943	2,33,000	2,42,926	8	42·2
13	1944	1,60,000	2,43,500	7	36·9
14	1945	1,74,795	2,55,716	6	31·6
15	1946	3,14,311	2,56,754	5	26·3

RAVI AT SHAHDARA

(Exceedence study on Geyer's method)

Y = base value = 10,000 cusecs.

Discharge groups (9)	Counting (2)	Frequency (3)	No. of exceedence (4)	Exceedence interval (21/col. 4)	No. of years for which record is available = 21 years	
					Y/10,000	Log Y/10,000
10,000	.....	18	94	0·224	1	0·0
15,000	.....	9	76	0·276	1·5	0·176
20,000	.....	7	67	0·315	2·0	·301
25,000	.....	8	60	0·35	2·5	·398
30,000	.	1	52	0·405	3·0	·477
35,000	.....	8	51	0·412	3·5	·544
40,000	.....	5	43	0·490	4·0	·602
45,000	.....	5	38	0·552	4·5	·653
50,000	.....	8	33	0·64	5·0	·699
55,000	.....	6	25	0·84	5·5	·740
60,000	.....	7	19	1·11	6·0	·778
70,000	....	4	12	1·75	7·0	·845
80,000	...	3	8	2·63	8·0	·901
1,00,000	..	2	5	4·2	10	1·0
1,20,000	.	1	3	7·0	12	1·079
1,40,000	.	1	2	10·5	14	1·146
2,00,000	.	1	1	21	20	1·301

RAVI AT ABDUL HAKIM

(Exceedence study = on Geyer's method)

Y = base value = 5,000 cusecs.

Discharge groups (1)	Counting (2)	Frequency (3)	No. of exceedence (4)	Exceedence interval (21/col. 4)	No of years for which record is available = 21-years Y/5,000	Log Y/5,000
5,000	. . . . .	68	129	·162	I	0
10,000	. . . . .	13	61	·345	2	·301
15,000	. . . . .	11	48	·439	3	·477
20,000	. . . . .	9	37	·57	4	·602
25,000	. . . . .	7	28	·75	5	·699
30,000	. . . . .	5	21	1	6	·778
35,000	. .	2	16	1·31	7	·845
40,000	. . .	3	14	1·5	8	·903
45,000	. . .	3	11	1·91	9	·954
50,000	.	1	8	2·63	10	1·00
55,000	. .	2	7	3·00	11	1·041
60,000	. .	2	5	4·20	12	1·080
65,000	.	1	3	7·00	13	1·114
70,000	.	1	2	10·50	15	1·176
75,000						
80,000	.	1	1	21	17	1·230
85,000						
90,000		129				

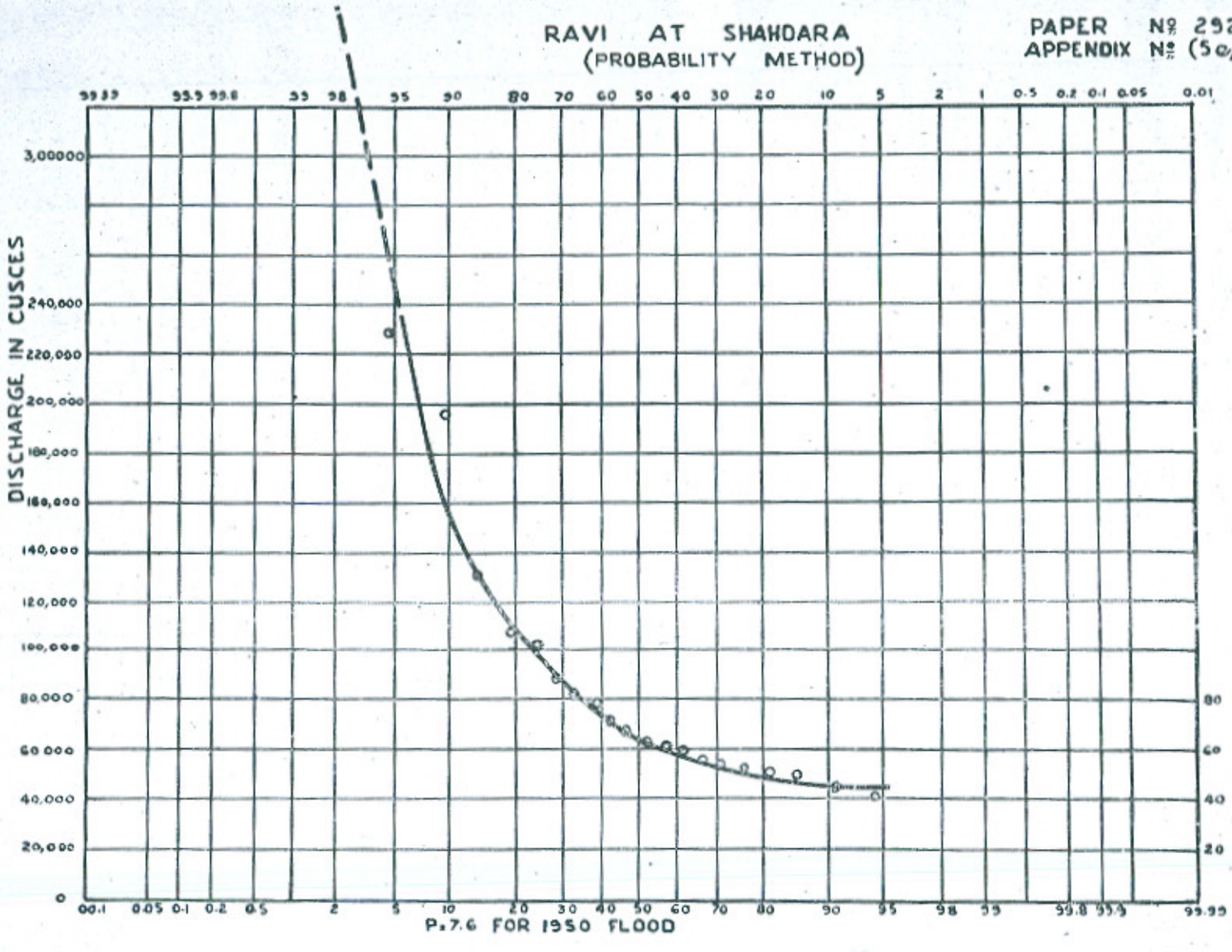
CHENAB AT WAZIRABAD

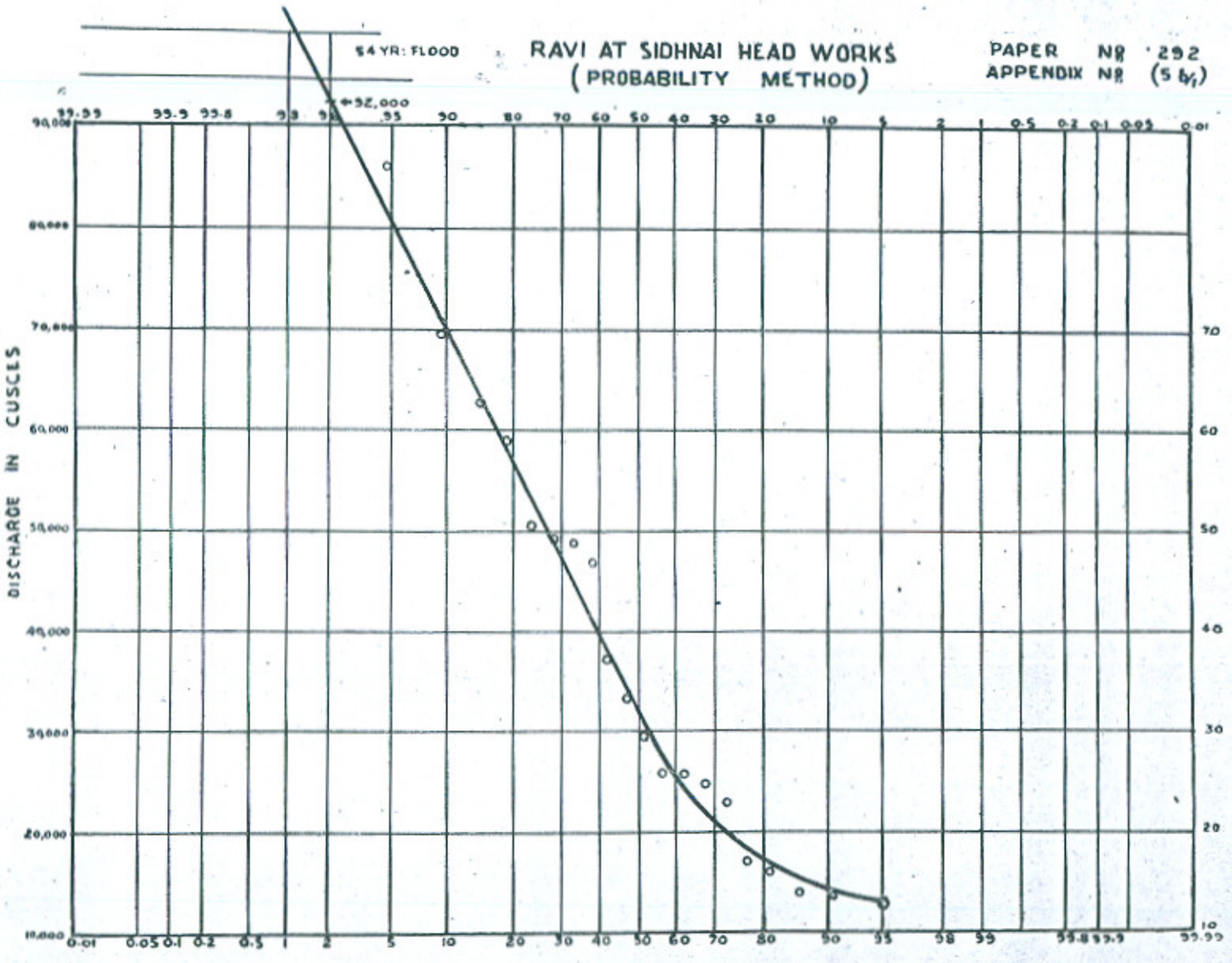
(Exceedence study on Geyer's method)

Y = Base value = 10,000 cusecs.

