TABLE - 4
HOURLY MANGLA RESERVOIR DATA - SEPTEMBER 10, 1992

DATE	TIME (Hrs.)	RESERVOIR LEVEL FT. SPD	INFLOW (1000xCusecs)	OUTFLOW (1000xCusecs)
10-9-1992	01.00	1207.08	742	675
"	02.00	1207.28	870	738
"	03.00	1207.53	965	858
"	04.00	1207.73	1090	933
"	05.00	1207.83	1013	933
"	06.00	1207.83	933	933
"	07.00	1207.63	769	933
"	08.00	1207.38	728	932
"	09.00	1207.08	687	932
"	10.00	1206.73	645	932
"	11.00	1206.38	639	919
"	12.00	1205.98	519	773
"	13.00	1205.73	569	774
"	14.00	1205.63	582	555
"	15.00	1205.58	468	508
"	16.00	1205.58	465	462
"	17.00	1205.53	397	414
"	18.00	1205.48	372	414
"	19.00	1205.48	414	414
"	20.00	1205.38	337	414
"	21.00	1205.28	271	333
"	22.00	1205.18	251	333
"	23.00	1205.18	245	258
"	24.00	1205.18	234	210
		Average	592	649

TABLE - 4
HOURLY MANGLA RESERVOIR DATA - SEPTEMBER 11, 1992

DATE	TIME (Hrs.)	RESERVOIR LEVEL FT. SPD	INFLOW (1000xCusecs)	OUTFLOW (1000xCusecs)
11-9-1992	0100	1205.23	251	210
"	0200	1205.28	251	210
"	0300	1205.28	230	210
"	0400	1205.33	230	159
"	0500	1205.38	200	159
"	0600	1205.43	200	159
"	0700	1205.48	200	159
"	0800	1205.53	200	159
"	0900	1205.58	200	159
"	1000	1205.58	159	159
"	1100	1205.58	159	159
"	1200	1205.63	200	159
"	1300	1205.63	159	159
"	1400	1205.63	154	150
"	1500	1205.63	149	148
"	1600	1205.63	148	148
"	1700	1205.63	146	146
"	1800	1205.58	143	146
"	1900	1205.58	146	146
"	2000	1205.58	146	146
"	2100	1205.58	146	146
"	2200	1205.53	125	146
"	2300	1205.53	144	144
"	2400	1205.48	137	144
		Average	176	160

TABLE - 4
HOURLY MANGLA RESERVOIR DATA - SEPTEMBER 12, 1992

DATE	TIME (Hrs.)	RESERVOIR LEVEL FT. SPD	INFLOW (1000xCusecs)	OUTFLOW (1000xCusecs)
12-9-1992	01.00	1205.48	146	146
"	02.00	1205.48	144	144
"	03.00	1205.48	125	144
"	04.00	1205.43	123	144
"	05.00	1205.43	123	144
"	06.00	1205.38	122	143
"	07.00	1205.33	110	144
"	08.00	1205.28	103	143
"	09.00	1205.23	102	143
"	10.00	1205.18	102	143
"	11.00	1205.13	102	143
"	12.00	1205.08	102	143
"	13.00	1205.03	101	141
"	14.00	1204.98	101	144
"	15.00	1204.93	103	144
"	16.00	1204.78	103	144
"	17.00	1204.78	103	144
"	18.00	1204.78	103	144
"	19.00	1204.68	104	144
"	20.00	1204.63	104	147
"	21.00	1204.63	147	147
"	22.00	1204.58	106	147
"	23.00	1204.48	105	147
"	24.00	1204.38	115	147
		AVERAGE;	113	144

TABLE - 4
HOURLY MANGLA RESERVOIR DATA - SEPTEMBER 13, 1992

DATE	TIME (Hrs.)	RESERVOIR LEVEL FT. SPD	INFLOW (1000xCusecs)	OUTFLOW (1000xCusecs)
13-9-1992	01.00	1204.33	106	147
"	02.00	1204.28	106	147
"	03.00	1204.23	106	147
"	04.00	1204.18	106	147
"	05.00	1204.08	99	156
"	06.00	1203.98	92	146
"	07.00	1203.88	78	147
"	08.00	1203.78	78	147
"	09.00	1203.73	78	147
"	10.00	1203.68	106	147
"	11.00	1203.63	106	147
"	12.00	1203.58	105	147
"	13.00	1203.48	65	147
"	14.00	1203.38	65	147
"	15.00	1203.28	65	147
"	16.00	1203.18	65	147
"	17.00	1203.08	57	100
"	18.00	1203.03	81	100
"	19.00	1203.03	103	100
"	20.00	1203.03	101	100
"	21.00	1203.08	141	100
"	22.00	1203.13	141	100
"	23.00	1203.13	111	122
"	24.00	1203.08	114	122
		AVERAGE:	95	134

TABLE-5

MANGLA RESERVOIR

RAINFALL, INFLOW OUTFLOW AND LEVELS DATA DURING SEPTEMBER, 1992 FLOOD

Date	Rainfall		Inflow (1000 x Cusecs)			Outflow (1000xCusecs)		Reservoir Level (FT.SPD)
	Forecast by Met. Deptt	Actual (inches)	Forecast by Met. Deptt	Actual Min	Actual Max	Min	Max	
Sept.6	Scattered Thunder Showers	0.09	20-40	10	69	10	33	1201.93
Sept.7	Scattered Thunder Showers	1.75	25-50	10	136	11	33	1202.33
Sept.8	Widespread Thunder Showers	3.98	25-50	22	113	29	33	1202.33
Sept.9	Widespread Thunder Showers with Scattered Moderately Heavy Fall	37.16	25-50 350-80 350-450	32	987	29	645	1206.98
Sept.10	Widespread Thunder Showers	7.11	500F150	234	1090	210	933	1207.85
Sept.11	Isolated Thunder Showers	0.05	200F50	125	251	144	210	1205.63

F : falling

TABLE-6

ROUTING OF SEPTEMBER 9 & 10, 1992 SUPER FLOOD THROUGH MANGLA RESERVOIR . RELEVANT INFORMATION

1.	Function of Reservoir for Flood Control :		
	- Impounding Stage (Below 1202)	-	Considerable flood control, consistent with the Maximum Rule Curve.
	- Full Stage (1202)	-	No space for flood control, only incidental mitigation.
2.	Super Flood of September 9 & 10, 1992 :		
	- Previous High Floods (In excess of 7,00,000 cs)	-	Single peak with generally sharp fall.
	- Current Flood:		
	a. Cause	-	Extremely unusual event of the combined effect (within 24 hours) of monsoon Depression (over Rajasthan and westerly (over Afghanistan), which caused intense rain in catchment within a very short period.
	b. Characteristic	-	Double peak (within 11 hrs).
		-	First peak of 987,000 cusecs, second largest in record.
		-	Second peak of 1,090,000 cusecs exceeding the previous 1929 record of 1,040,000 cusecs.

- This peak was about 1 in 2000 year frequency.

3. Flood Mitigation Effect:

- First Peak - Managed with outflow of 645,000 cusecs. (reduction of 342,000 cusecs).
- Second Peak - Managed with outflow of 933,000 cusecs. (reduction of 157,000 cusecs).

4. Rainfall Run-off in the Catchment on September 6,7 & 8 :

a. Type - Slight though wide spread rains with insignificant run-off generation.

b. Corresponding Run-off at Reservoir Rim-Stations:

Date	Mean Daily Discharge Azad Pattan + Kotli (cs)
Sept. 7	29,100
Sept. 8	27,100
Sept. 9	40,300

5. Rainfall in Catchment on September 9 :

- Kallar - Heavy rain of 5.52" (0200-0800)
- Kotli - Heavy rain of 5.60" (0300-0600)
- Pallandri - Heavy rain of 1.50" (0100-0600)
- Domel - Heavy rain of 2.15" (0100-0800)

6. Flood Routing preparedness on September 9:

- Upto 0600 Hours	- Local freshet of 115,000 cusecs due to rainfall in lower catchment with Kohala still low.
- 0700 Hours	- Anticipation of possible flood with inflow jumping to 235,000 cusecs.
- 0800 Hours	- Reservoir inflow of 274,000 cusecs providing conclusive evidence of large flood.
- 0830 Hours	- Decision to start flood regulation.
- 0912 Hours	- Start of spillway gates operation leading to outflow of about 110,000 cusecs by 1000 hours.

7. Flood Forecast by FFWC Lahore :

- Previous (September 8)	25,000 - 50,000 cusecs
- Special Based on Rainfall Data of Early September 9	350,000 - 450,000 cusecs
At 1330 Hrs. of September 9,	350,000 - 80 Cusecs
- Time of Special Forecast from Lahore	- 0855 Hours
- Time of Receipt at Mangla	- 0930 Hours
- Action	- Already initiated before receipt of Forecast.

8.	Flood Regulation Through Reservoir on September 9 & 10:		
	Sept. 9: 1000 - 1300 hrs.	-	140,800 to 183,700 cusecs
	1400 - 1500 hrs.	-	Due to impending high flood out-flows increased to 238,900 cusecs.
	1500 - 2400 hrs.	-	Due to very high flood peak of 987,000 cusecs at 1700 hrs., the outflows progressively increased to 644,700 by 2400 hrs. with maximum reservoir level of 1206.98.
	Sept. 10: 0000 - 1000 hrs.	-	Whereas after initial peak recession, the inflows started rising again the outflow was increased to 933,000 cusecs by 0400 hrs. through full opening of spillway gates. At this time the second peak of 1,090,000 cusecs (historic maximum) was experienced. This continued upto 1000 hrs. with maximum reservoir level of 1207.83 attained at 0500 hrs.
	1100 - 2000 hrs.	-	Due to receding inflows the outflow throttling was started effective 1100 hrs. and by 2400 hrs. it had been reduced to 210,000 cusecs balancing thereby the inflow and outflow at reservoir level of 1205.18.
9.	Flooding in the Catchment due to extensive rain of September 9 :		
	Garhi Habib Ullah		Gauge overflowed after 1300 hrs.

