(2) Simulation Results of River Flow

<River Flow for Upper Area >

The summary of river flow of the upper area for 32 years (1959/60 - 1990/91) is as shown in Table-5.20 and Fig.-5.38.

Table-5.20 River Flow for Upper Area

No.	Name of Points	Catchment Area(km2)	Mean Discharge (m3/s)	Mean Discharge (bcm/yr)
<Upper Zambezi River>				
1	Cholose	73,512	584	18.42
2	St.(1-150) Zambezi Pump H.	87,275	693	21.87
3	Zambezi R. Portion	90,353	718	22.64
4	St.(1-650) Kabompo Boma	42,740	219	6.90
5	Kabompo R. Portion	45,029	223	7.03
6	Dongwe R. Portion	20,568	39	1.23
7	Confluence with Dongwe R.	65,597	263	8.29
8	St.(1-950) Watopa Pontoon	66,449	264	8.33
9	Kabompo R. Portion	72,347	275	8.67
10	Confluence with Kabompo R.	162,700	993	31.32
11	St.(2-030) Lukulu	206,531	808	25.48
12	Zambezi R. Portion	228,076	868	27.37
13	St.(2-250) Kalabo	34,621	74	2.33
14	Luanginga R. Portion	41,233	93	2.92
15	Confluence with Luanginga R.	269,309	961	30.31
16	St.(2-400) Senanga	278,298	986	31.09
<Kafue River>				
21	St.(4-050) Raglam Farm	4,999	37	1.17
22	Kafue R. Portion	7,730	72	2.27
23	St.(4-120) Mwambashi	869	8	0.25
24	St.(4-130) Smith's Bridge	8,599	79	2.49
25	St.(4-200) Mpatamato	11,655	98	3.09
26	St.(4-280) Machiya Ferry	22,920	145	4.57
27	Kafue R. Portion	24,582	151	4.76
28	Luswishi R. Portion	8,866	35	1.10
29	Confluence with Luswishi R.	33,448	186	5.88
30	St.(4-350) Chilenga	34,162	189	5.96
31	St.(4-450) Lubungu	54,442	199	6.28
32	St.(4-560) Chifumpa Pontoon	21,445	99	3.12
33	Lunga R. Portion	24,416	105	3.31
34	Confluence with Lunga R.	78,858	304	9.59
35	St.(4-669) Kafue Hook Bridge	95,053	336	10.60
<Luangwa River>				
43	St.(5-940) Luangwa Br.	143,781	626	19.74
44	Luangwa R. Portion	150,586	656	20.69