Discharge groups (1)	Counting (2)	Frequency (3)	No. of exceedence (4)	Exceedence interval (21/col. 4)	No. of years for which record is available = 19 years Y/10,000	Log Y/10,000
10,000	. . . . .	12	163	·117	1	·0
15,000	. . . . .	13	151	·126	1·5	·1761
20,000	. . . . .	13	138	·138	2	0·301
25,000	. . . . .	7	125	.125	2·5	0.3979
30,000	. . .	3	118	·161	3	·4771
35,000	. . . . .	7	115	·166	3·5	·5441
40,000	. . . . .	12	108	·176	4·	·6021
45,000	. . . . .	5	96	·198	4·5	·6532
50,000	. . . . .	14	91	·209	5	·699
60,000	. . . . .	9	77	·246	6	·778
70,000	. . . . .	5	68	·28	7	·8451
80,000	. . . . .	7	63	·302	8	·9031
90,000	. . . . .	7	56	·340	9	·9542
1,00,000	. . . . .	5	49	·388	10	1·0
1,20,000	. . . . .	14	44	·434	12	1·079
1,40,000	. . . . .	11	30	·634	14	1·146
1,60,000	. . . . .	7	19	1	16	1·204
2,00,000	. . . .	4	12	1·59	20	1·301
2,40,000	. . . . .	5	8	2·375	24	1·3802
2,80,000	. .	2	3	6·33	28	1·4472
4,00,000	.	1	1	19	40	1·6021

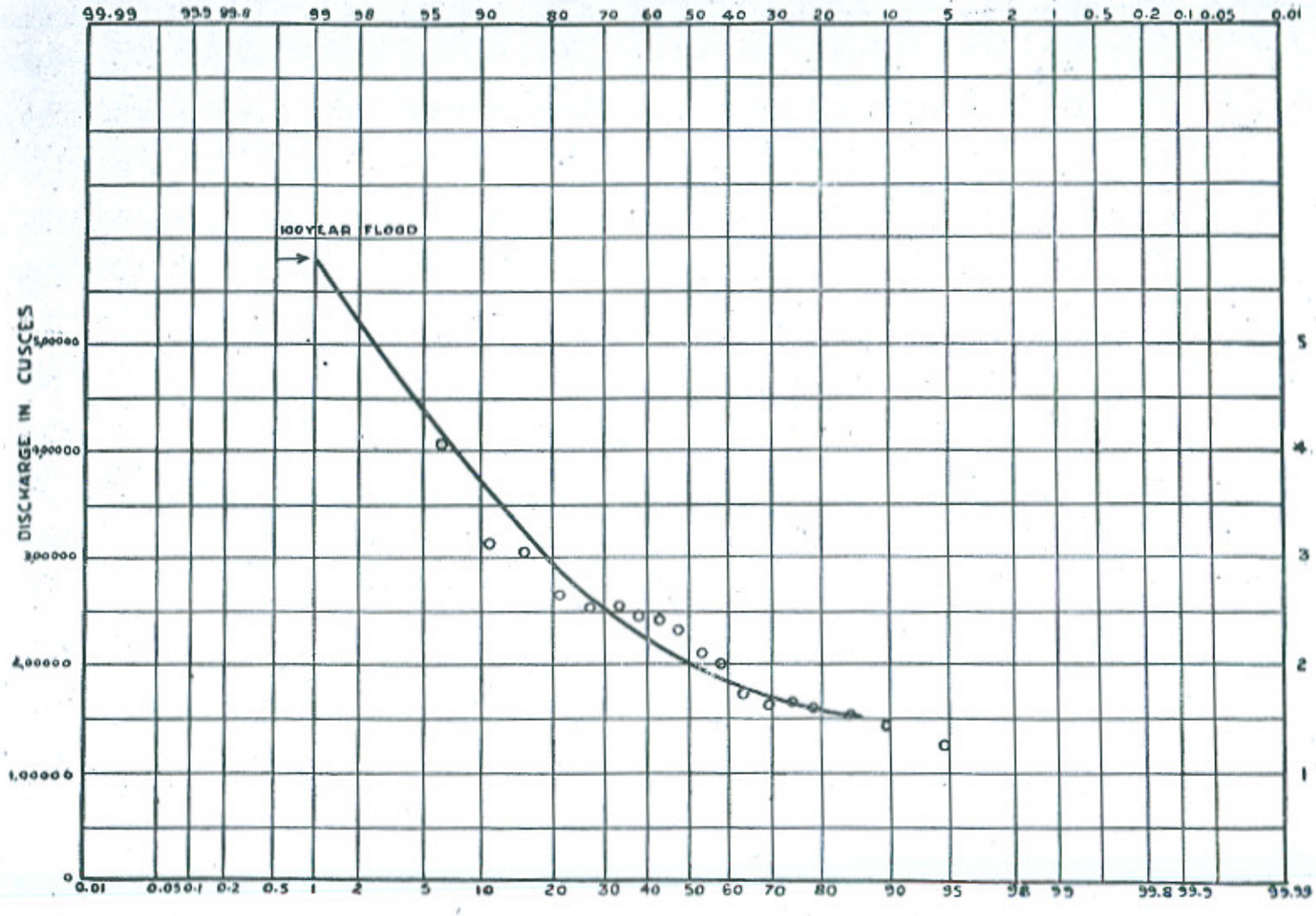
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54 YR: FLOOD
RAVI AT SIDHNAI HEAD WORKS
(PROBABILITY METHOD)
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APPENDIX NO. (5 b/i)
DISCHARGE IN CUSECS
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

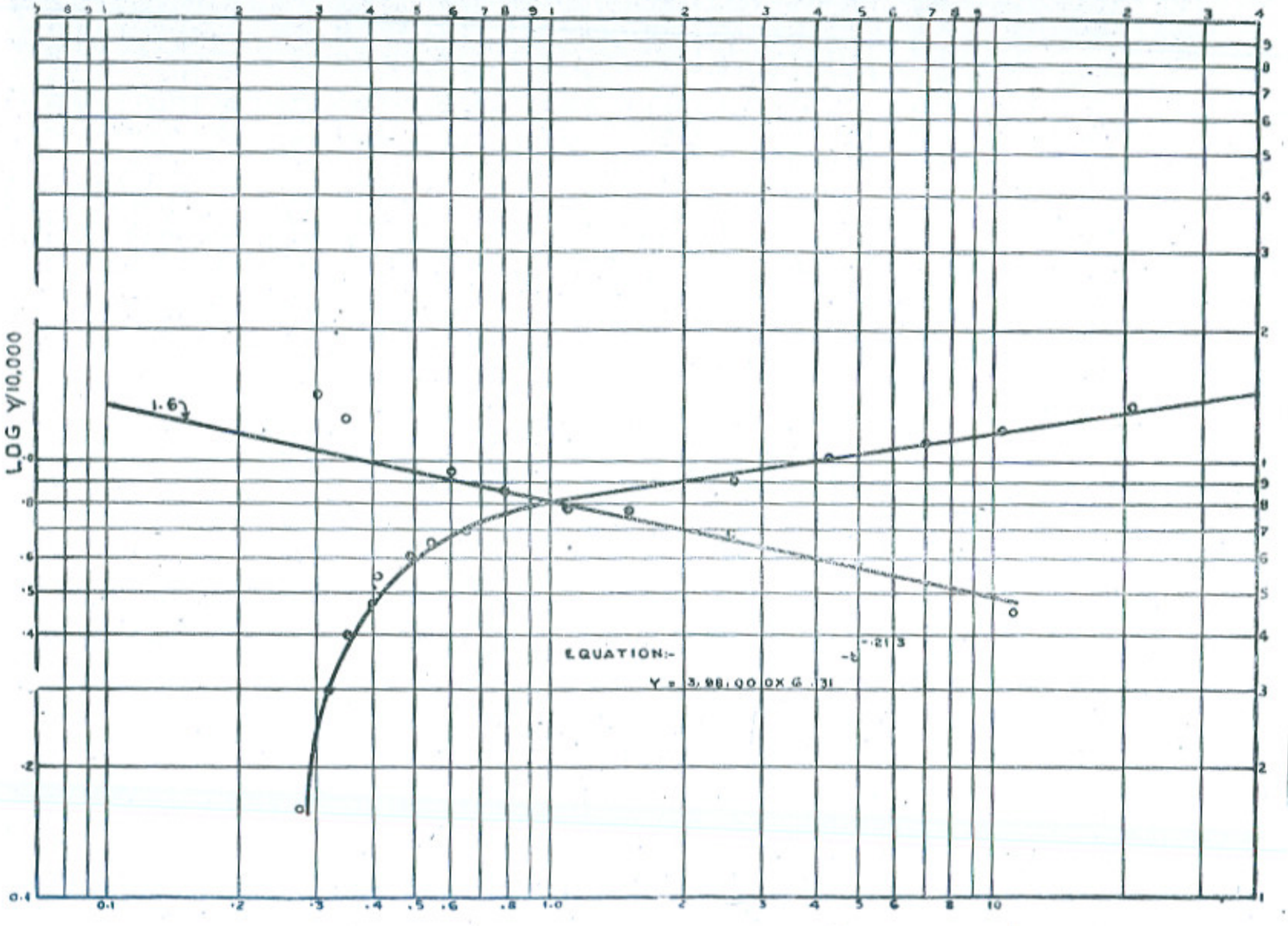
PAPER Nº 292
APPENDIX Nº 5C/1

CHENAB AT WAZIRABAD
(PROBABILITY METHOD)