- Domel	-	Gauge remained overflowed between 1500 hrs. to 1600 hrs. & after 2200 hrs.
- Kohala	-	Gauge overflowed after 1200 hrs.
- Azad Pattan	-	Gauge overflowed after 1200 hrs.

10. Conclusions:

- Without Mangla Reservoir	-	Jhelum River would carry a superflood of 2 peaks (987,000 cusecs and 1,090,000 cusecs).
- Due to Mangla Reservoir	-	Even in full stage condition it received peaks of 645,000 and 933,000 cusecs, thus affecting a considerable attenuation of 342,000 and 157,000 cusecs for first and second peaks respectively.

TABLE - 7

PERFORMANCE OF REPORTING RAIN/RIVER GAUGES IN MANGLA CATCHME

	Station	Parameters	Communicated System	Performance During Floc
1.	Jhelum River at Domel	Streamflow/ Rainfall	Telemetry & Wireless	Manual System remained operative, telemetric syste inoperative since Novemb 1991.
2.	Neelum River at Muzaffarabad	Streamflow/ Rainfall	Telemetry & Wireless	Manual system remained operative, telemetric syste inoperative since Novemb 1991.
3.	Kunhar River at Garhi Habib Ullah	Stream flow	Wireless only	Manual system remained operative till complete washing away of t. .e gauging station on afternoon of 9.9.1992.
4.	Jhelum River at Azad Pattan	Stream flow	Wireless only	Manual system remained operative till complete washing away of the gauging station on after-noon of 9.9.1992.
5.	Jhelum River at Kohala	Streamflow/ Rainfall	Telemetry & Wireless	Manual system remained operative, telemetric syste inoperative since Nov. 19
6.	Poonch River near Kotli	Streamflow/ Rainfall	Telemetry & Wireless	Manual system remained operative, telemetric syste inoperative since March, 1992.
7.	Palandri	Rainfall	Telemetry & Wireless	Both the system remainec operative.
8.	Kallar	Rainfall	Wireless only	Remained operative.
9.	Sehr Ka Kota	Rainfall	Telemetry only	Remained partially operati
10.	Sohawa	Rainfall	Telemetry only	Remained operative
11.	Mangla	Streamflow/ Rainfall	Telemetry/ Wireless	Both operative

TABLE - 8

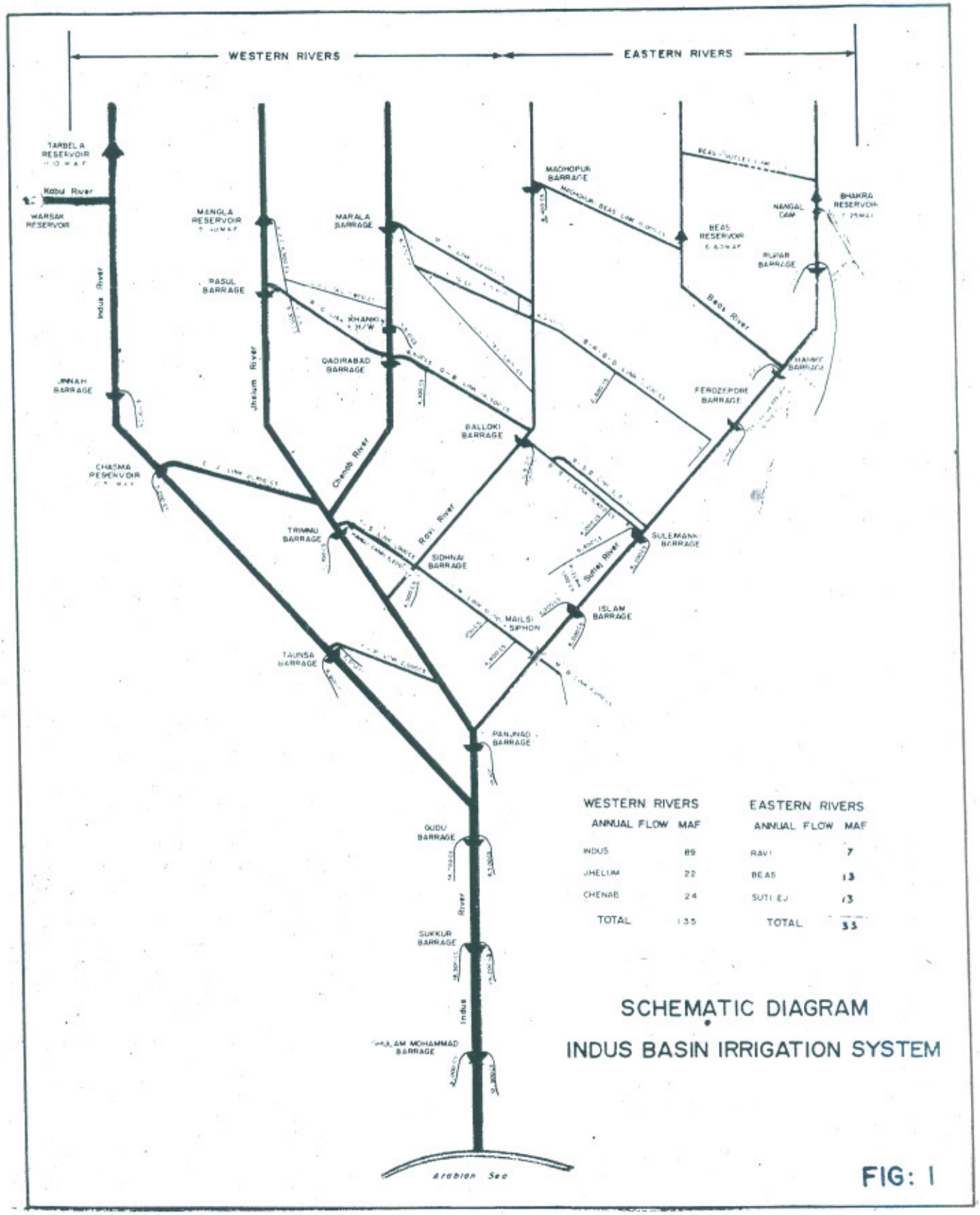
PROBABLE MAXIMUM FLOOD JHELUM RIVER AT MANGLA

Time in Hours	Inflow (1000xCusecs)	Time in Hours	Inflow (1000xCusecs)	
0	85	87	1000	
3	85	90	2075	
6	85	91	2275	
9	85	92	2540	
12	90	93	2600	Single Peak
15	115	94	2540	
18	170	95	2585	
21	184	96	2554	
24	170	97	2462	
27	146	98	2400	
30	123	99	2308	
33	108	100	2154	
36	138	101	2000	
39	338	102	1861	
42	475	105	1354	
43.5	546	108	954	
45	500	111	750	
48	300	114	815	
51	215	117	1000	
54	185	120	892	
57	170	123	662	
60	200	126	460	
63	246	129	325	
66	370	132	250	
69	260	135	275	
72	215	138	525	
75	170	141	740	
78	155	144	710	
81	170	147	540	
84	340	150	370	
86	700	153	260	
		156	220	

TABLE - 9

ISSUE OF WARNINGS FROM MANGLA DURING 1992 FLOOD

TYPE	FREQUENCY	RECIPIENTS	REMARKS
Mandatory (under Flood Management Procedure)	Hourly from the start of medium flood stage after 0600 hours on September 9,1992	i) Flood Warning Centre working under Flood Relief Commissioner Punjab	Through Wireless Network of WAPDA, Police and Postal Wire
		ii) Following concerned offices of Punjab Irrigation Department:- - S.E. UJC Jhelum - XEN Rasul - S.E. LJC Sargodha - S.E. Haveli Multan - S.E. Muzaffargarh - S.E. LBDC Sahiwal	
Additional on initiative of Project Authorities	As frequently as possible	i) D.C. Jhelum ii) D.C. Mirpur iii) Station Commander Mangla Cantt.	Through Telephones


WESTERN RIVERS
EASTERN RIVERS
TARBELA RESERVOIR
Kabul River
WARSAK RESERVOIR
MANGLA RESERVOIR
MARALA BARRAGE
MADHOPUR BARRAGE
BHAKRA RESERVOIR
NANGAL DAM
BEAS RESERVOIR
RUPAR BARRAGE
PASUL BARRAGE
Indus River
Jhelum River
Beas River
JINNAH BARRAGE
QADIRABAD BARRAGE
FEROZEPORE BARRAGE
BALLOKI BARRAGE
CHASMA RESERVOIR
Chenab River
Ravi River
TRIMMU BARRAGE
SULEMANKI BARRAGE
SIDHNAI BARRAGE
Sutlej River
MAILSI SIPHON
ISLAM BARRAGE
TAUNSA BARRAGE
PANJNAD BARRAGE
GUDU BARRAGE
SUKKUR BARRAGE
Indus River
GHULAM MOHAMMAD BARRAGE
Arabian Sea
WESTERN RIVERS
ANNUAL FLOW MAF
INDUS 89
JHELUM 22
CHENAB 24
TOTAL 135
EASTERN RIVERS
ANNUAL FLOW MAF
RAVI 7
BEAS 13
SUTLEJ 13
TOTAL 33
SCHEMATIC DIAGRAM
INDUS BASIN IRRIGATION SYSTEM
FIG: 1