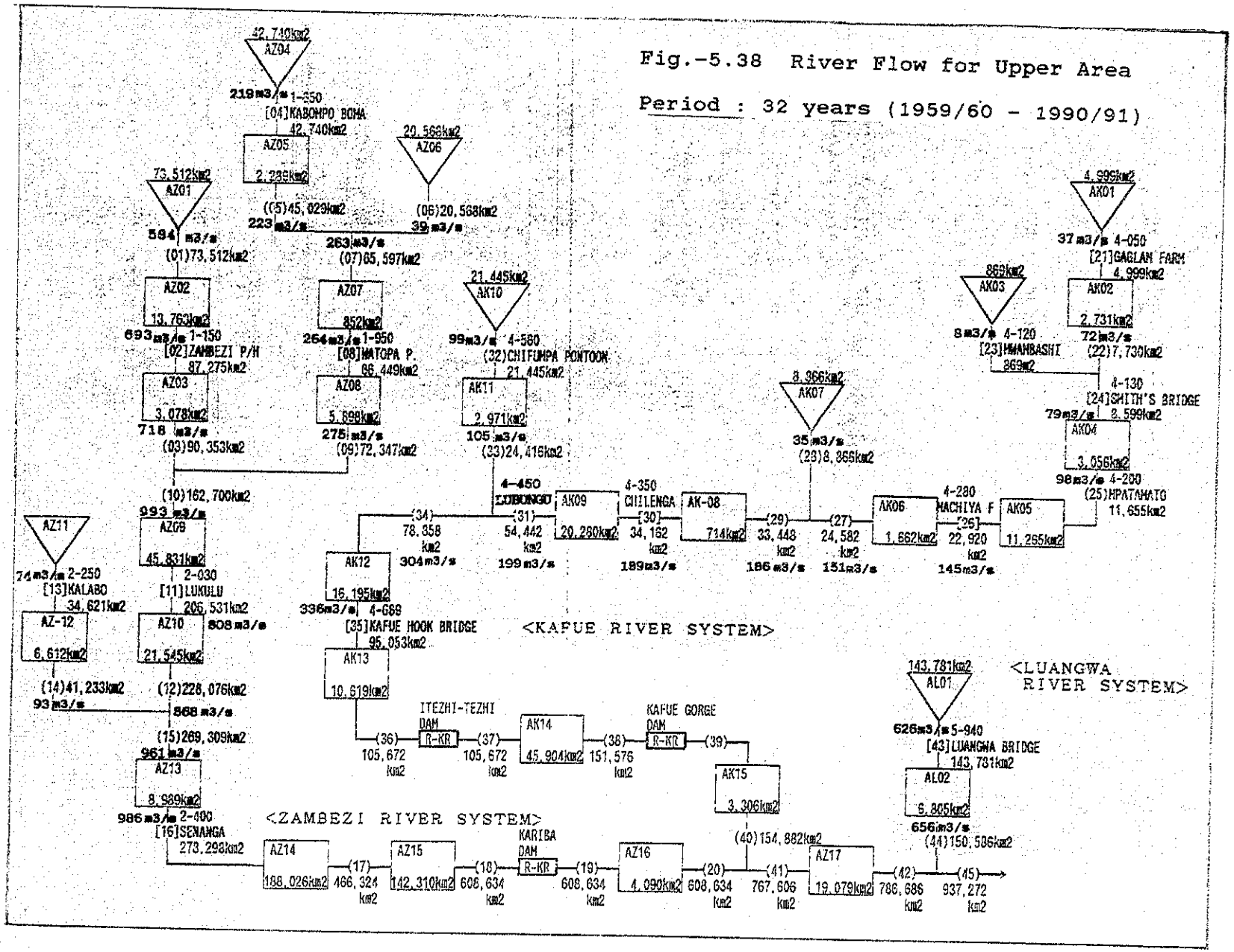
Fig.-5.38 River Flow for Upper Area
Period : 32 years (1959/60 - 1990/91)
42,740km2
AZ04
219m3/s 1-650
[04]KABOMPO BOMA
42,740km2
AZ05
2,239km2
20,568km2
AZ06
73,512km2
AZ01
584 m3/s
(01)73,512km2
((5)45,029km2
223m3/s
(06)20,568km2
39m3/s
263m3/s
(07)65,597km2
AZ02
13,763km2
693m3/s 1-150
[02]ZAMBEZI P/H
87,275km2
AZ03
3,078km2
718 m3/s
(03)90,353km2
AZ07
852km2
264m3/s 1-950
[08]MATOPA P.
66,449km2
AZ08
5,698km2
275m3/s
(09)72,347km2
21,445km2
AK10
99m3/s 4-580
(32)CHIFUMPA PONTOON
21,445km2
AK11
2,971km2
105 m3/s
(33)24,416km2
(10)162,700km2
AZ11
74m3/s 2-250
[13]KALABO
34,621km2
AZ-12
6,612km2
(14)41,233km2
93m3/s
993 m3/s
AZ09
45,831km2
2-030
[11]LUKULU
205,531km2
AZ10
21,545km2
808m3/s
(12)228,076km2
868 m3/s
(15)269,309km2
961m3/s
AZ13
8,989km2
986m3/s 2-400
[16]SENANGA
273,298km2
4-450
LUBONGO
(34)
78,358
km2
304m3/s
(31)
54,442
km2
199m3/s
AK09
20,280km2
4-350
CHILENGA
[30]
34,152
km2
189m3/s
AK-08
714km2
(29)
33,448
km2
186m3/s
(27)
24,582
km2
151m3/s
AK12
16,195km2
336m3/s 4-669
[35]KAFUE HOOK BRIDGE
95,053km2
AK13
10,619km2
<KAFUE RIVER SYSTEM>
8,366km2
AK07
35m3/s
(28)8,366km2
AK06
1,662km2
4-280
MACHIYA F
[26]
22,920
km2
145m3/s
AK05
11,265km2
4,999km2
AK01
37m3/s 4-050
[21]GAGLAM FARM
4,999km2
869km2
AK03
8m3/s 4-120
[23]MWAMBASHI
869km2
AK02
2,731km2
72m3/s
(22)7,730km2
4-130
[24]SMITH'S BRIDGE
79m3/s 8,599km2
AK04
3,056km2
98m3/s 4-200
(25)MPATAMATO
11,655km2
143,781km2
AL01
626m3/s 5-940
[43]LUANGWA BRIDGE
143,781km2
AL02
6,805km2
656m3/s
(44)150,586km2
<LUANGWA
RIVER SYSTEM>
(36)
105,672
km2
ITEZHI-TEZHI
DAM
R-KR
(37)
105,672
km2
AK14
45,904km2
(38)
151,576
km2
KAFUE GORGE
DAM
R-KR
(39)
AK15
3,306km2
(40)154,882km2
<ZAMBEZI RIVER SYSTEM>
AZ14
188,026km2
(17)
466,324
km2
AZ15
142,310km2
(18)
608,634
km2
KARIBA
DAM
R-KR
(19)
608,634
km2
AZ16
4,090km2
(20)
608,634
km2
(41)
767,606
km2
AZ17
19,079km2
(42)
786,686
km2
(45)
937,272
km2