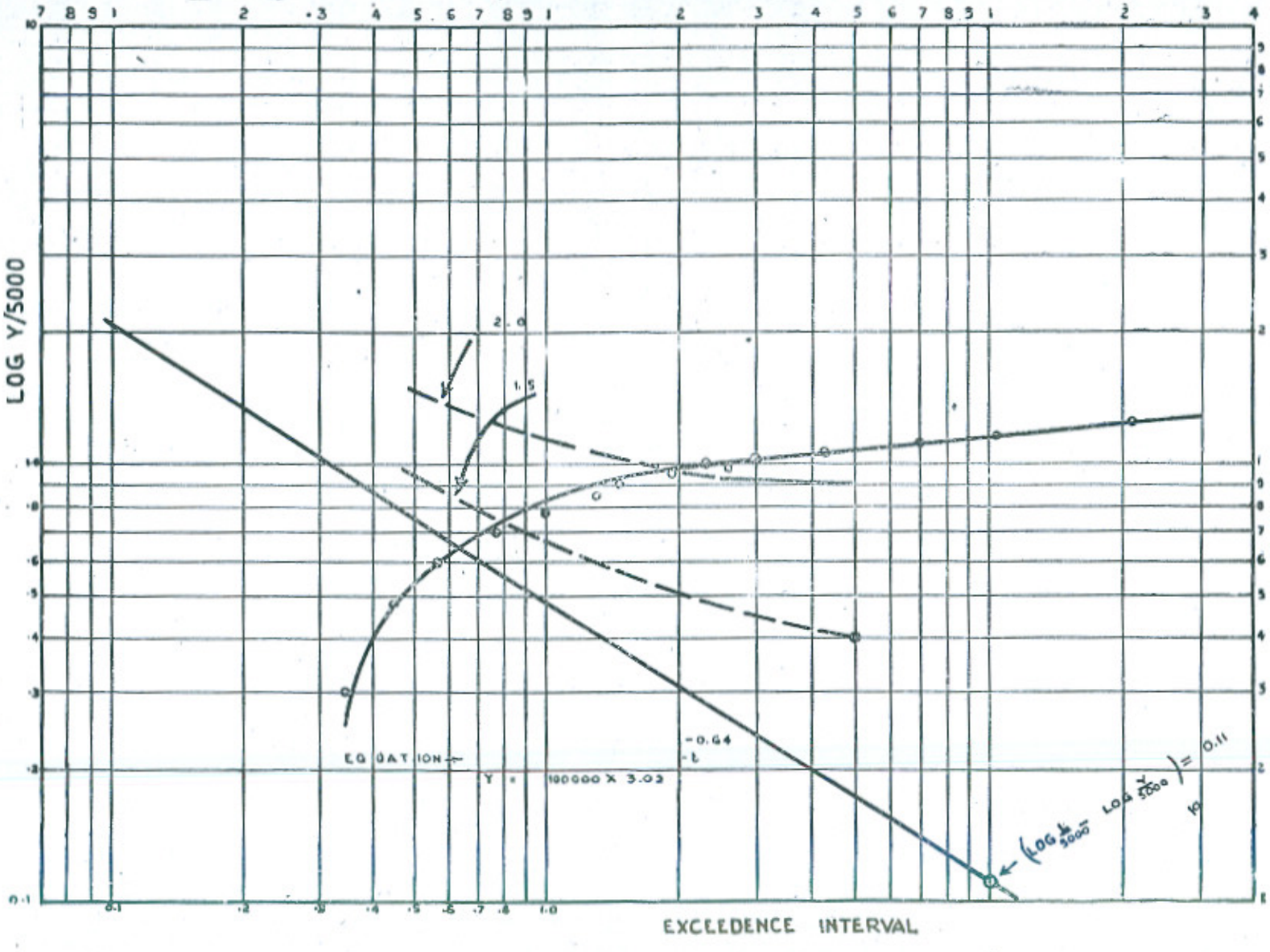
RAVI AT SHAHDARA
(EXCEEDENCE METHOD)

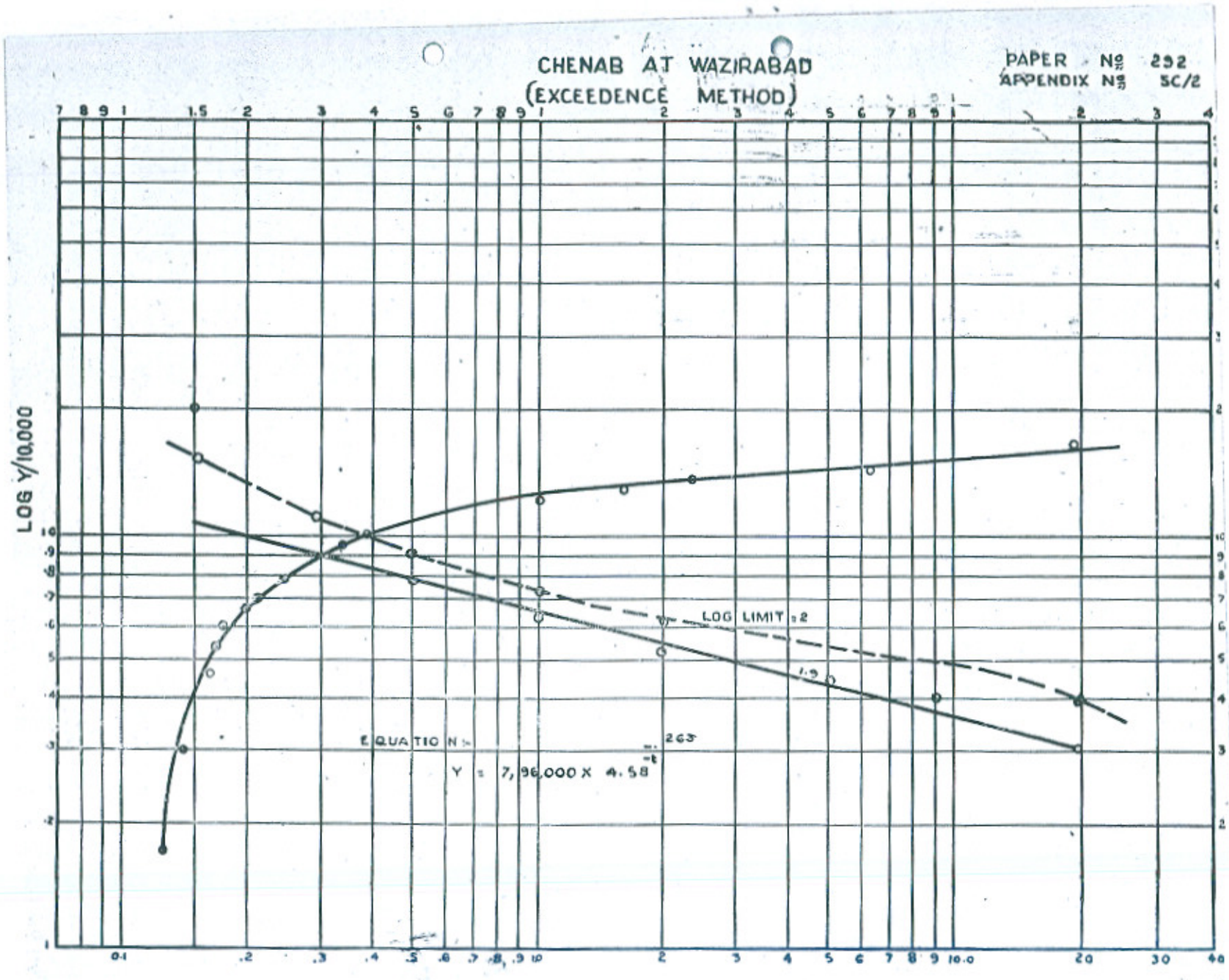
PAPER No. 292
APPENDIX No. (5a/2)



PAPER No 292
APPENDIX No (5 b/2)

RAVI AT SIDHNAI HEAD WORKS NEAR ABDUL HAKIM
(EXCEEDENCE METHOD)




CHENAB AT WAZIRABAD
(EXCEEDENCE METHOD)
PAPER No 252
APPENDIX No SC/2
LOG Y/10,000
LOG LIMIT = 2
1.9
EQUATION =
Y = 7,96,000 X 4.58
-.263
-t

Mian Alim-ud-Din :—There were three points about which I said as follows :—

The first point is about accretion, sub-para (a) of ' Secondary Causes' on page 91, seems to give the idea that accretion is entirely due to heading up caused to the flow of the river by the construction of a weir, barrage or bridge. This is partly correct; accretion does take place with the heading up, but it also takes place independently without any such external cause. It would take place if the obstruction were not there, though not perhaps to the same degree. The gauge discharge curves regarding Chichawatni site on the Ravi river, Mithankot site on the Indus river and Haveli site on the Chenab river before the construction of Trimmu weir, diagrams for which are attached will bear me out. The obstructions accentuate the effect upstream.

The second point is regarding training works required upstream obstructions in the rivers. While 1'13 provides in case of weirs training works, the Railway and the B & R bridges don't have any. The Ruehlman's formula regarding afflux is :—

$$L = \frac{D}{S} + \frac{(H)}{D}$$

D—is the depth of the river.
S—Slope.
H—Afflux.
L—Total length upto which the afflux travels.

With 20 feet depth, 1 ft. slope 3 ft. afflux, the afflux length is 20 miles.

With 20 feet depth 1 ft. slope and 2' afflux, the afflux length is 16½ miles.

With 20 feet depth 1 ft. slope and 1' afflux, the afflux length is 10 miles.

With 20 feet depth 1 ft. slope and ½' afflux, the afflux length is 6¼ miles.

River in its afflux length is in disturbed regime, with the result that it tries to make loops and curves and deposits its silt resulting in raising of bed and therefrom spill. It indicates, therefore, that there should be training upstream all such obstructions at least upto afflux length.

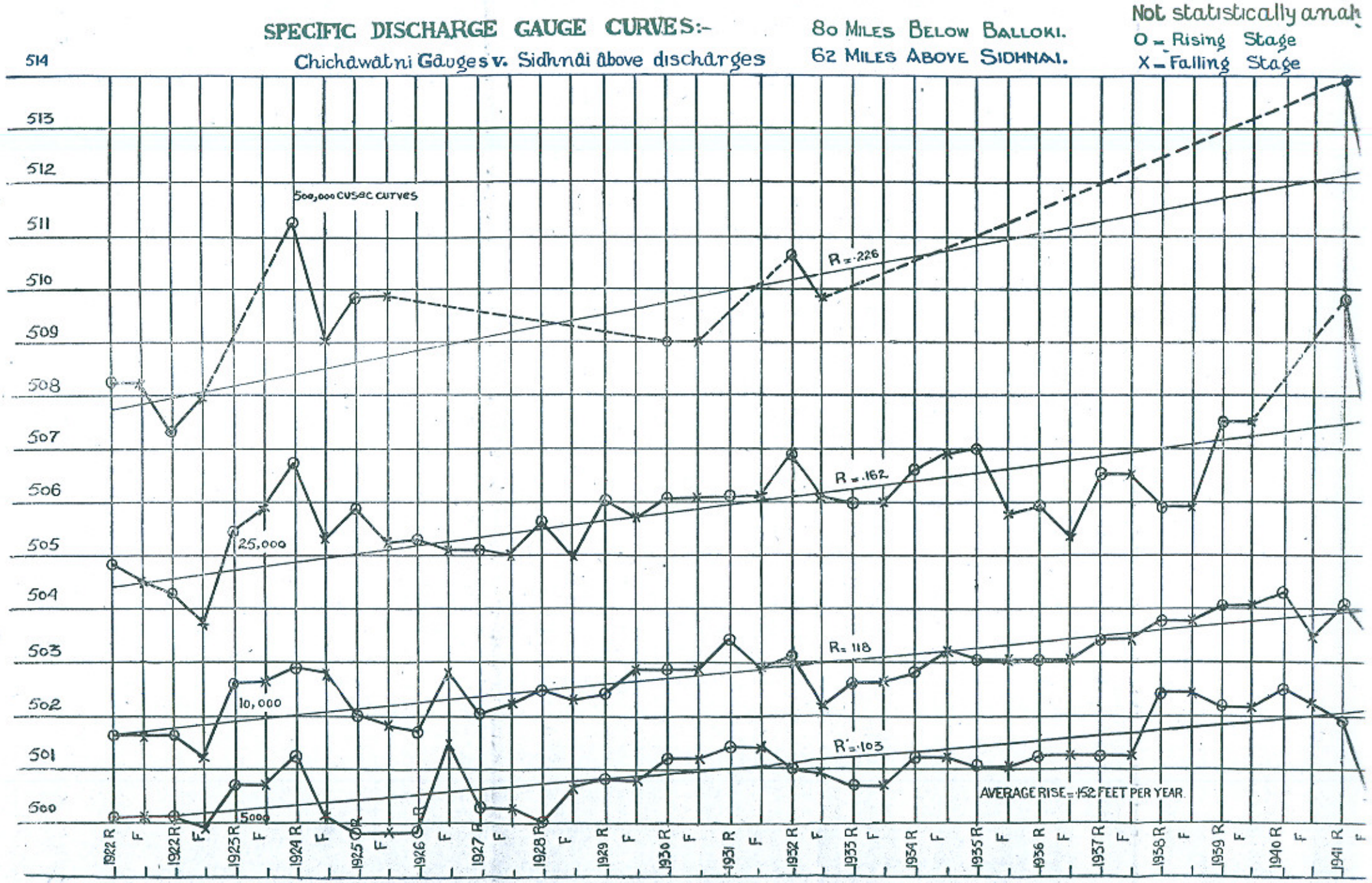
Regarding sub-para (b) of ' Secondary Causes' on page 91. In case of weirs I would hesitate to admit the truth of the statement for the reason that the rivers upstream are properly trained. The training works on all Headworks are kept in pace with the changing configuration of the river current. The main reason of spill at the flanks of the marginal bund in 1950 was that at a number of weirs, the discharge received was more than what the weirs are designed for.