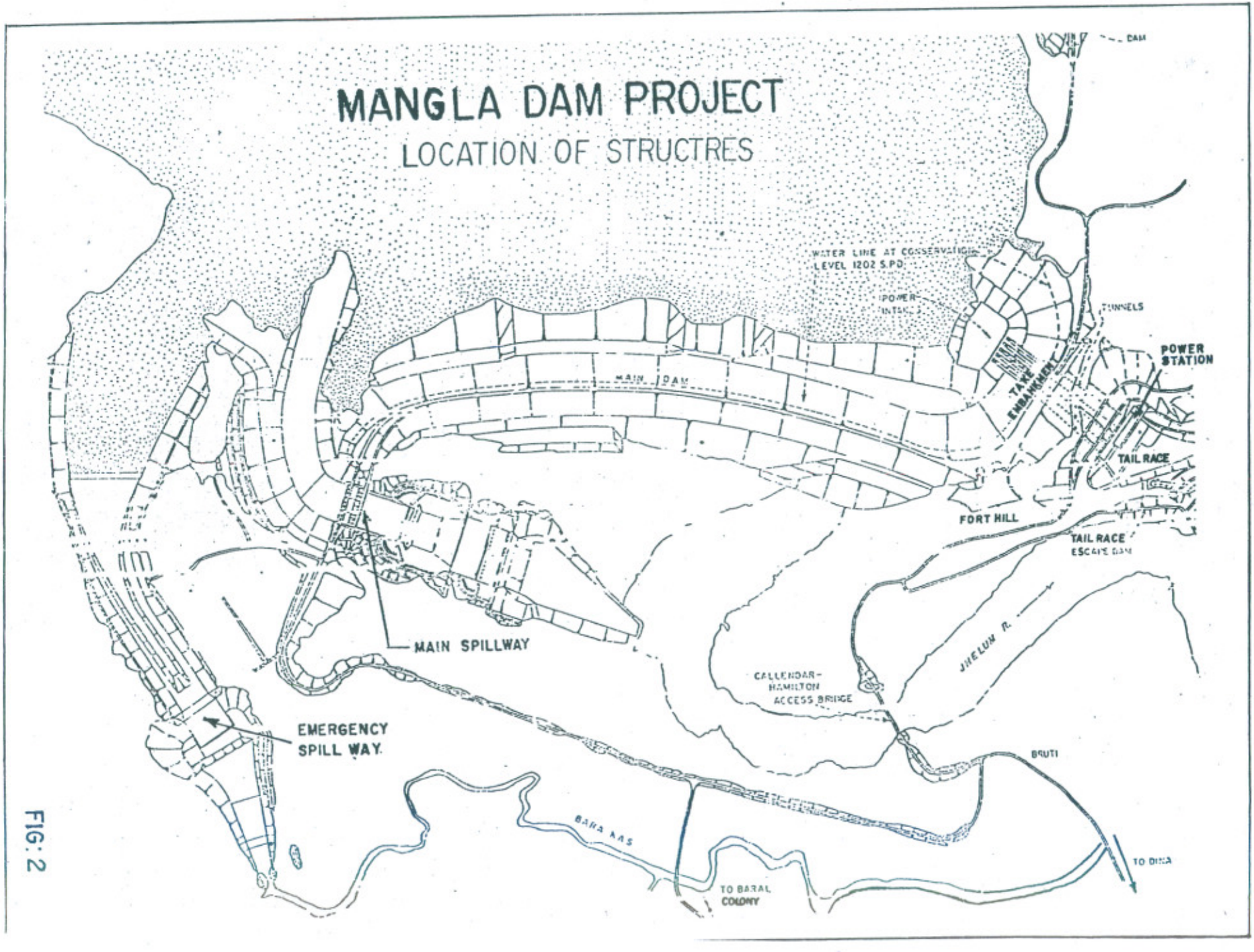
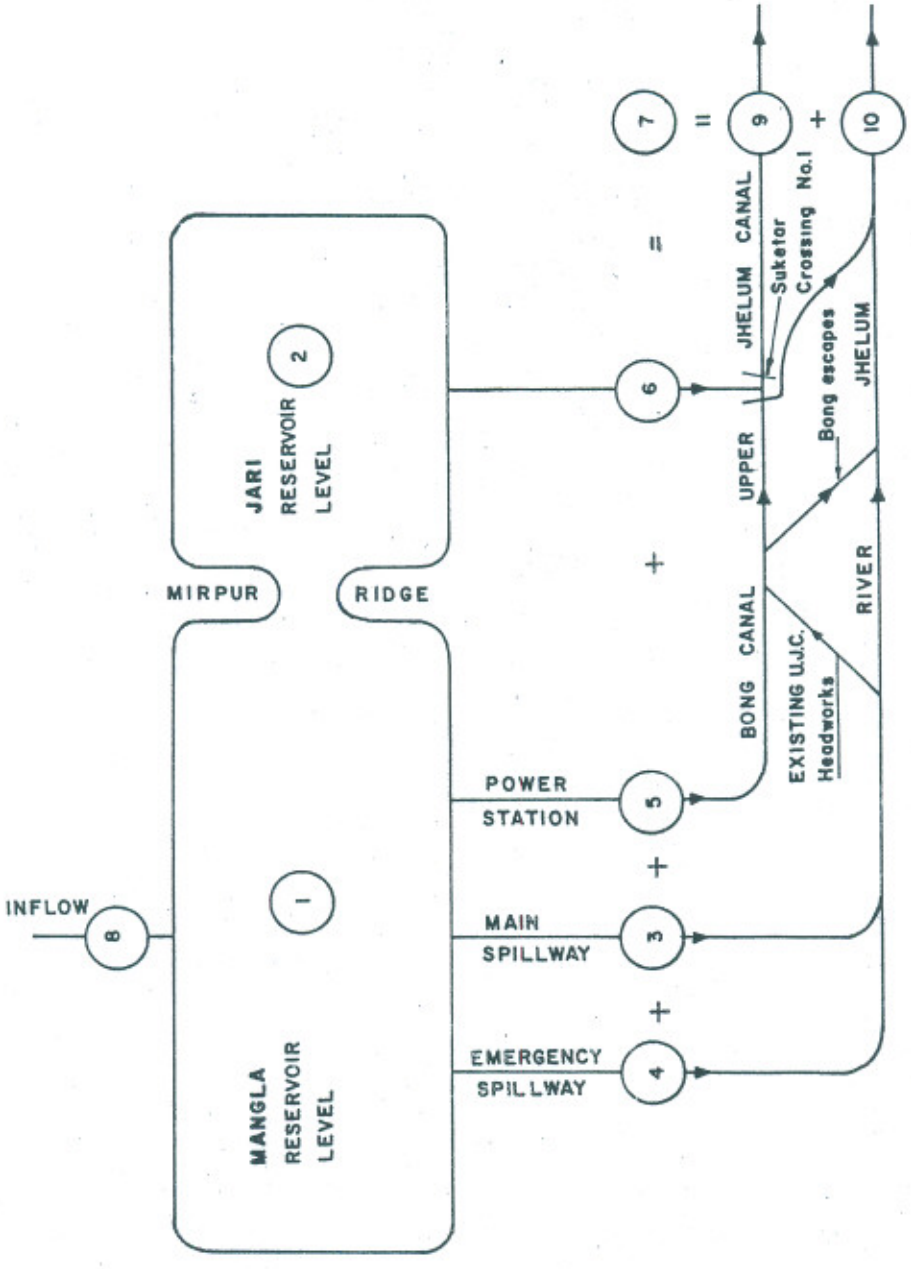

MANGLA DAM PROJECT
LOCATION OF STRUCTRES
DAM
WATER LINE AT CONSERVATION LEVEL 1202 S.P.D.
POWER INTAKE
TUNNELS
POWER STATION
TAKE EMBANKMENT
MAIN DAM
TAIL RACE
FORT HILL
TAIL RACE ESCAPE CANAL
MAIN SPILLWAY
JHELUM R.
CALLENDAR-HAMILTON ACCESS BRIDGE
EMERGENCY SPILL WAY
BRUTI
BARA AAS
TO BARAL COLONY
TO DINA