< River Flow for Whole Area >

The summary of river flow of the whole area for the last 12 years (1979/80 - 1990/91) is as shown in Table-5.21, and Fig.-5.39.

Table-5.21 River Flow for Whole Area

No.	Name of Points	Catchment Area(km2)	Mean Discharge (m3/s)	(bcm/yr)
<<<	Upper Area >>>			
1	Cholose	73,512	430	13.56
2	St.(1-150) Zambezi Pump H.	87,275	510	16.08
3	Zambezi R. Portion	90,353	528	16.65
4	St.(1-650) Kabompo Boma	42,740	185	5.83
7	Confluence with Dongwe R.	65,597	210	6.62
8	St.(1-950) Watopa P.	66,449	211	6.65
10	Confluence with Kabompo R.	162,700	746	23.53
11	St.(2-030) Lukulu	206,531	691	21.79
13	St.(2-250) Kalabo	34,621	60	1.89
14	Luanginga R. Portion	41,233	73	2.30
15	Confluence with Luanginga R.	269,309	806	25.42
16	St.(2-400) Senanga	278,298	824	25.99
21	St.(4-050) Raglam Farm	4,999	30	0.95
23	St.(4-120) Mwambashi	869	7	0.22
24	St.(4-130) Smith's Bridge	8,599	76	2.40
25	St.(4-200) Mpatamato	11,655	92	2.90
26	St.(4-280) Machiya Ferry	22,920	130	4.10
27	Kafue R. Portion	24,582	136	4.29
28	Luswishi R. Portion	8,866	29	0.91
29	Confluence with Luswishi R.	33,448	165	5.21
30	St.(4-350) Chilenga	34,162	167	5.27
31	St.(4-450) Lubungu	54,442	168	5.30
32	St.(4-560) Chifumpa Pontoon	21,445	81	2.55
33	Lunga R. Portion	24,416	83	2.62
34	Confluence with Lunga R.	78,858	252	7.95
35	St.(4-669) Kafue Hook Bridge	95,053	266	8.39
43	St.(5-940) Luangwa Br.	143,781	652	20.67
44	Luangwa R. Portion	150,586	683	21.54
<<<	Lower Area >>>			
17	Livingstone	466,324	1,003	31.63
18	Kariba Dam In	608,634	1,259	39.70
19	Kariba Dam Out	-	1,049	33.03
20	Zambezi R. Portion	612,724	1,057	33.33
36	Iteshi-tezhi Dam In	105,672	261	8.23
37	Iteshi-tezhi Dam Out	-	248	7.82
38	Kafue Gorge Dam In	151,576	282	8.89
39	Kafue Gorge Dam Out	-	253	7.98
40	Kafue R. Portion	154,882	259	8.17
41	Confluence with Kafue R.	767,606	1,316	41.50
42	Zambezi River Portion	786,686	1,350	42.57
45	Confluence with Luangwa R.	937,272	2,033	64.11