Dr. Mushtaq Ahmad :—It is gratifying to note that the authors have collected and presented very useful information on one of the very important subjects to this Province. It is strange to note that the subject of Flood Control has not come under the deliberations of this Congress so far. The recent floods, doing incalculable harm to our province, have atleast invited our attention to this very important subject which must be tackled if future recurrences of such havocs have to be avoided.

While discussing primary causes of floods, the Authors have rightly stressed the need for recording rainfall and for having snow surveys but as the rainfall is only heavy in the hill catchment and the snow surveys can also be carried out in the mountainous reaches, it indirectly points out to us the value, and need of Kashmir for efficient working of our flood control schemes.

While discussing the secondary causes of floods, the authors have referred to continuous accretion in our rivers. With the present state of affairs when the rivers are in the charge of an Irrigation Engineer for only a short stretch near the head works, he is liable to look at it from his primary need—viz. the efficient working of irrigation system, and the maintenance of his canal head works; the flood control as a general problem is likely to be overlooked. He is keen to see that there is proper sediment exclusion at the head of the canal. In fact a very large amount of useful experimental and field work has been done on this subject with very good results. Now, look to the problem of sediment exclusion from the canal from the point of view of flood control. The sediment excluded from the canal will have to be carried by the depleted river discharge which may be unable to carry its extra load, and therefore must drop its burden some where, just to raise the river bed level and increase the flood heights. It is therefore very essential that the flood control problems should also be the concern of the Irrigation Engineer not only in the reach of his Head works but for the entire river system.

Another cause of raising the flood heights is said to be the defective guide bank system. The clear water way between the guide banks is generally kept for the maximum—ever flood which may occur once in 50 or 100 years, and the medium floods, for which the water way is loose, only help to form islands within the guide banks. It is believed that the guide bank system shall pass water through it uniformly and normally and that the marginal bunds shall not be threatened by the river forming a loop behind a guide bank. The above objects have generally not been achieved and it is time that we take stocks of things. In how many of our bridges have we been able to get uniform and normal flow without the appearance of shoals and islands? Invariably we have had oblique approaches resulting in the formation of huge islands between the guide banks. The island some times makes as much as half the width between the guide banks. Vegetation and jungle growth consolidates the islands and does not allow them to be washed in the short duration of the flood. The members of this Congress know too well that even the last year's record flood has not been able to wash the island between the guide banks at the Railway and the road bridge on River Ravi near Lahore. Naturally the afflux has to be much more than would normally occur. It appears essential, therefore, that ways and means be determined to achieve the objectives kept in view for the guide bank systems. In addition to the proper approach of the river to the guide bank, which is very essential to avoid islands of very large size, it is necessary that islands if and when formed may be scrapped every year at the surface by clearing the jungle so that erodeable surface is offered to the water and the island could at least be partially washed away.

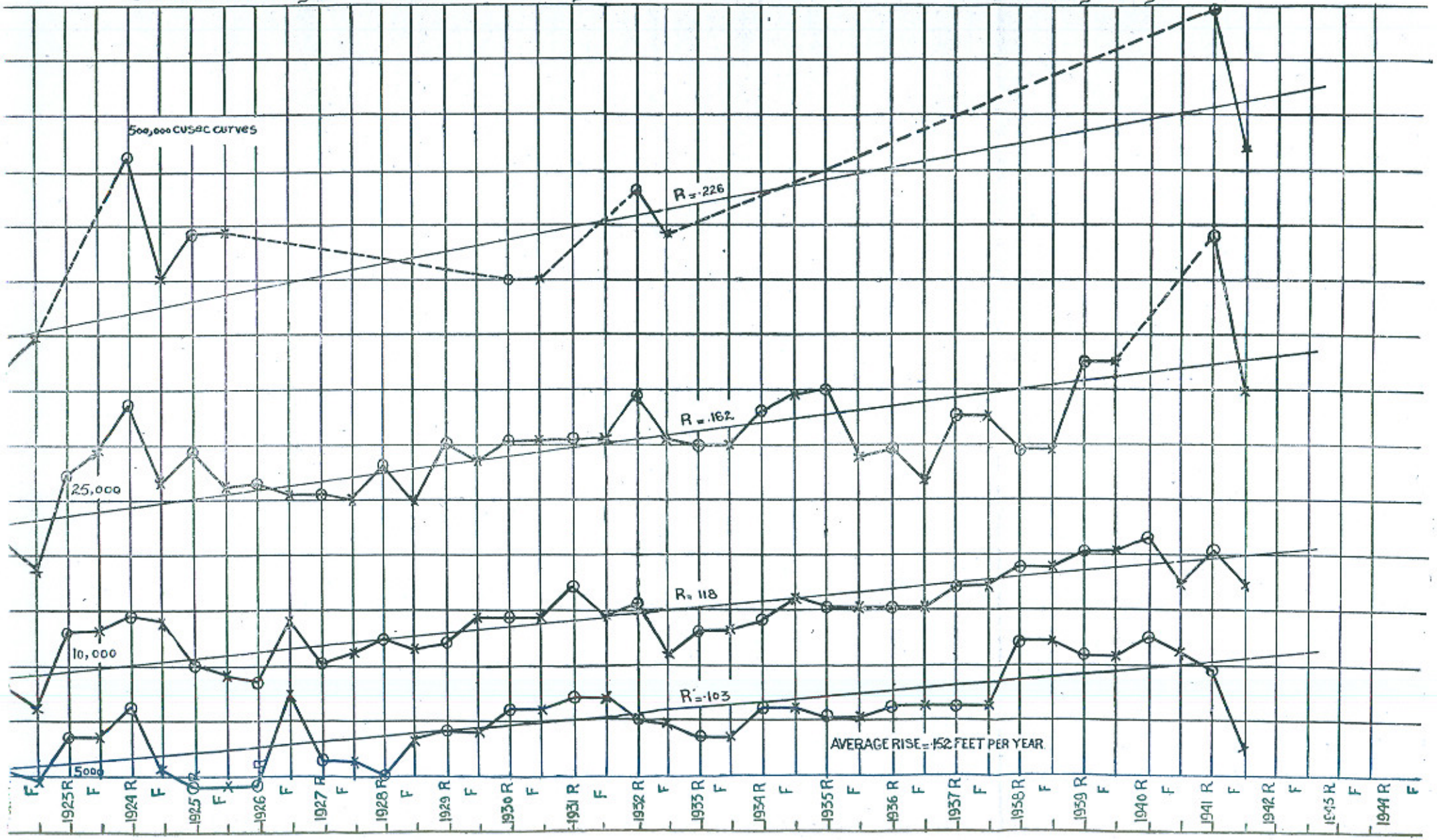

SPECIFIC DISCHARGE GAUGE CURVES:-
Chichawatni Gauges v. Sidhnai above discharges
80 Miles Below Balloki.
62 Miles Above Sidhnai.
Not statistically anal
O - Rising Stage
X - Falling Stage
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513
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500,000 CUSEC CURVES
25,000
10,000
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R = .226
R = .162
R = 118
R = 103
AVERAGE RISE = 152 FEET PER YEAR
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F
1923 R
1924 R
1925 R
1926 R
1927 R
1928 R
1929 R
1930 R
1931 R
1932 R
1933 R
1934 R
1935 R
1936 R
1937 R
1938 R
1939 R
1940 R
1941 R