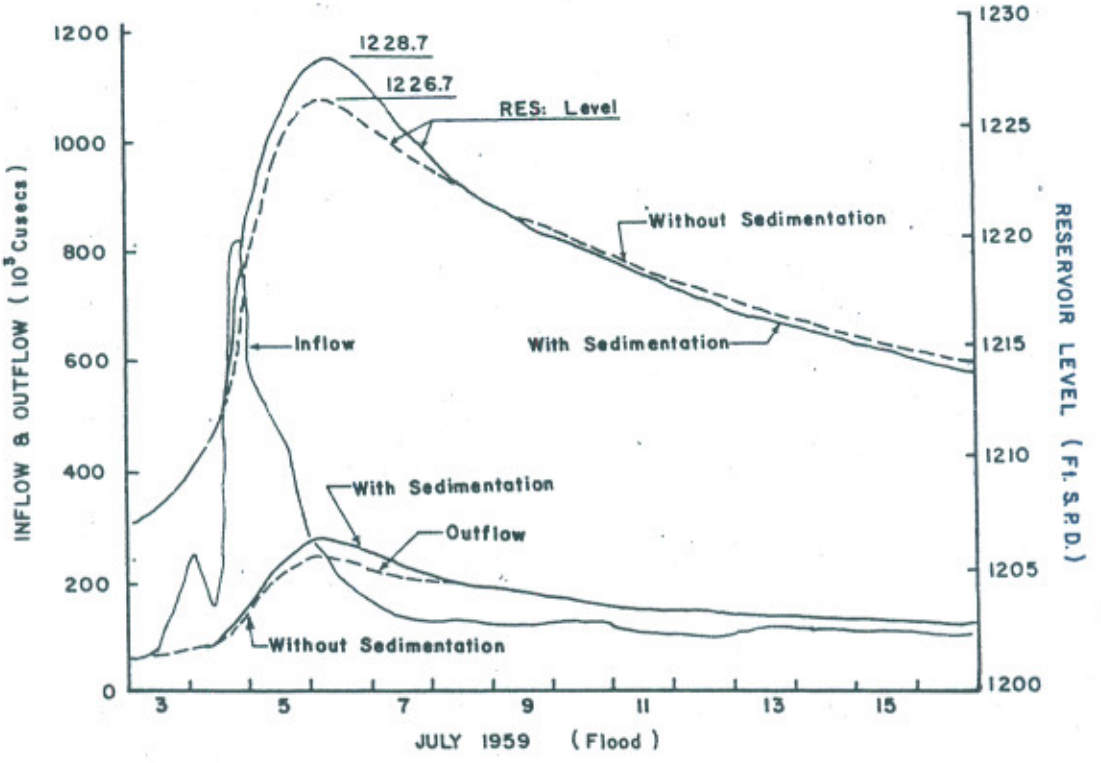
FIG: 2

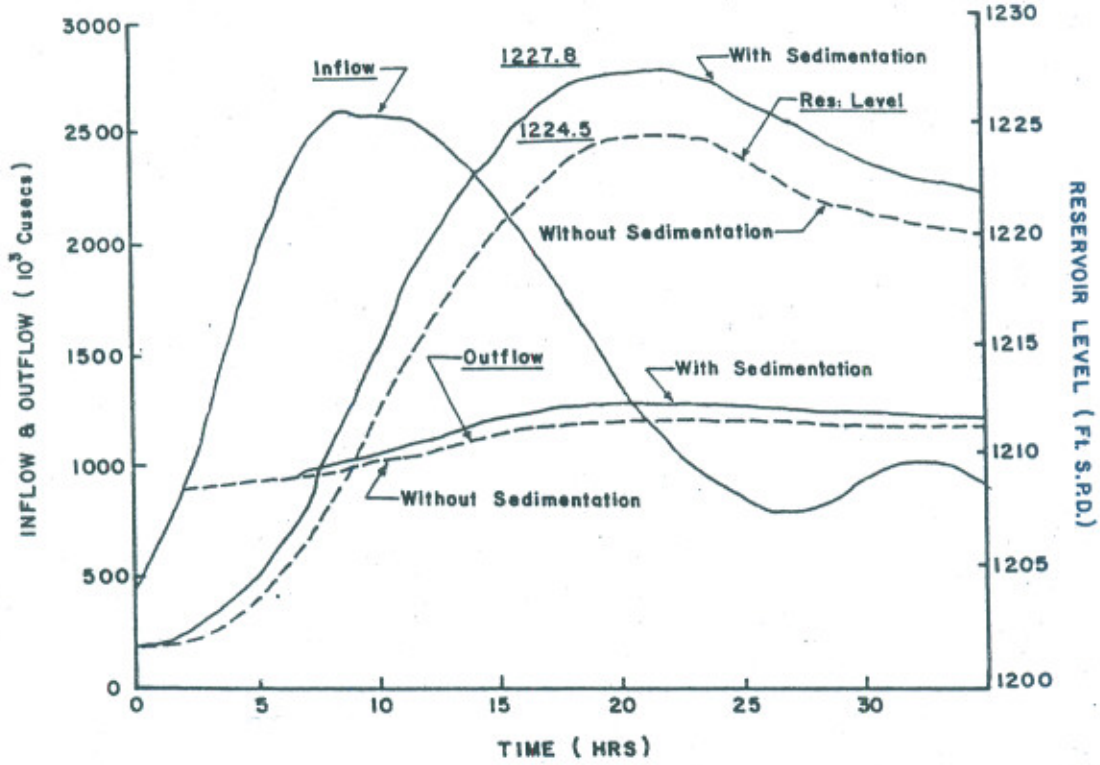


MANGLA DAM PROJECT

WATER FLOW DIAGRAM

FIG. 3.





(ABOVE) Flood routing of flood of record through emergency spillway only.

(BELOW) Flood routing of probable maximum flood through main and emergency spillway.

FIG: 4

MANGLA FLOOD ROUTING 1973

AUGUST 9 – 12, 1973

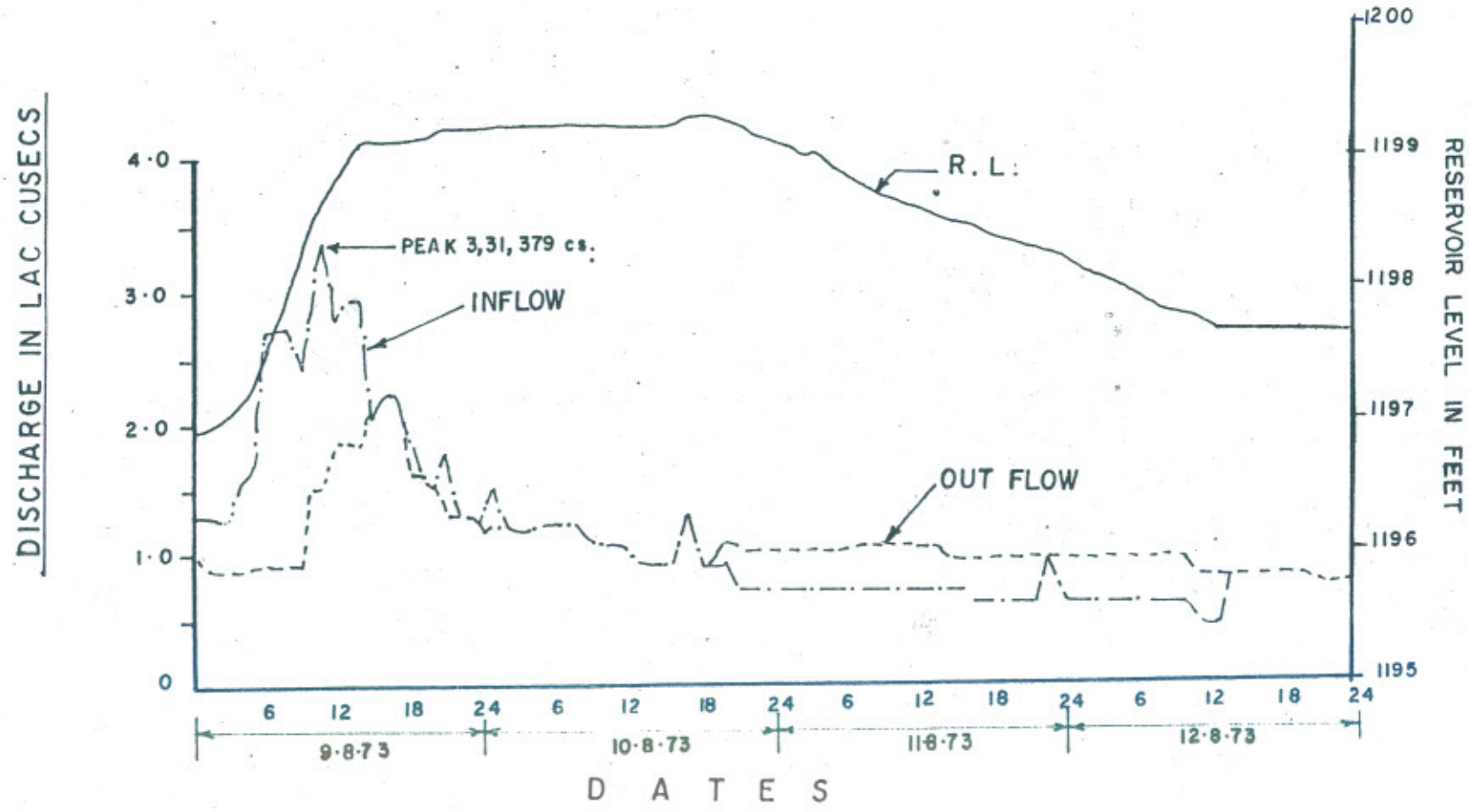
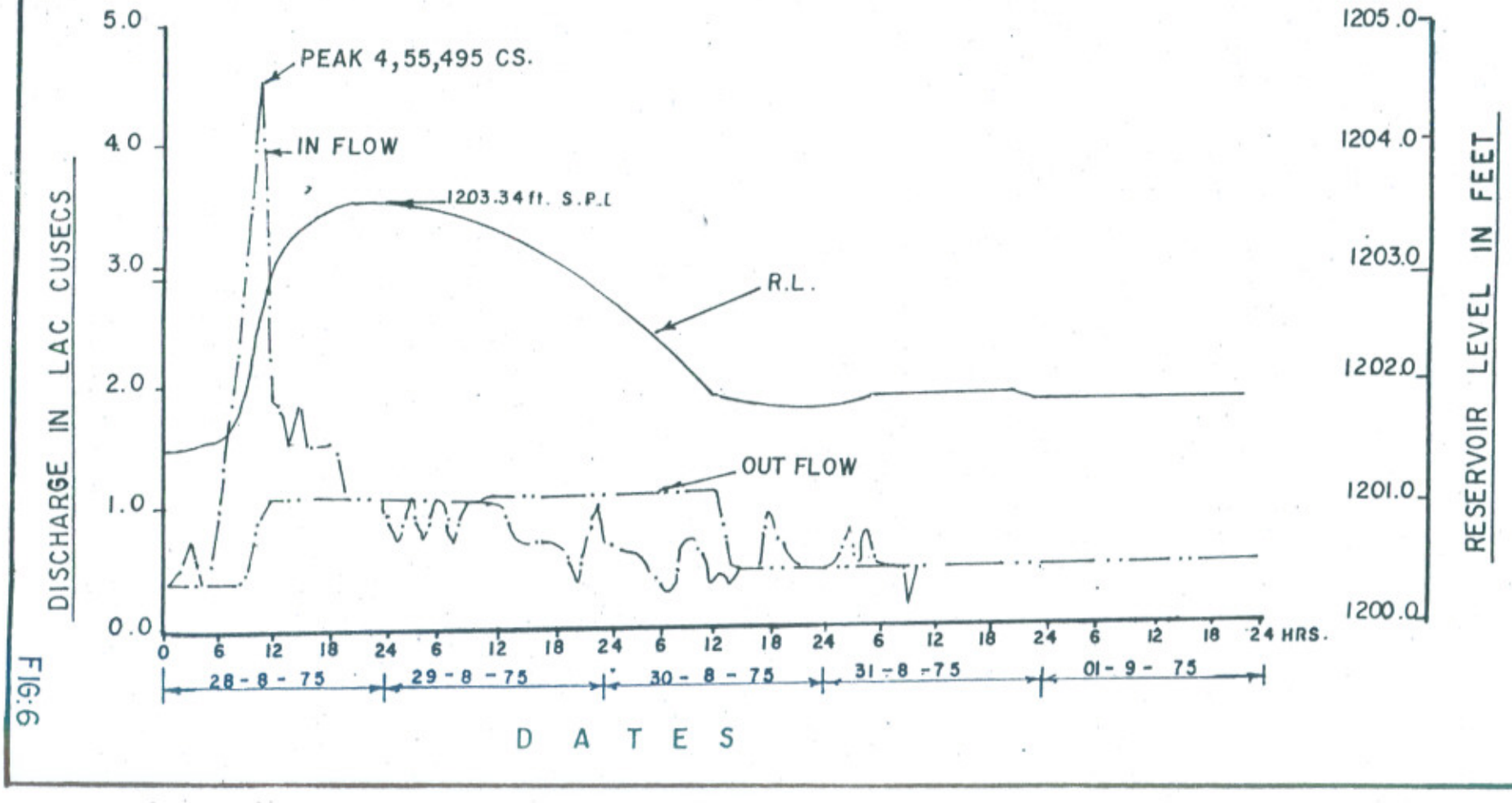