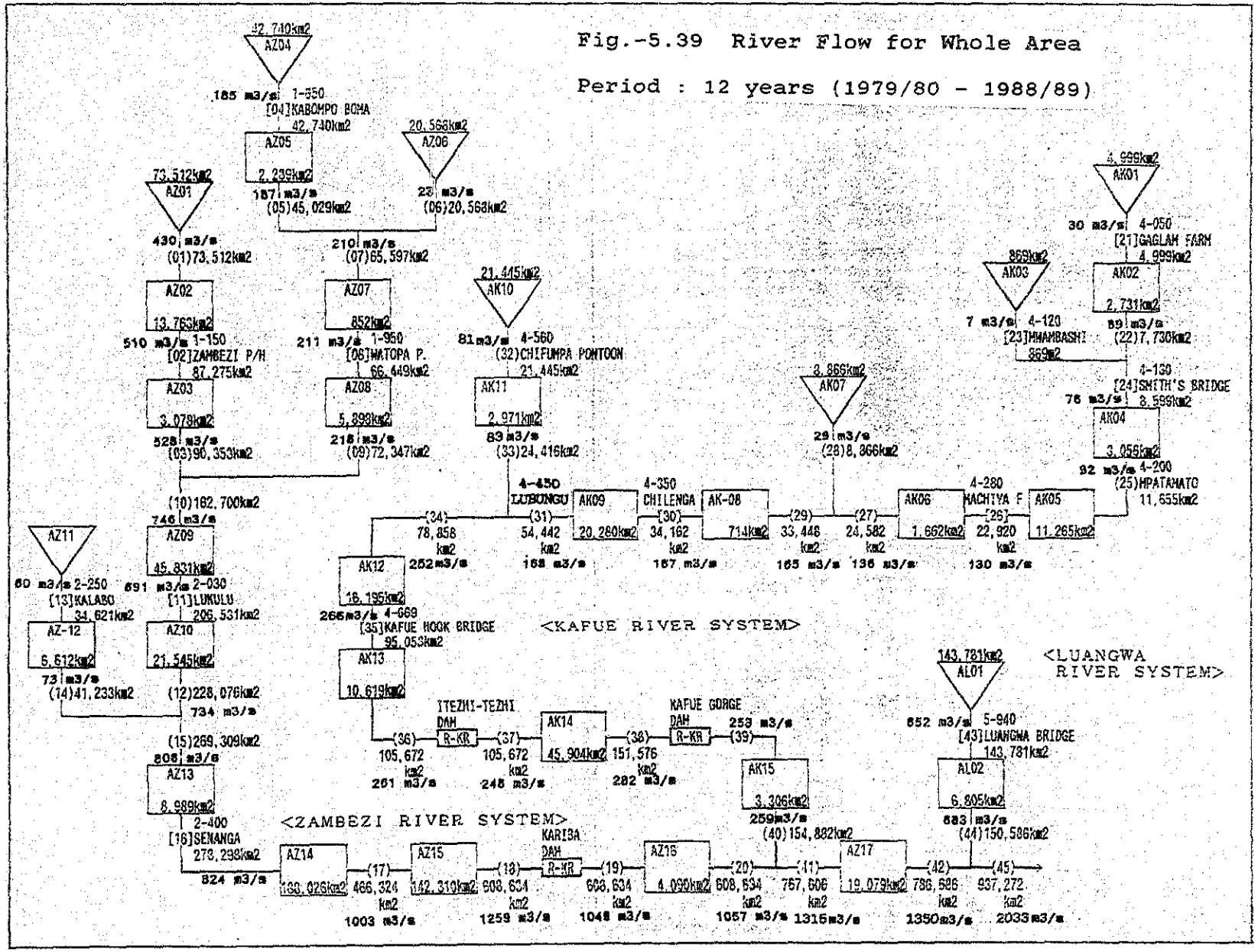
Fig.-5.39 River Flow for Whole Area
Period : 12 years (1979/80 - 1988/89)
42,740km2
AZ04
185 m3/s 1-550
[04]KABOMPO BOMA
42,740km2
AZ05
2,239km2
187 m3/s
(05)45,029km2
20,568km2
AZ06
23 m3/s
(06)20,568km2
73,512km2
AZ01
430 m3/s
(01)73,512km2
210 m3/s
(07)65,597km2
AZ02
13,763km2
510 m3/s 1-150
[02]ZAMBEZI P/H
87,275km2
AZ03
3,078km2
528 m3/s
(03)90,353km2
AZ07
852km2
211 m3/s 1-950
[08]MATOPA P.
66,449km2
AZ08
5,898km2
218 m3/s
(09)72,347km2
21,445km2
AK10
81m3/s 4-560
(32)CHIFUMPA PONTOON
21,445km2
AK11
2,971km2
83 m3/s
(33)24,416km2
(10)162,700km2
746 m3/s
AZ09
45,831km2
691 m3/s 2-030
[11]LUKULU
206,531km2
AZ10
21,545km2
734 m3/s
(12)228,076km2
AZ11
60 m3/s 2-250
[13]KALABO
34,621km2
AZ-12
6,612km2
73 m3/s
(14)41,233km2
(15)269,309km2
806 m3/s
AZ13
8,989km2
2-400
[16]SENANGA
278,298km2
824 m3/s
<ZAMBEZI RIVER SYSTEM>
AZ14
180,026km2
(17)
466,324 km2
1003 m3/s
AZ15
142,310km2
(18)
908,634 km2
1259 m3/s
KARIBA DAM
R-KR
(19)
668,634 km2
1048 m3/s
AZ16
4,000km2
(20)
608,634 km2