SPECIFIC DISCHARGE GAUGE CURVES:-

Chichawatni Gauges v. Sidhnai above discharges

80 Miles Below Balloki.
62 Miles Above Sidhnai.

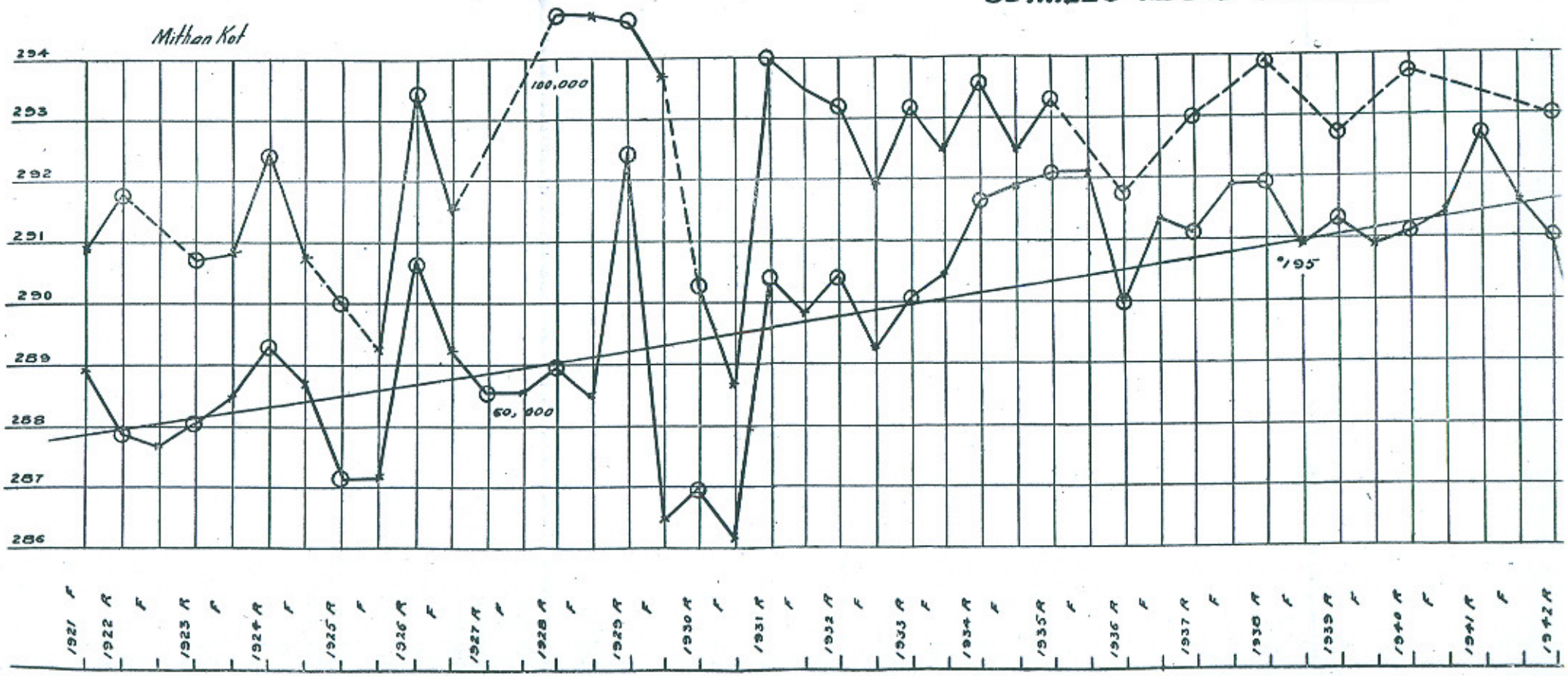
Not statistically analysed
O – Rising Stage
X – Falling Stage



PAPER
№ 292

SPECIFIC DISCHARGE GAUGE CURVES: MITHAN KOT 58 MILES BELOW TRIMMU 90 MILES ABOVE MACHKA

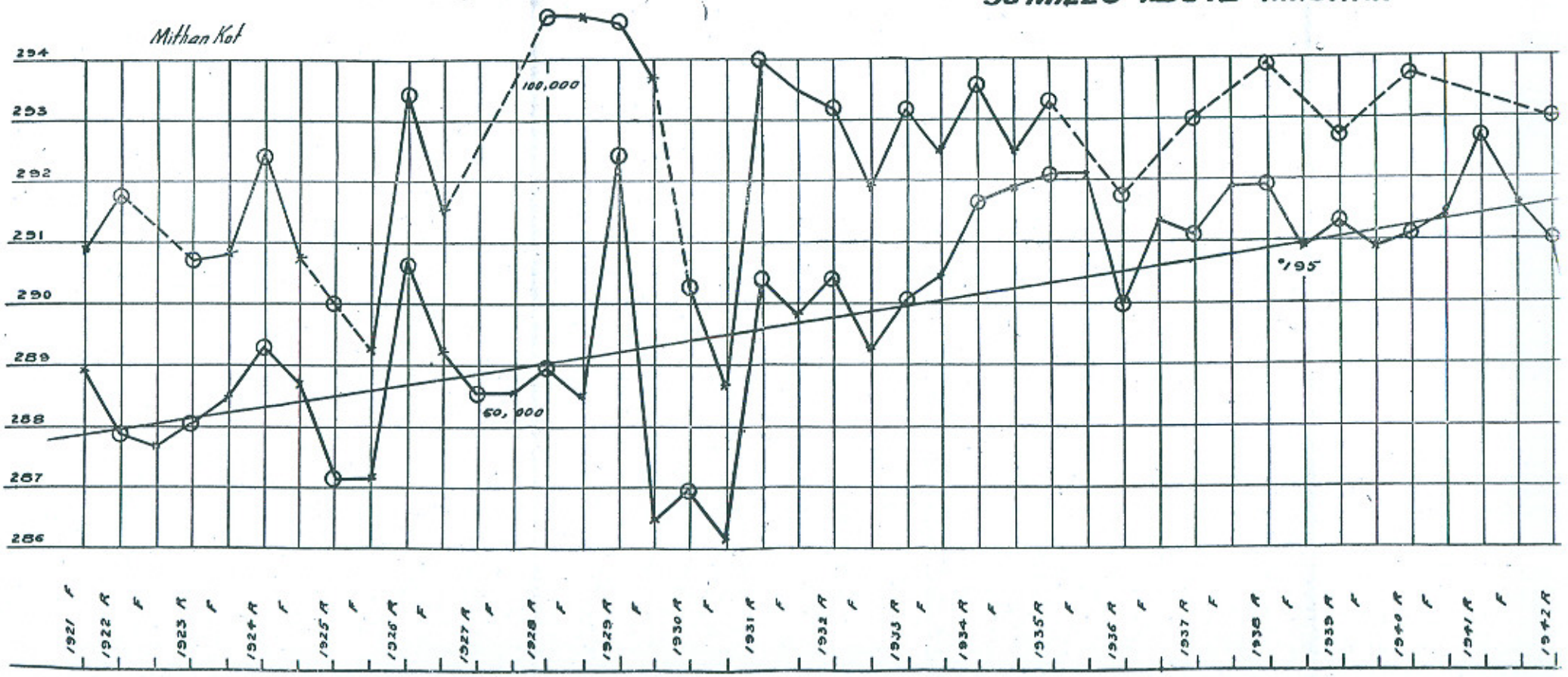
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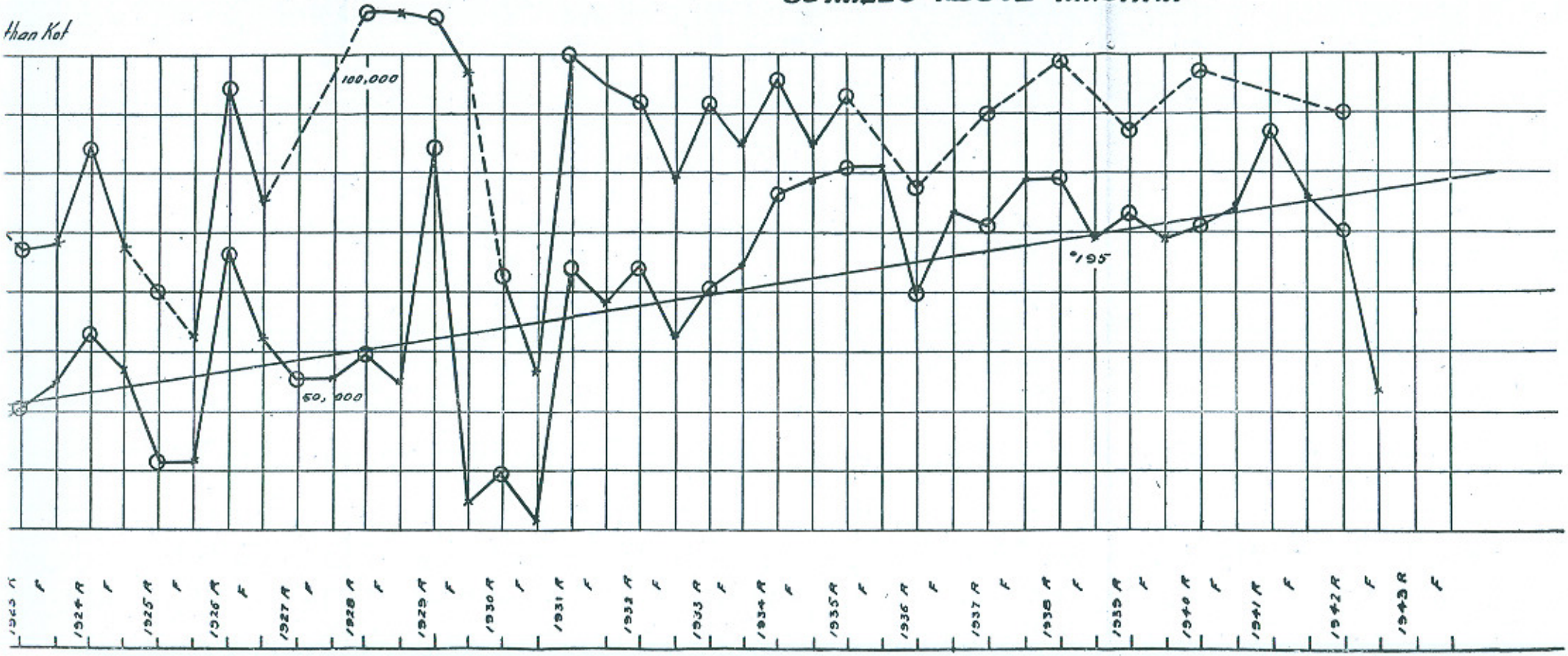
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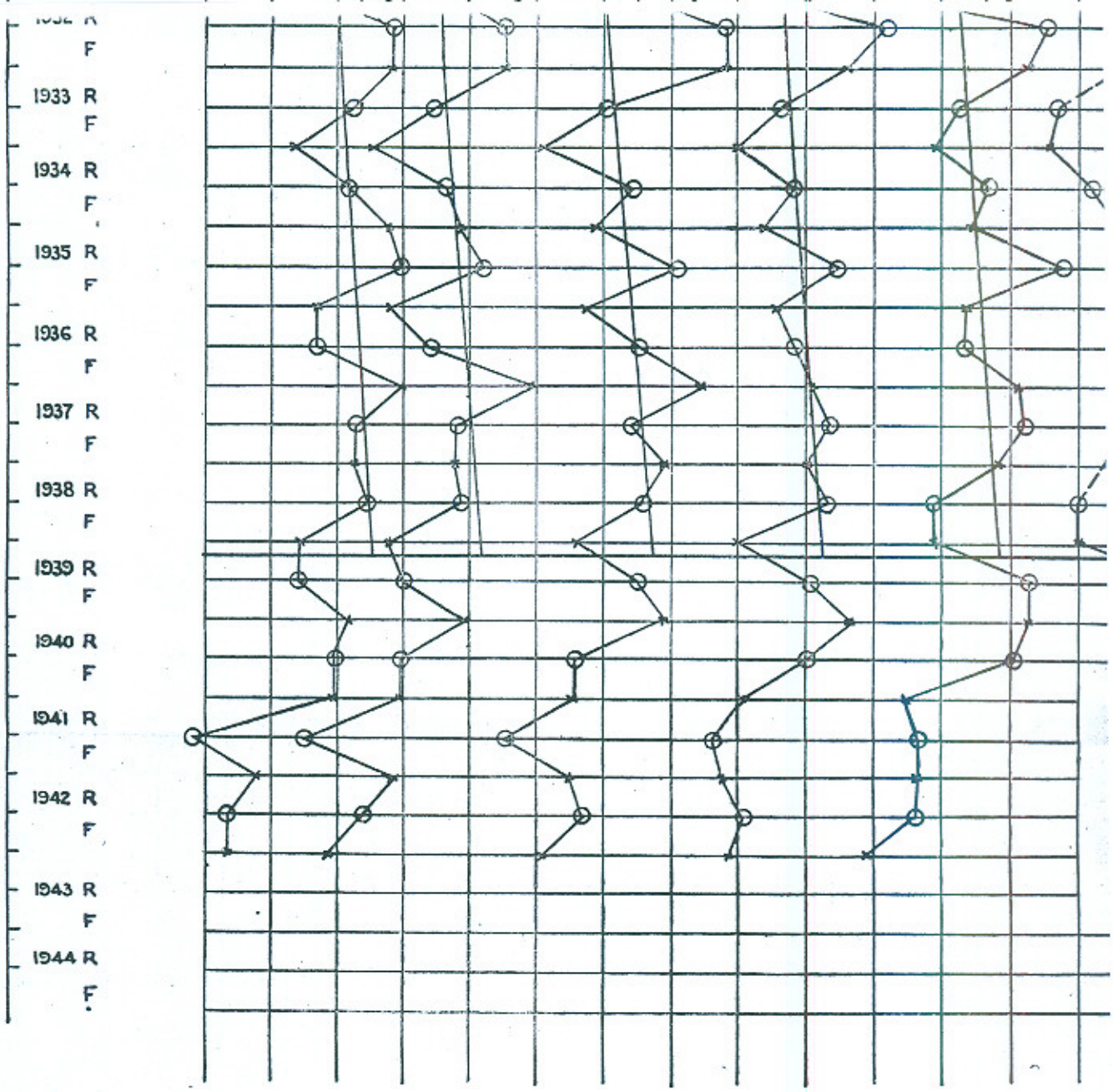
SPECIFIC DISCHARGE GAUGE CURVES: MITHAN KOT 58 MILES BELOW TRIMMU 90 MILES ABOVE MACHKA