FIG: 5

MANGLA FLOOD ROUTING 1975

. August 28 - Sep; 1, 1975



F16:6

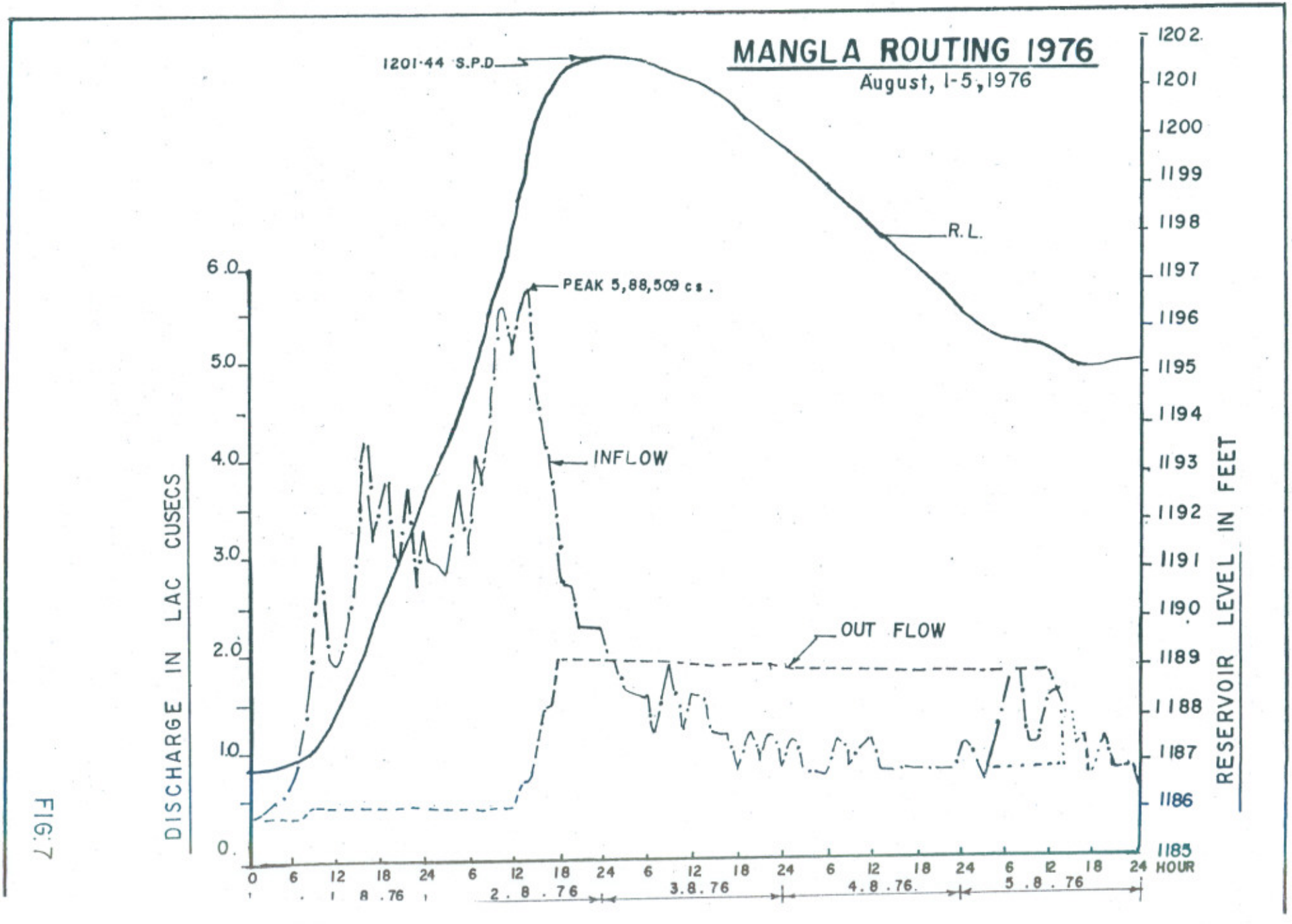

MANGLA ROUTING 1976
August, 1-5, 1976
1201·44 S.P.D
R.L.
PEAK 5,88,509 cs.
INFLOW
OUT FLOW
DISCHARGE IN LAC CUSECS
RESERVOIR LEVEL IN FEET
6.0
5.0
4.0
3.0
2.0
1.0
0.
1202
1201
1200
1199
1198
1197
1196
1195
1194
1193
1192
1191
1190
1189
1188
1187
1186
1185
0 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 HOUR
1.8.76
2.8.76
3.8.76
4.8.76
5.8.76