1057 m3/s
(21)
767,606 km2
1315m3/s
AZ17
19,079km2
(42)
786,685 km2
1350m3/s
(45)
937,272 km2
2033m3/s
4-450
LUBONGU
AK09
20,280km2
(31)
54,442 km2
168 m3/s
4-350
CHILENGA
(30)
34,162 km2
167 m3/s
AK-08
714km2
(29)
33,446 km2
165 m3/s
(27)
24,582 km2
136 m3/s
3,866km2
AK07
29 m3/s
(28)8,866km2
AK06
1,662km2
4-280
MACHIYA F
(26)
22,920 km2
130 m3/s
AK05
11,265km2
(25)HPATAMATO
11,655km2
4,999km2
AK01
30 m3/s 4-050
[21]GAGLAM FARM
869km2
AK03
7 m3/s 4-120
[23]MWAMBASHI
869km2
4,999km2
AK02
2,731km2
89 m3/s
(22)7,730km2
4-130
[24]SMITH'S BRIDGE
76 m3/s 8,999km2
AK04
3,056km2
92 m3/s 4-200
AK12
16,195km2
252m3/s
(34)
78,858 km2
4-669
[35]KAFUE HOOK BRIDGE
95,053km2
AK13
10,619km2
266m3/s
ITEZHI-TEZHI DAM
R-KR
(36)
105,672 km2
261 m3/s
(37)
105,672 km2
245 m3/s
AK14
45,904km2
(38)
151,576 km2
282 m3/s
KAFUE GORGE DAM
R-KR
253 m3/s
(39)
AK15
3,306km2
259m3/s
(40)154,882km2
<KAFUE RIVER SYSTEM>
143,781km2
AL01
652 m3/s 5-940
[43]LUANGWA BRIDGE
143,781km2
AL02
6,805km2
683 m3/s
(44)150,586km2
<LUANGWA RIVER SYSTEM>