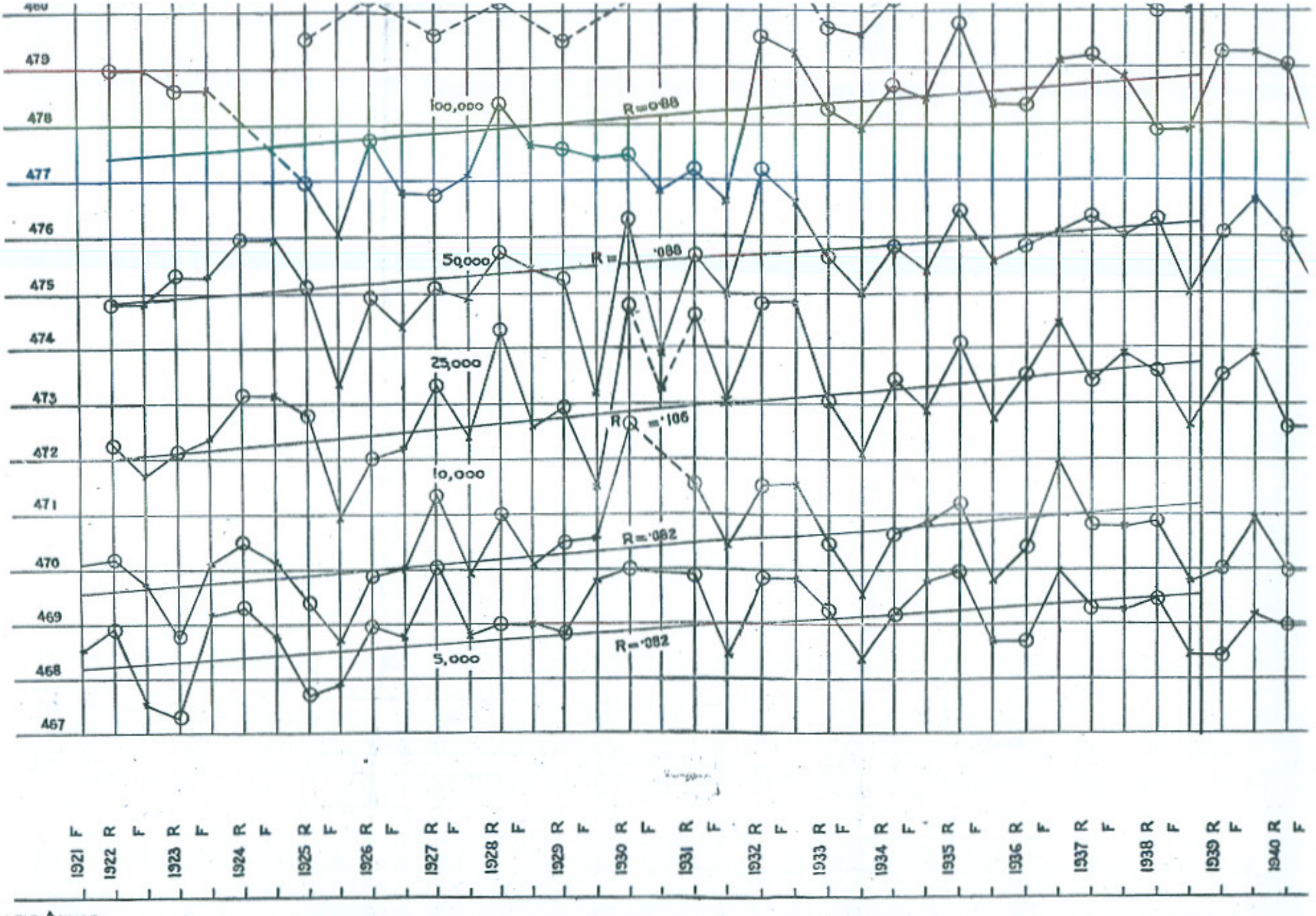
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PECIFIC DISCHARGE GAUGE CURVES: MITHAN KOT 58 MILES BELOW TRIMMU 90 MILES ABOVE MACHKA P. 1943-11




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1944 R
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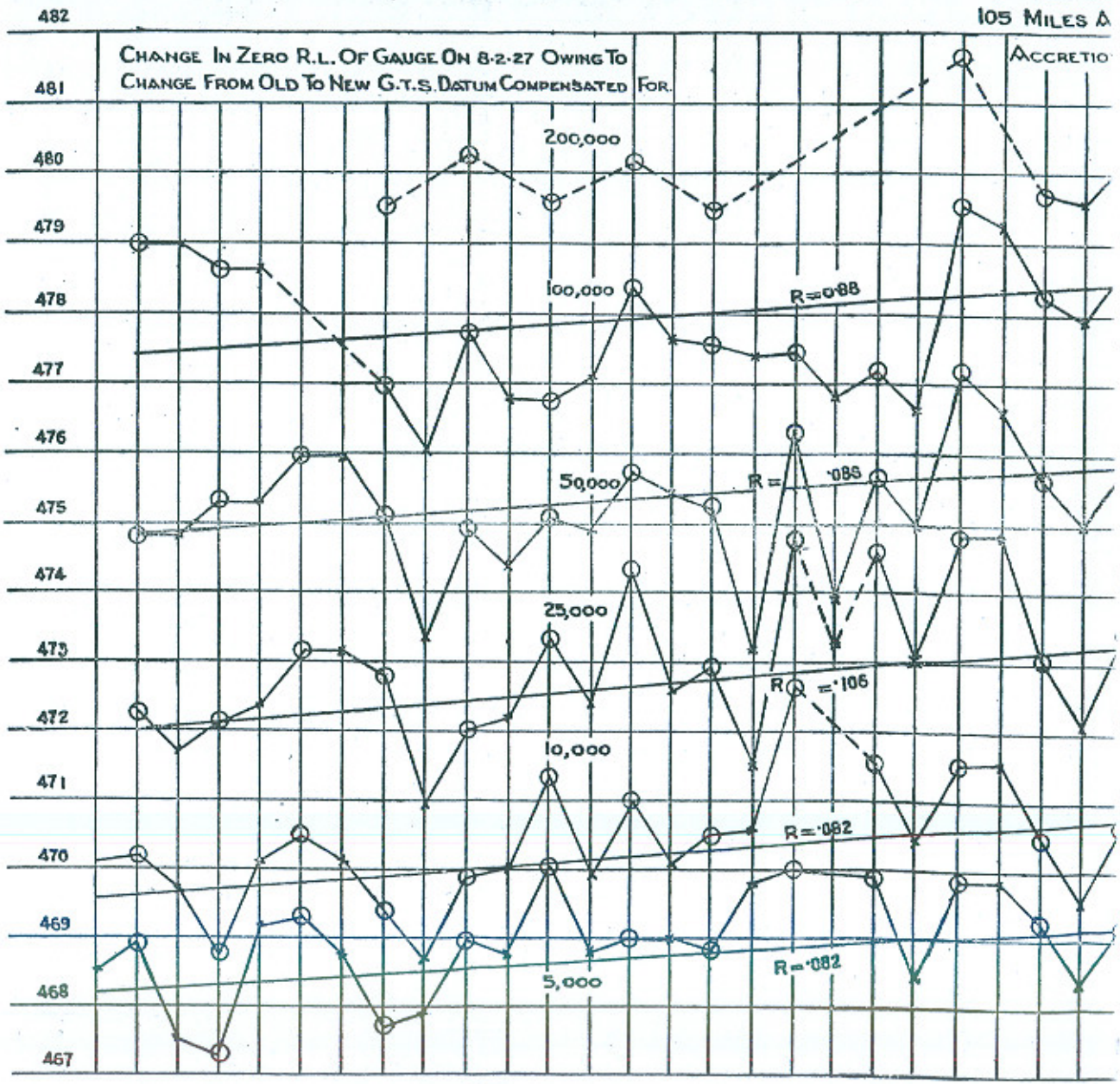


T. BY:- SHAFIQ AHMAD.
B.A. St.
Compound By:- S. A. Hussain

PAPER
№ 292

Specific Discharge Gauge Curves:— Haveli.

8 Miles Be
105 Miles A



:HARGE GAUGE CURVES:— HAVELI. 8 MILES BELOW TRIMMU.
105 MILES ABOVE SHERSHAH.

P. 1943-16

RIVER DIVERTED OVER TRIMMU WEIR 8 MILES D.S.

:E ON 8-2-27 OWING TO
S. DATUM COMPENSATED FOR.