FIG.7

MANGLA FLOOD ROUTING 1978

March, 16 - 18, 1978

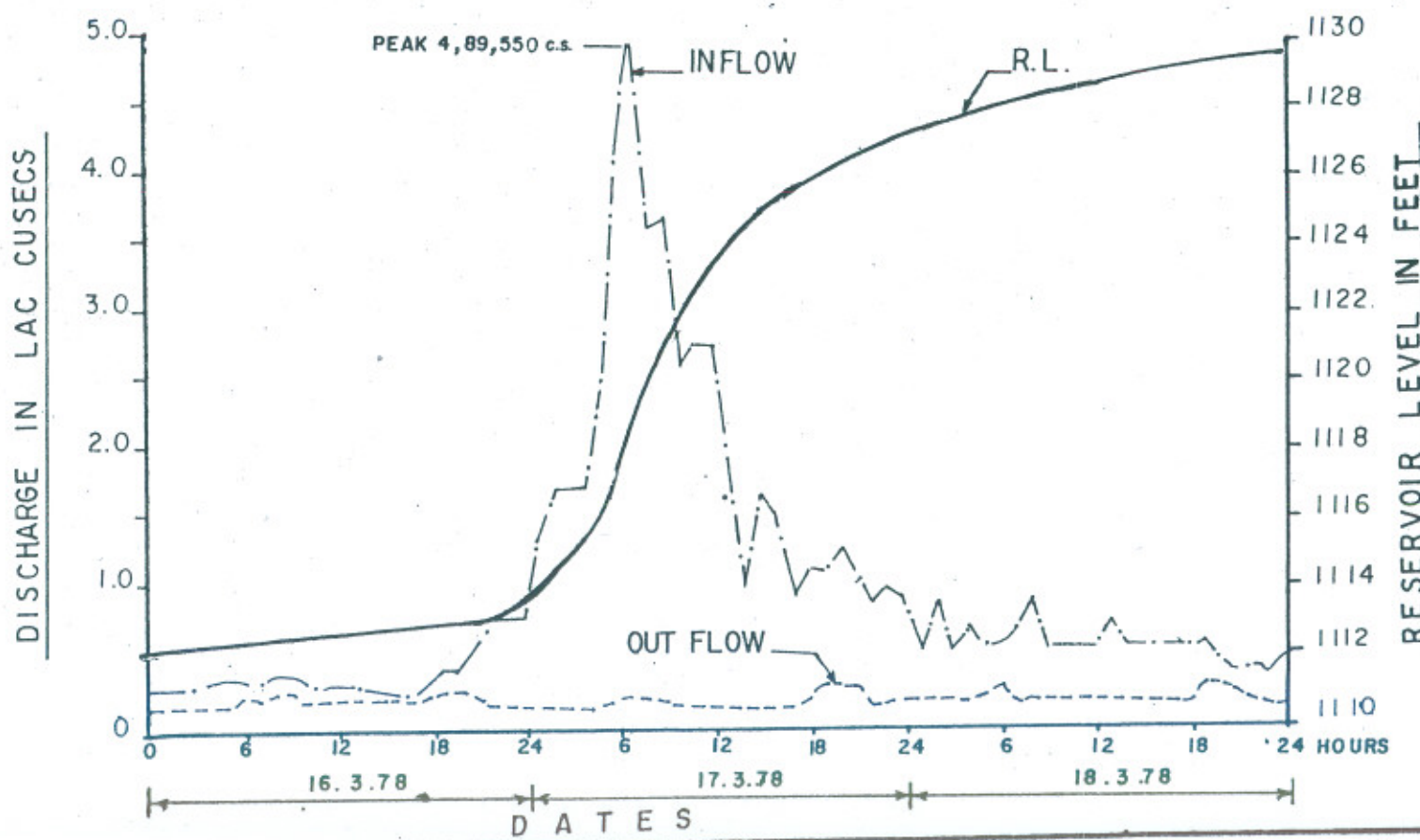


FIG: 8

MANGLA FLOOD ROUTING 1988

July, 15 - 19, 1988

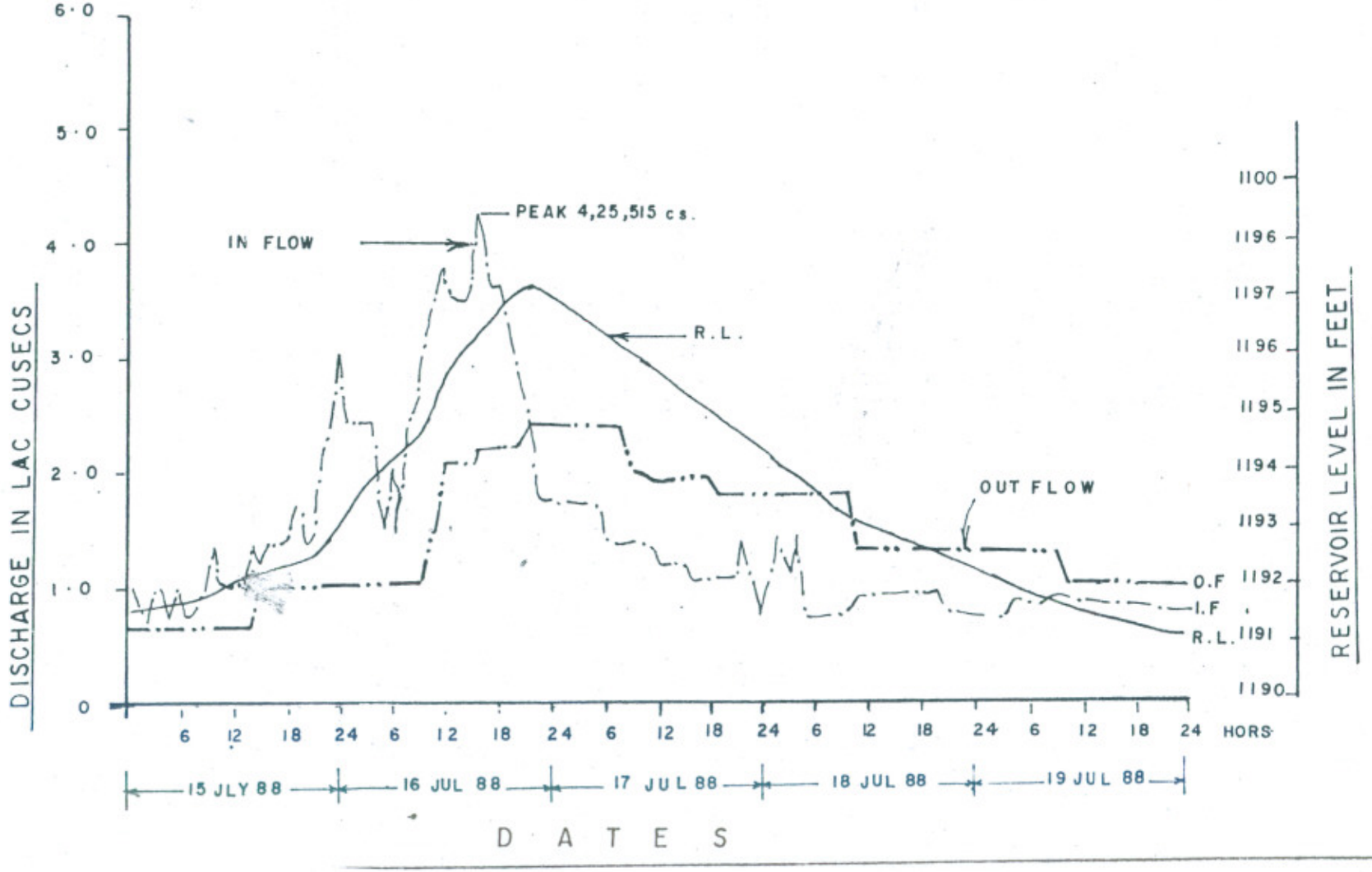


FIG: 9

MANGLA RESERVOIR CATCHMENT

SCHEMATIC DIAGRAM OF HYDROMET NETWORK

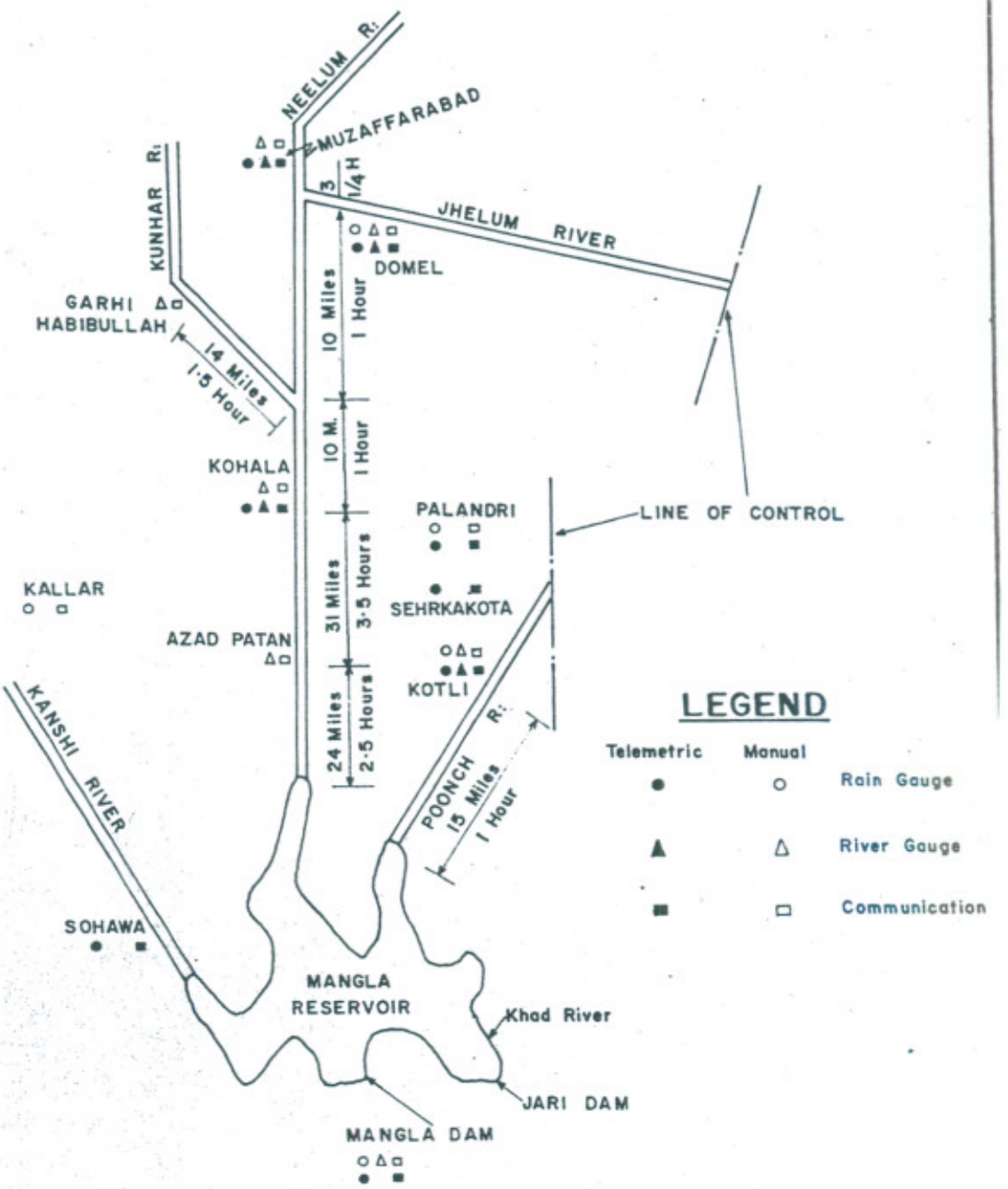
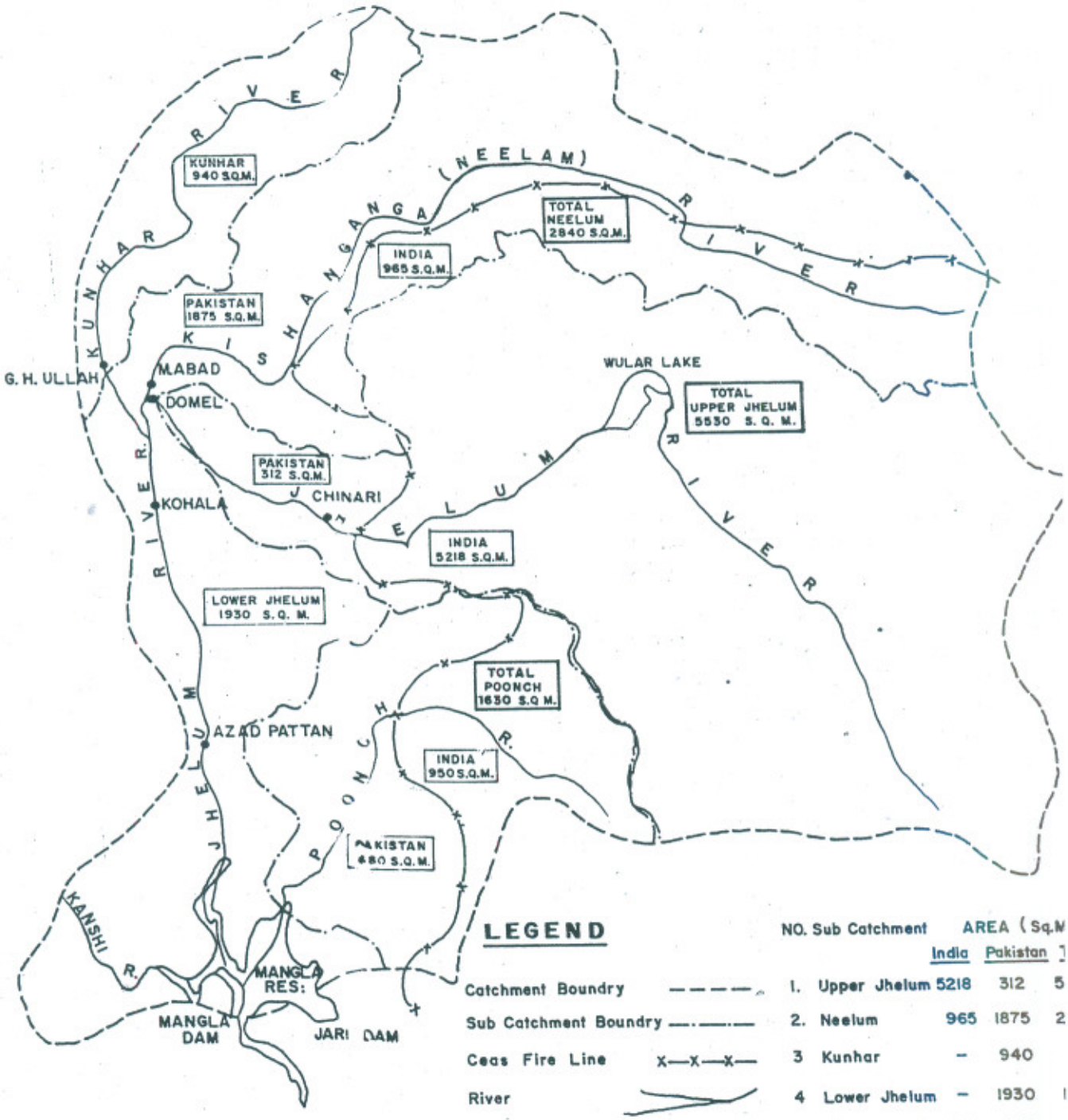