5.4.2 Characteristics of River Flow

(1) Annual Discharge and Monthly Discharge

< Annual Discharge and Monthly Discharge >

The characteristics of discharge at each hydrometric stations are as shown in Table-5.22.Refer to Fig.-5.40 - 5.58.

Table-5.22 Characteristics of Discharge

Station	Annual (m3/s)			Daily Discharge (m3/s)					
	Mean	Max.	Min	Max.	Min.	High	Normal	Low	Drought
1-150	693	1301	278	5106	21	978	258	121	77
1-650	219	451	109	1703	17	290	151	99	61
1-950	264	597	120	2582	36	355	155	105	74
2-030	808	1125	514	2943	197	1102	543	385	315
2-250	74	175	13	881	3	104	34	13	9
2-400	986	1433	637	3500	261	1459	722	444	337
4-050	37	80	10	333	0.2	56	17	7	3
4-120	7.8	15.2	3.4	177	0.6	10.8	4.4	2.5	1.2
4-130	79	142	31	531	3	124	50	23	11
4-200	98	178	35	562	7	149	56	28	15
4-280	145	298	47	889	5	221	76	39	21
4-350	189	396	59	1164	8	297	98	47	25
4-450	199	414	62	1230	5	324	109	54	28
4-560	99	245	26	1642	12	142	70	42	24
4-669	336	832	128	2811	28	480	187	108	67
4-941	0.24	0.43	0.09	15	0.00	0.21	0.18	0.14	0.01
4-958	0.31	0.85	0.00	103	0.00	0.16	0.10	0.08	0.00
5-030	0.22	0.72	0.05	21	0.00	0.15	0.07	0.04	0.02
5-940	626	1505	301	7754	11	863	206	82	37

[Note] Period of Discharge Data: 32 years (1959/60 - 1990/91)
Min.: Minimum discharge
High : 95th discharge from greatest
Normal : 185th discharge from grearest
Low : 275th discharge from greatest
Drought : 355th discharge from greatest

< Monthly Pattern of Discharge >

The monthly discharge pattern of selected 19 stations is as shown in Table-5.22. Refer to Fig.-5.40 - 5.58. As can be seen from Table-5.23, the highest discharge appears during January and April in all stations.

Table-5.23 Monthly Discharge Unit: m3/s

[Remarks] Period of Discharge Data:
32 years (1959/60 - 1990/91)

St.Nos.	St. Names	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1	1-150 Zambezi P/H	84.7	106.3	240.2	707.7	1474.3	2161.4	1955.3	806.0	338.8	205.0	139.7	100.5	693.3
2	1-650 Kabompo Bma	74.2	94.0	175.6	257.4	377.2	497.0	460.3	223.7	153.1	125.7	103.9	82.8	218.7
3	1-950 Watopa Pontoon	78.5	98.3	184.4	311.0	502.6	691.6	590.9	244.9	151.2	125.0	104.7	86.8	264.2
4	2-030 Lukulu	333.8	369.8	532.8	899.6	1342.0	1749.3	1646.5	985.7	609.2	470.7	399.4	351.9	807.6
5	2-250 Kalabo	11.8	10.1	14.2	45.7	134.2	229.4	190.5	99.6	64.2	43.2	26.8	16.7	73.9
6	2-400 Senanga	357.2	387.0	523.8	798.3	1231.7	1803.1	2086.0	1777.4	1195.5	739.0	522.4	411.8	986.1
7	4-050 Raglan Farm	3.4	4.3	14.0	37.1	75.6	107.3	99.4	48.4	21.6	13.4	9.4	5.8	36.6
8	4-120 Mwanbashi	1.6	2.3	6.1	11.8	17.7	21.0	13.6	6.8	4.4	3.6	2.8	2.0	7.8
9	4-130 Smith's Bridge	15.0	19.0	48.5	110.6	172.5	200.1	162.3	92.1	53.9	36.4	27.0	18.9	79.7
10	4-200 Mpatamato	18.1	23.3	60.9	134.9	225.2	255.9	197.7	102.0	60.4	41.7	31.7	23.4	97.9
11	4-280 Machiya Ferry	24.6	29.5	76.8	189.5	319.7	385.6	321.3	164.2	84.6	59.4	45.7	33.5	144.5
12	4-350 Chilenga	29.4	34.6	83.7	216.3	379.1	509.0	454.6	261.2	122.4	79.7	58.8	41.3	189.2
13	4-450 Lubungu	35.9	37.8	85.3	216.7	378.0	498.1	472.6	309.4	148.1	90.2	66.8	51.3	199.2
14	4-560 Chifumpa Pon.	25.6	29.5	64.5	119.2	209.2	262.1	200.4	91.5	57.9	46.6	39.5	31.3	98.1
15	4-669 Kafue Hook B.	80.1	83.8	162.1	365.0	638.9	805.7	752.7	475.6	262.0	170.3	133.9	104.8	336.2
16	4-941 Kaleya D/S	0.14	0.19	0.36	0.40	0.47	0.26	0.20	0.18	0.18	0.18	0.17	0.16	0.2
17	4-958 Urueff Farm	0.16	0.24	0.50	0.66	1.10	0.32	0.23	0.10	0.10	0.09	0.10	0.11	0.3
18	5-030 Exchange Farm	0.04	0.09	0.30	0.41	0.81	0.49	0.18	0.09	0.07	0.06	0.05	0.05	0.2
19	5-940 Luangwa Bridge	45.3	53.2	383.8	1238.7	1961.6	1904.2	975.3	404.8	226.4	143.7	105.0	72.3	626.2