ACCRETION = ·089 FEET/ANNUM

— — NOT STATISTICALLY ANALYSED.
O = RISING STAGE.
X = FALLING STAGE.

200,000

100,000 R = 0·88

50,000 R = ·088

25,000 R = ·106

10,000 R = ·082

5,000 R = ·082

While discussing protective measures against the flood attacks, the Authors have reviewed various measures that can be adopted. I would very briefly discuss the effect of only three measures on the flood heights, namely.

(*a*) Levies.

(*b*) Diversion or escape.

and (*c*) straightening of excessive loops.

These three measures were tested by the speaker while experimenting on the flood protection problem of River Gumti in East Bengal. It is a common knowledge that the effect of levies is to raise the flood heights in the levied reaches over the normal flood heights attained in the unlevied period. Another effect of the levies is that in the lower reaches the magnitude of the peak discharge will rise but the duration of the flood will decrease. The Authors have said that the system of levies are best suited to river conditions in Pakistan. I would like to sound a note of caution here. In Western Pakistan we have a number of Head Works on our rivers. A continuous levy system would increase the discharge at the lower head works over and above the design discharges for the weirs, thereby completely upsetting our present capacities of weirs and barrages. If, however, levies are constructed in short reaches to protect only important cities, the restricted water way between the levies will to some extent increase the silt carrying capacity; the extra silt burden thus obtained will be dropped by the stream just below the reach where levies end, thereby raising the bed level there. This effect is bound to travel up with time and the effectiveness of levies might decrease with age. The problem is really fraught with danger and I think cautious and considerable planning is needed if levies are to be used in the rivers having canal headworks.

The main purpose of providing by-pass or diversion channel to divert a portion of river discharge to a side flood-way is to cause local steepening of the slope above the point of the off-take, and a reduction in discharge and flattening of slope in the downstream reach. The provision of diversion channel is easily possible in the Deltaic reach of a river. In our case it is not as easy a problem. But working from the consideration that our rivers may not be simultaneously in spate we should examine the possibility of diverting a part of the discharge of one river to the other by a natural drain or an artificial channel which may connect the two. Experiments on river Gumti have shown that diversion is an effective way of lowering the flood heights in a levied river particularly in the reach lower down the off-take.

Another important conclusion from this series of experiments was that when the discharge is very much more than the bankful discharge, the method of short circuiting the loops is not as effective in lowering the flood height as the method of providing escapes.

In the end I would say a word about recommendations of the Authors for the establishment of a Central Water-ways Laboratory for tackling all problems connected with behaviour of river and flood control. The useful role of a hydraulic laboratory in tackling river problems

cannot be questioned. Fortunately the Punjab has already got a very well-equipped Hydraulic Laboratory and a Field Research Station which can take up nearly all of the problems connected with flood control and I suggest that more use be made of this laboratory in solving these problems.

Dr. Nazir Ahmad :—The paper on flood control investigations is really an exhaustive one in which all the points in this connection have been put forth. The authors have given many suggestions for further investigation and I feel it is the right time that we should take it up systematically both from the point of view of information and control. The information side will include the estimation, intensity, duration, frequency etc., of floods and we may have to rely partly on the co-operation of Indian Government because all the regions which orginate floods lie in their territories.

For timely floods warning the co-operation of our Meteorological Department is also very essential and I understand from Regional Director Meteorology that they are actively taking up steps to collect as much information as possible from old and new observations and previous records. The problem of estimation is some what of a statistical nature and I think such methods of approach as was attempted by Blench and Latif can be of help. This method can be extended to longer periods and with the inclusion of all sources of floods into our territories.

I think statistical section of the Institute can help in this problem collecting and analysing the records of old Indian Government and whatever information we have in our files. This information will help in a better lay out about the protective measures with which we are mainly concerned.

Our country is mainly alluvium planes with little possibility of such structures as we call detention or check Dam, high embankment and levees and other methods which are usually employed in America.

We can control floods only by proper training devices. For the success of such protective measures the first necessity is the survey of rivers and of important Nallas. Estimation of the existing water ways of channels and them to improve them by such devices as artificial islands, suitability of located spurs and strengthening of embankment.

These seem to be some of the possible methods which we can adopt on our side to control floods.

Mr. S. S. Kirmani :—The Paper presented by the authors is more general than specific. I would like to add some specific information regarding the drainage basings of Punjab Rivers so that the causes of floods may be appreciated.

Causes of floods.. The factors causing floods fall under two classes, viz , those that determine the intensity of the storms that are likely to visit any drainage basing and the physical characteristics of the basin or catchment as they affect and determine the disposal of that rainfall.

They are as follows :—

Storm Characteristics

1. Distance from ocean
2. Direction of prevailing winds with respect to ocean.
3. Mean annual temperature.
4. Elevation.
5. Topography.

Drainage Basin or Catchment Characteristics

1. Size of catchment.
2. Shape of catchment.
3. Orientation and location of catchment with respect to storm paths.
4. Kind of soil and nature of vegetation.
5. Soil moisture deficiency.
6. Drainage.
7. Extent of surface storage in the catchment.
8. Mean slope of catchment.

We shall deal with the above factors with particular reference to the Punjab Rivers.

We shall consider the catchment areas above the 1000 ft. contour only as below this elevation all the rivers flow in the plains. The size, the orientation and the location of the catchment with respect to storm paths are very important. The following table gives these characteristics for the five rivers of the Punjab.

TABLE No. 1

River	Catchment area in sq. miles up to 1000 ft. contour.	Average slope in feet per mile from source to 1000 ft. contour.
Indus	103,823	15
Jhelum	13,030	37
Chenab	10,588	40
Ravi	3,123	115
Sutlej	18,554	30

It will be seen from the above table that the Ravi has the steepest slope. The slope of the Jhelum excludes the length of the river where it crosses the alluvial plains in Kashmir. If we include the length of the river in these plains the slope works out to 28 ft/mile. The following table gives information about the shape of the catchment.

TABLE 2.

River	Length in miles from source to 1000 ft. countour L	Average width in miles (wv)	Maximum width in miles.	Minimum width in miles.	Ratio L/Wv.
Indus	1100	94·4	176	88	11·7
Jhelum	400	32 5	160	36	12·3
Chenab	380	27·8	96	24	13·6
Ravi	130	24·1	53	20	5·4
Sutlej	560	33·1	112	30	16·9

Therefore the catchment of the Ravi and its slope are quite ideal for quick flood flows while those of the other rivers are not so ideal. Tnis is the reason why Ravi is so sensitive to even slight precipitations.

Location of the catchments with respect to storm paths.

According to Sir John Eliott the storms in the Bay of Bengal have great influence on the Punjab Rivers. In the 25 years of investigation 45 storms were reported in the month of September in the Bay of Bengal. Of these 11 storms travelled to the catchment of Sutlej, Ravi and Chenab and the remaining ones to other parts of India. During the same period only one storm was reported in the Arabian Sea but it had not great effect on the Punjab Rivers. This shows that the maximum number of storms occur in the Bay of Bengal during September and the catchment of the Sutlej, Ravi and Chenab are located in their paths. It will be recalled that the heavy precipitation in the catchment of the Ravi and Chenab in September 1950 and the consequent high floods were due to storms in the Bay of Bengal.

Mean Temperatures.

For the catchments of Jhelum, Chenab, Ravi and Sutlej, the mean monthly temperature (average of 20 years) for the month of September is 85°F at the 1000 ft contour. The temperature rapidly reduces with the altitude. The mean maximum and the mean minimum temperatures for the same period are 95°F and 70°F respectively and reduces rapidly with altitude For the Indus river the figures are slightly lower. In view of the short length of tne Ravi, the temperature gradient is quite steep.

Rainfall characteristics :—

The rainfall in the Punjab is mostly confined to the monsoon period from July to September when more than 66% of the annual rainfall occurs. The bulk of the South West Monsoon rainfall is deposited on the outer and lower Himalayas and the rainfall beeomes less and less as each range northwards is traversed. The following table gives the distribution of rainfall in various catchments and it will be seen that in about 96 5% of the catchment area of Ravi the rainfall is widespread. The number of rainy days in the catchment areas in the Monsoon period also prove the same fact.

TABLE 3.

Mean Annual Rainfall.	Percentage of Catchment Area.				
	Indus	Jhelum	Chenab	Ravi	Sutlej.
60 inches	...	...	3.8	54·0	16·4
50-60″	...	12·5	3·2	21·0	7·6
40-50″	...	13·5	18·6	21·5	12·1
30-40″	2-0	10·7	6·1	...	10·3
30-20″	3·0	4·2	...	...	...
20-15″	2·5	5·4	...	...	...
Below 15	5·8	0·5	...	...	...
Total.	13·3%	46·8%	31·7%	96·5%	46·4%

TABLE 4

Rivers	Number of rainy days in the Monsoon period June-October.
Indus	10-15
Jhelum	30-40
Chenab	30-40
Ravi	30-50
Sutlej	30-50

Contribution from snow and glaciers.

The authors of the Paper have given the extent of glacier areas contributing to the various rivers and it will be interesting to note their percentage with respect to the total catchment.

TABLE 5.

Rivers	Catchment area up to 1000 ft. contour (sq. miles)	Glacier areas (Sq. miles.)	Percentage
Indus	103,823	14,415	13·9
Jhelum	13,030	142	1·1
Chenab	10,588	1,475	13·9
Ravi	3,123	100	3·2
Sutlej	18,554	2,745	14·7

I do not know how far the information about the glacier, areas in the Jheulm catchment is correct. After Jhelum, Ravi gets the least contribution from glacier areas. According to preliminary surveys carried out by R N. Alyward in 1922, the permanent snow line rises to 15000 ft. during summer months and drops to about 9000 ft. during winter. Occasionally storms during winter will bring the snow line to 4000 ft. but it seldom lies there for a long time.

Flood waves in Ravi.

We have seen that the catchment area of Ravi is small and compact and is situated in the path of storms. It has the steepest slope of all the rivers and its source is nearest from the flat plains. The precipitation is high and almost the whole catchment can have precipitation at one time. Thus the flood wave finds its way very quickly to the plains and as it enters it, the river has quite different. characteristics. Due to the flat slope of the river, the velocity is reduced and there is the danger of synchronization with subsequent flood waves. The slope of the drains that outfall into the river are so flat that if precipitation occurs both in the plains and in the hilly catchment at the same time the chances are that before the storm water of the drains outfalls into the river the flood wave in the main river would have already travelled upto that point. This gives the worst results as the intensity and duration of the floods will be increased.

The chances of synchronization of flood waves in other rivers are not so great. Chenab and Sutlej are also very bad in this respect as compared to Indus and Jhelum whose catchments are long and thus damp the flood waves.