FIG: 10

JHELUM RIVER CATCHMENT ABOVE MANGLA DAM



LEGEND

Catchment Boundry

Sub Catchment Boundry

Ceas Fire Line

River

City Town

NO.	Sub Catchment	AREA (Sq.M		
		India	Pakistan	
1.	Upper Jhelum	5218	312	5
2.	Neelum	965	1875	2
3	Kunhar	–	940	
4	Lower Jhelum	–	1930	
5	Poonch	950	680	
	Total =	7133	5737	1

FIG:

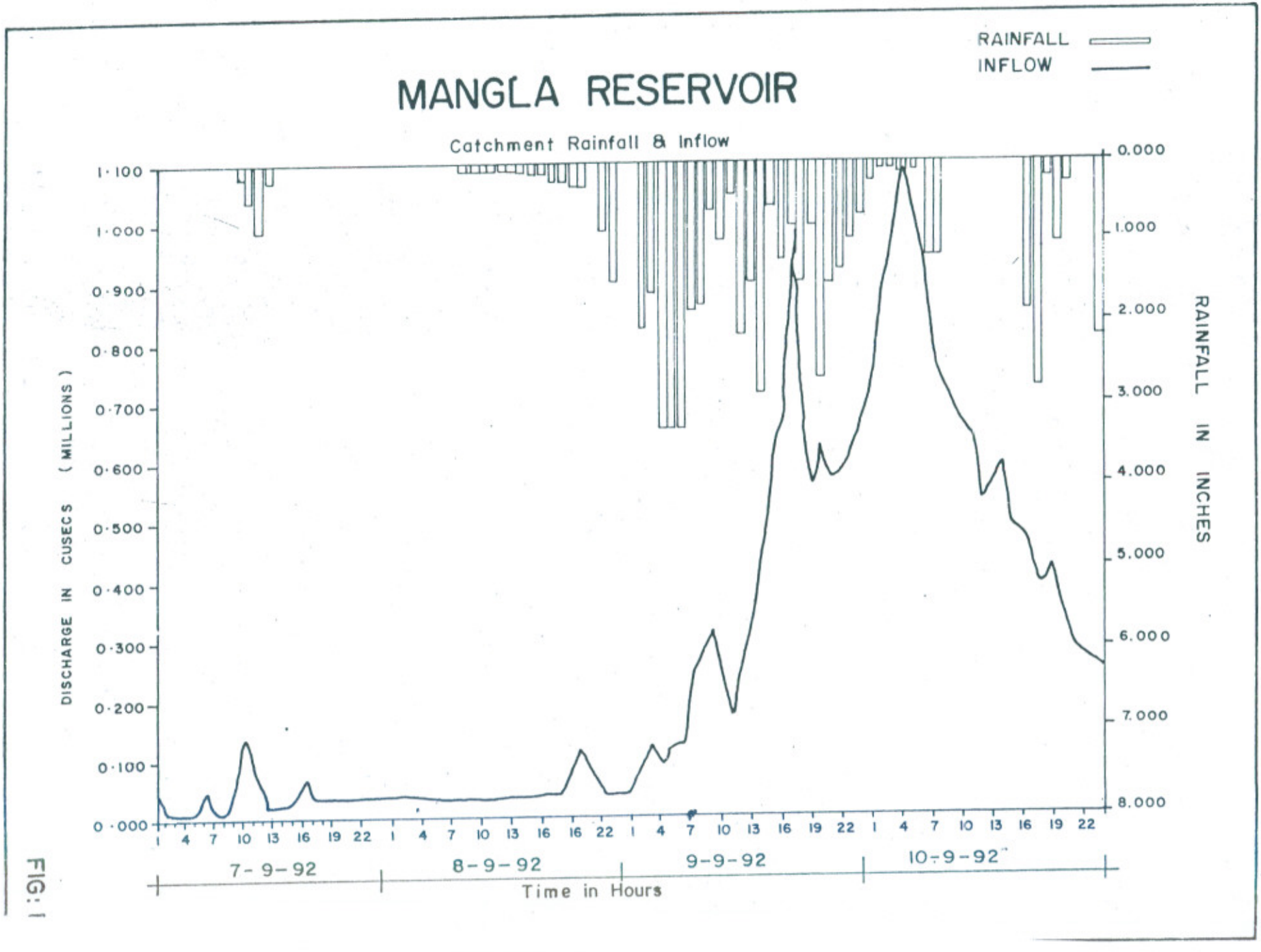

RAINFALL
INFLOW
MANGLA RESERVOIR
Catchment Rainfall & Inflow
DISCHARGE IN CUSECS (MILLIONS)
RAINFALL IN INCHES
1·100
1·000
0·900
0·800
0·700
0·600
0·500
0·400
0·300
0·200
0·100
0·000
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
1 4 7 10 13 16 19 22 1 4 7 10 13 16 16 22 1 4 7 10 13 16 19 22 1 4 7 10 13 16 19 22
7-9-92
8-9-92
9-9-92
10-9-92
Time in Hours

FIG: 1

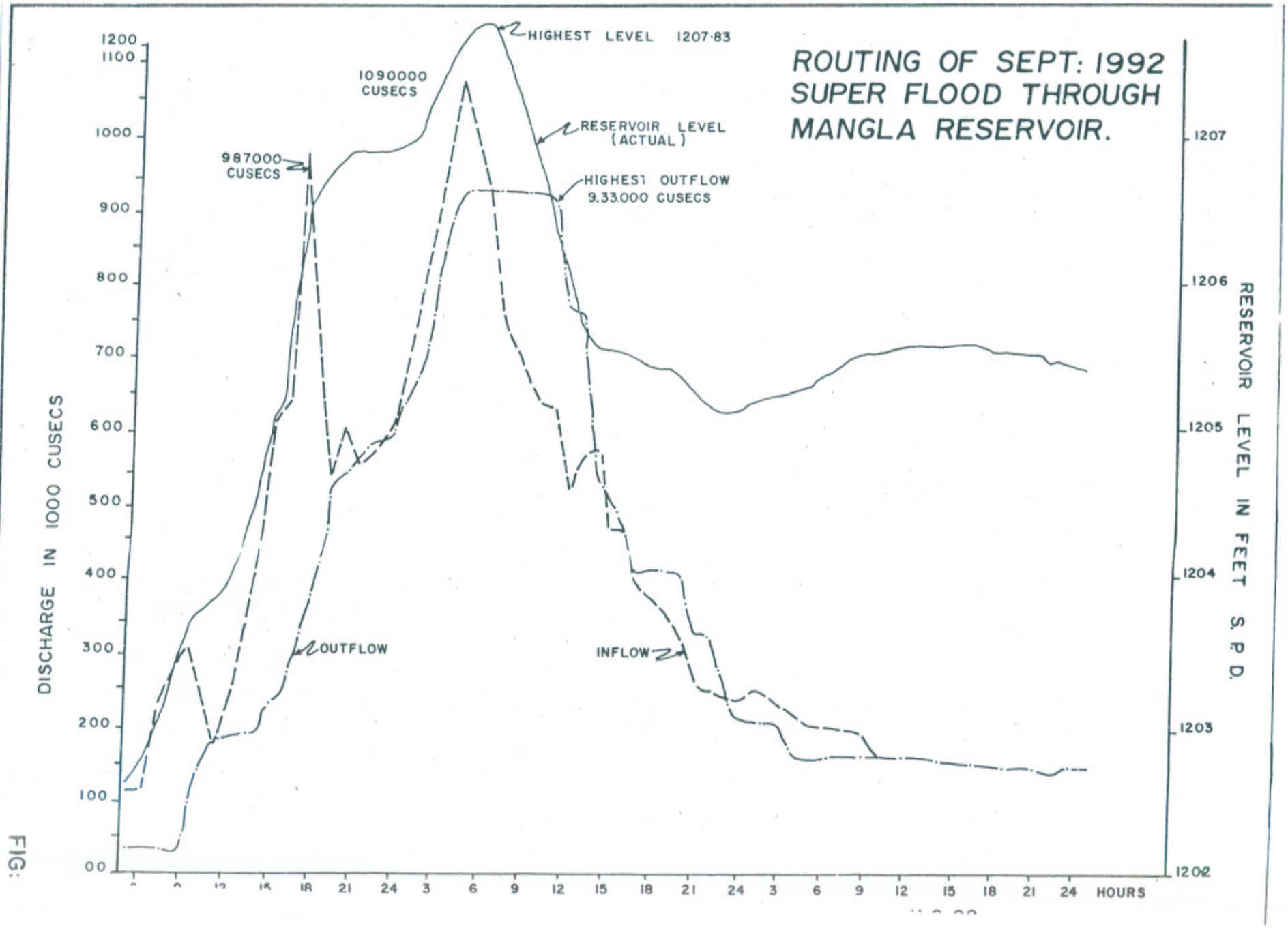

ROUTING OF SEPT: 1992
SUPER FLOOD THROUGH
MANGLA RESERVOIR.
HIGHEST LEVEL 1207·83
1090000
CUSECS
RESERVOIR LEVEL
(ACTUAL)
987000
CUSECS
HIGHEST OUTFLOW
9,33,000 CUSECS
OUTFLOW
INFLOW
DISCHARGE IN 1000 CUSECS
RESERVOIR LEVEL IN FEET S. P. D.
1200
1100
1000
900
800
700
600
500
400
300
200
100
00
1207
1206
1205
1204
1203
1202
12 15 18 21 24 3 6 9 12 15 18 21 24 3 6 9 12 15 18 21 24 HOURS