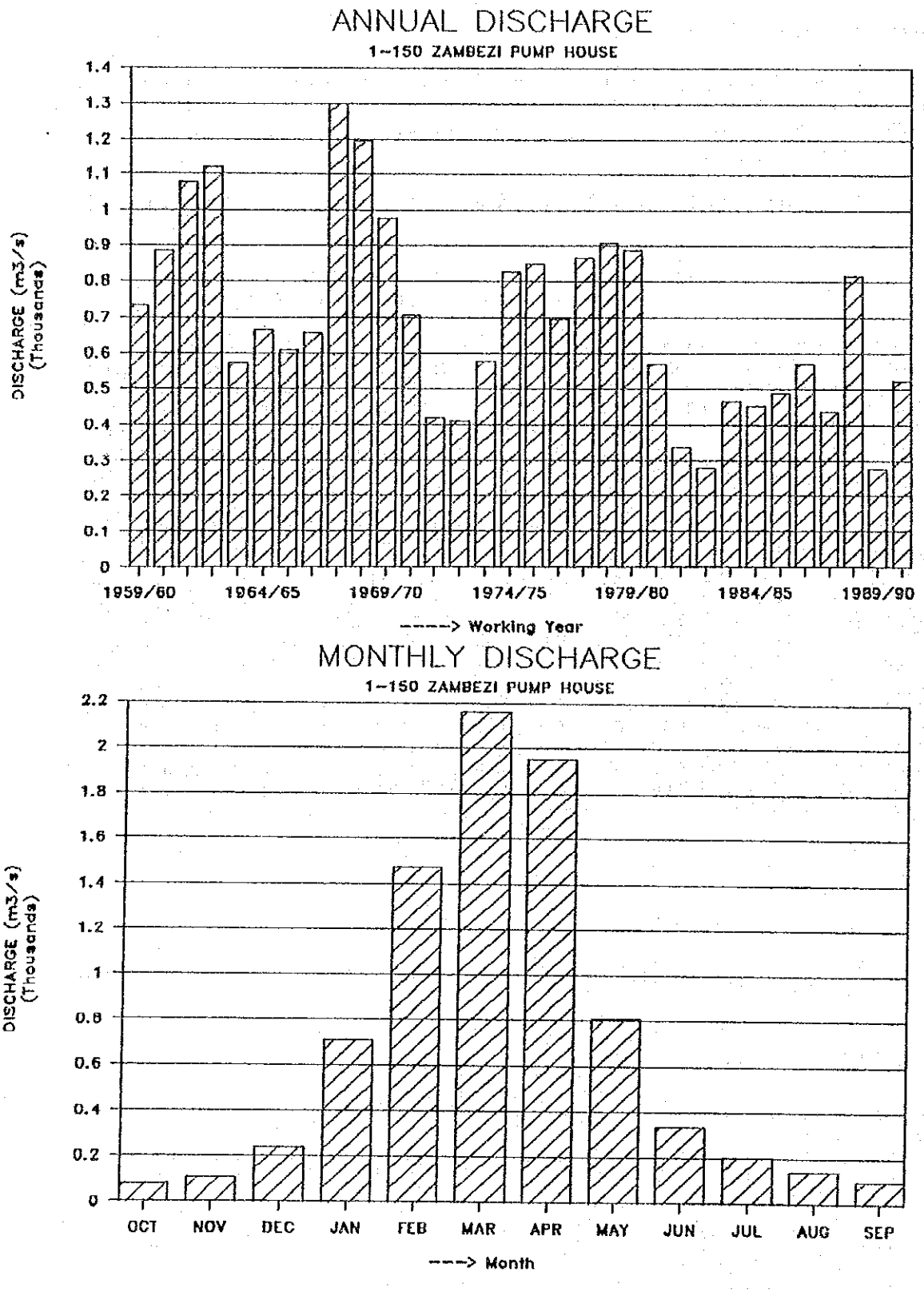

Fig.-5.40 Discharge Fluctuation (1-150 / Zambezi P/H)