Magnitude of Floods

The formula for maximum flood given by Inglis and De Sunza viz :—$Q = 7,000 \times A^{0.8}$ is not applicable to all the Punjab rivers as can be seen from the following table :—

	Q as per Inglis Formula
Indus	22,56,800
Jhelum	7,99,400
Chenab	7,20,300
Ravi	3,92,000
Sutlej	9,53,400

The discharges as estimated from the above formula for Indus, Ravi and Sutlej are too high. Besides such formulae do not include the various factors affecting the flood flows and therefore they are not accurate. Some rational formulae have been put forward by various authors one of which is by Mr. Khosla for Indian Rivers which take into account the storm and drainage characteristics. But here again the factors affecting flood flows are so many that it 's difficult to give one formula which is applicable to all rivers.

Another method of estimating the flood flows developed during the recent years is by the application of the law of probability. The authors have mentioned about the flood discharges calculated by Mr. Blench applying the formula.

$P = \frac{100N}{Y}$ and it was shown that the results obtained are too high to be believed. Another formula developed by PAO–TAI–TAN is in the form.

$$F = \frac{2M-1}{2N} \text{ where}$$

F is the frequency or percentage chance of flood being exceeded.
N is the total No. of years of record.
and M is the sequence of floods arranged in order of magnitude.

All the probability formulae are based on the statistical method of flood analysis. Dr. Sam Sio, an eminent engineer of Sweden after extensive study of floods in various rivers evolved the formula.

$$\left\{ P = \frac{3n-1}{3N+1} \text{ where} \right.$$

P = probability of a higher annual maximum flood than the plotted discharge.
n = the number of sequence of a given observation.
N = Total number of observations.

This formula gave satisfactory results when applied to the Kabul River in N.W.F.P. and the Karnafuli river in East Pakistan. After collecting the data of the Punjab rivers I obtained the following results using Dr. Samsios methods.

TABLE 6.

	100 year flood from probability curve	500 year flow from probability curve
Indus at Kalabagh ...	10,30,000	11,30,000
Jhelum at Mangla ...	8,01,000	9,75,000
Chenab at Marala ...	8,20,000	9,45,000
Ravi at Shahdara	2,20,000	2,49,000

This formula gives the probability curve as a straight line and hence can be drawn with great accuracy. It is wrong to apply the probability method for finding flood frequencies for 1000, 10,000 and higher periods unless we have the river data for a long period. In all probability methods the assumption is that available data is the representative mean of the period for which flood frequency is to be determined.

The Geyer's formula recommended by the authors gives too low results for Ravi and Jhelum. In the case of Ravi we know for certain that the 1947 and 1950 floods have exceeded 2 lakhs.

Flood Control

The authors have described various methods of flood control but here again they have not recommended specific methods for each river. The foregoing study has shown that Chenab, Ravi and Sutlej are dangerous from the point of view of floods. With the construction of Bhakra dam the flood peaks in the Sutlej will be reduced.

As the upper catchments of the Punjab rivers, particularly Jhelum, Chenab, Ravi and Sutlej lie in Kashmir and India, we cannot adopt direct control measures by constructing storage dams which are the most effective methods of flood control. We can do so in collaboration with Kashmir and India in accordance with the International Law which lays down the rights of the upper and lower riparians. Flood control measures in the plains are very expensive and are not so effective. For the Ravi and Chenab which have caused great havoc in the Punjab during recent years, I suggest a combination of the following methods of flood control :—

(1) To develop cut-offs and eliminate meanderings throughout the length of the rivers in plains. This will accelerate the travel of flood waves and reduce their duration and therefore the chances of synchronization.

(2) Flood protection bunds or levees should be constructed to protect important towns only where heavy damage is expected. Construction of levees throughout the length of the rivers will be very costly.

(3) We should encourage formation of natural banks of the rivers. Here I would like to refer to the proposal of the Chief Conservator of Forests for the formation of silt banks. The idea is based on the successful practice of river control in Burma where they drive a number of deep logs on both sides of the river. This reduces the velocity and encourages silting. As timber is difficult to obtain in Pakistan forests may be grown for a width of say 300 ft. on either side of the river. In course of some years the forest belts will silt up, thus forming natural banks. The restriction of the river spill section will result in increased depth of the river during floods and the possibilities of accretion in the river bed will also be reduced. Although this method of river control was adopted in Burma for small rivers, I do not see why they should not prove satisfactory for the Punjab rivers. We have so many drains and nallahs on which this method can be adopted. The forest belts grown will serve double purpose, namely encourage formation of silt banks and also add to the country's forest wealth.

A combination of the above three methods will be the solution of the flood control problems in the Punjab plains.

K. B. Pir Mohd Ibrahim :—"I was in Delhi in January attending a flood control organization meeting held under the United Nations, In that meeting flood control by means of building dams, was considered to be the most effective. Practically every nation was represented on that Organization. That Organization of the United Nations considered it their duty to make certain recommendations. Those recommendations were put up before the Economic Commission for Asia and Far East, in its Session held at Lahore. These recommendations envisaged that no country which happened to be in joint possession of the river should either construct a dam, or any other multi-purpose project on the River, whatever it might be, without sharing its benefit. In face of this recommendation of the Flood Control Organization, which was endorsed by the Economic Commission for Asia and Far East, the argument of Mr. Kirmani that we are helpless because upper reaches of our rivers lie in India is wrong, especially because India is a country which is at peace with us.

Mr. I. A. Zafar.—It is said in opening part of the paper that its scope is not to solve any specific problems but to set a number of them and create an incentive for the engineers to think seriously about the scientific methods for the flood control. It is encouraging to note that our task is achieved to a great extent and that the paper has aroused a keen and lively discussion.

Mian Alim-ud-Din has mentioned about three points in his discussion. He admits that extent of the normal accretion will not be to the same degree as caused by the control points in course of the river It is a fact that a particular reach of a river may have accretionary tendency to-day but due to certain regime change or influence of certain works like barrages etc; it might have retrogression after some years. On the other hand a bridge constructed or a weir inserted in bed of the river will be sure to bring up silting due to heading up caused. The paper mentions the effect of the normal accretion and thenforced accretion due to control structures built in its bed and it is not correct to say that effect of the normal accretion has been lost sight of. However, it does not have a pronounced effect in adding to the flood problems. Detailed examination of flood routing after 1950 floods has fully confirmed this.

Mian Alim-ud-Din has advanced a hypothesis for extension of the training works to cover up the entire length of the back water curve. To start with it is absolutely incorrect to say that the railways do not have any system of training works. Most of the railway bridges are provided with properly designed main guide bund system and the retired bund system according to springs.' investigations. The relation giving the length of back water curve is independent of the length of the bridge or width of the river at the controlled point. Mian Sahib should know that economics of design of the training works as compared with the length of the bridge chosen depends on the % restriction of the river bed caused by building the bridge and has to do nothing with the amount of afflux caused. Length of upstream and downstream training works is a direct function of the length of the bridge. The retired bund system is meant to take up the effect of afflux beyond the upstream length of the main guide bunds.

It is not correct to say that the afflux results in formation of loops and curves. The effect of afflux is to damp down the velocity and reduce the meanderings because at slow velocity the river can negotiate with a given bed material in shorter lengths and so the sinuous formation is not encouraged.

Dr. Mushtaq Ahmed has given a note of warning that before the levy system is adopted a thorough study of its implications on the maximum carrying capacity of the head works weirs and deposition of silt on the immediate down reaches should be made. This point has been vividly taken up by the authors in the paper. We have strongly advocated that before any scheme

either for flood prevention or flood protection is selected its repercussions on reaches upstream or downstream must be thoroughly studied and no short-sighted step should ever be taken to give relief to one point at cost of another.

Our recommendation for a central water ways laboratory is to make it under auspices of the proposed river control authority so that problems of entire Pakistan can be studied with an efficient research backing. The hydraulic laboratory in the Punjab is established to cater for requirement of a particular department in a particular province and it cannot function on an all Pakistan basis particularly in an advisory capacity and to achieve a true co-ordination for schemes of different departments confronted with flood problems.

Mr. Kirmani — While introducing the paper we have ourselves clearly stated that no specific problems in West Pakistan could be studied and brought in fold of this paper because of lack of time and handicaps in access to the data. It is true that the paper is more of a general nature but its aim was just to introduce this subject of such a vital importance so that various engineers can make it more definite by giving an account of their field experience, practical difficulties and valuable suggestions which when all incorporated could make it comprehensive and a true guide for similar problems in the future. We are indebited to Mr. Kirmani, who has devoted his particular attention to give a more practical colour to the topic.

Practically all the items narrated by him under the storm and the drainage basin or catchment characteristics have been dealt with in detail in the paper. It is said that Geyer's formula on which studies of various rivers have been made gives too low results for Ravi and Jhelum. We feel that Dr. Samsio's formula used by Mr. Kirmani gives slightly higher results. However, the two formalae do not give very much differing results. According to the observation of discharge made by the irrigation department the figure for 1950 was under 2 lacks for Ravi at Shahdara and if that is the criterian for Mr. Kirmani to judge about accurate fit of Dr. Samsio's formula then it may not sound accurate.

It is difficult to recommend specific methods for the flood control for various rivers unless a laboratory research for specific problems is conducted. The measures to be adopted will vary and it is difficult to specify a thumb rule.

Mr. Kirmani has suggested remedial measures for flood protection which have been dealt with in great detail in the paper and we too have proposed to adopt their combination as suited to particular problems. His suggestion for trying afforestation along the river banks needs investigation by the forest department to find out whether this anti-caving & anti-flood technique is applicable to big rivers in the alluvial plains.

K. B. M. A. Hamid. We quite agree about the economics aspect of flood but there is immediate need for compiling of statistics over a large number of years. These statistics should show the benefits both tangible and indirect and losses of all kinds accruing as a result of floods of different magnitudes in the flood plains of different rivers. During the course of the 1950 flood there was unfortunately no such organisation set up with the result that different authorities were just left in the dark to get a suitable data on which to base design of any good control structure. However, this calamity should have left us wiser and at least compelled us to make beginning from now onwards. Unfortunately we have not yet learnt a lesson from the advanced countries of the world where such like building up of the statistics is given a priority national importance irrespective of the fact whether a particular flood during a year is of great damaging nature or just a "Tame" one. It is not known precisely when the history will repeat itself and we might be called upon to face floods equal or greater intensity than the recent ones. We may not live to see them but the future generation of engineers will surely curse us if we do not make a start now for compilation of the data on correct lines and if we hand over blank records to them as we possess to day. It is not like an engineer to work by fits and starts and start planning late in the day. We strongly recommend that collection of data on the economics of floods should he collected according to the proforma which has been drafted by us, by a co-ordinated effort of various affected authorities irrespective of the fact whether particular flood control schemes receive recognition from the government or not.