FIG:

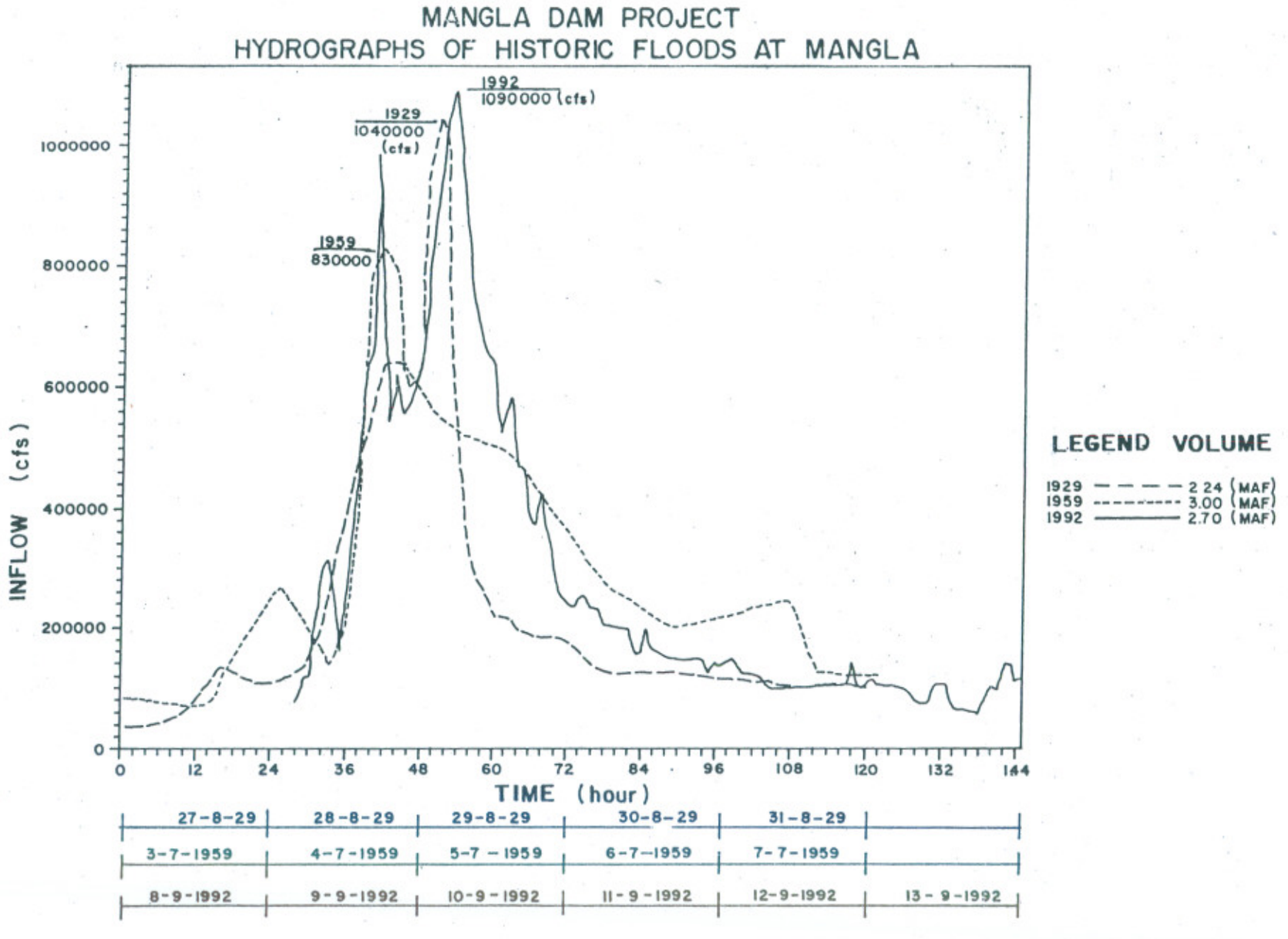
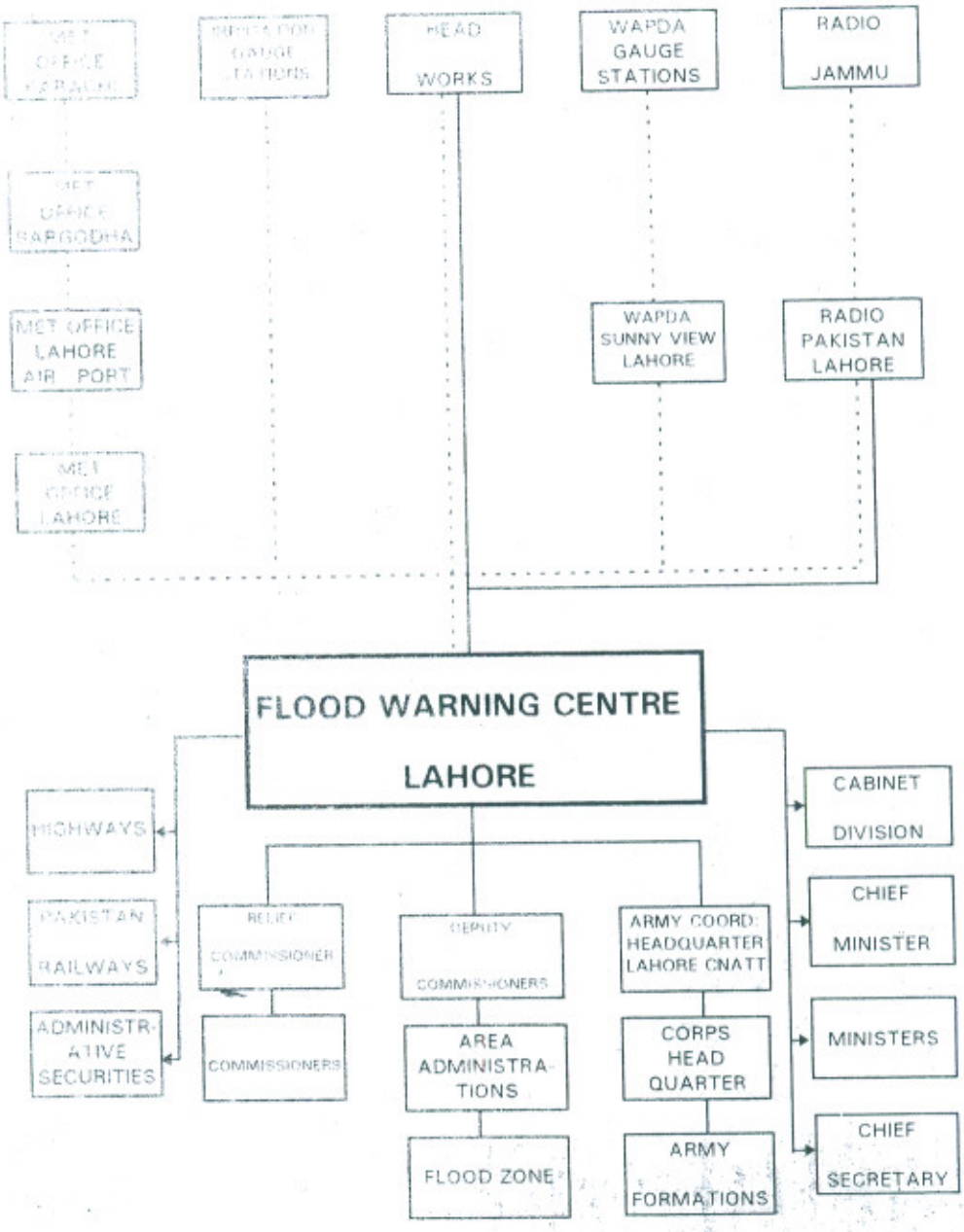

MANGLA DAM PROJECT
HYDROGRAPHS OF HISTORIC FLOODS AT MANGLA
1992
1090000 (cfs)
1929
1040000
(cfs)
1959
830000
INFLOW (cfs)
1000000
800000
600000
400000
200000
0
0
12
24
36
48
60
72
84
96
108
120
132
144
TIME (hour)
LEGEND VOLUME
1929 2.24 (MAF)
1959 3.00 (MAF)
1992 2.70 (MAF)
27-8-29
28-8-29
29-8-29
30-8-29
31-8-29
3-7-1959
4-7-1959
5-7-1959
6-7-1959
7-7-1959
8-9-1992
9-9-1992
10-9-1992
11-9-1992
12-9-1992
13-9-1992

FIG:

FIG.—15

FLOOD WARNING SYSTEM IN THE PUNJAB



LEGEND

..... INFLOW OF INFORMATION/DATA

_____ OUTFLOW OF FLOOD WARNING MESSAGES