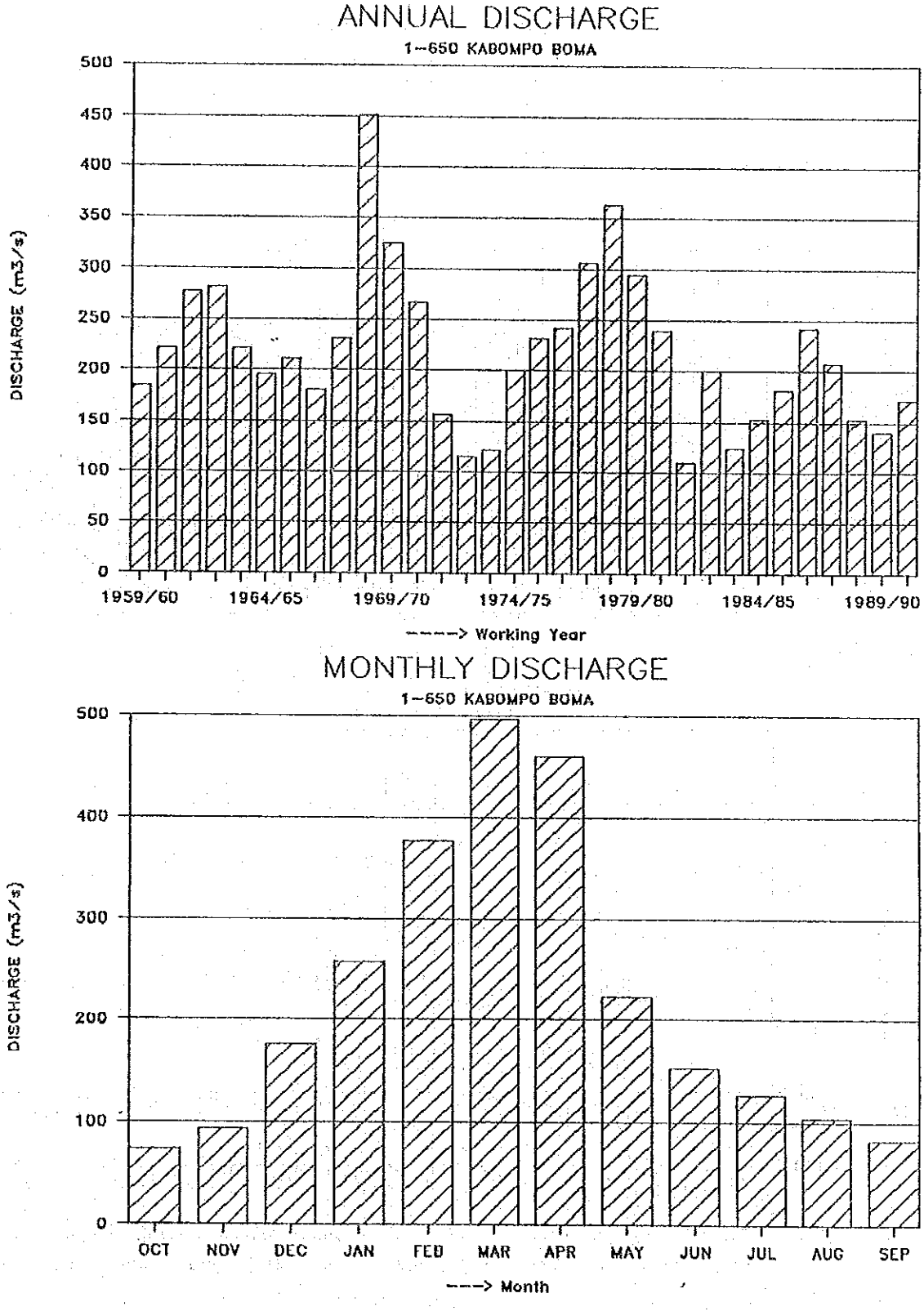

Fig.-5.41 Discharge Fluctuation (1-650 / Kabompo Boma)

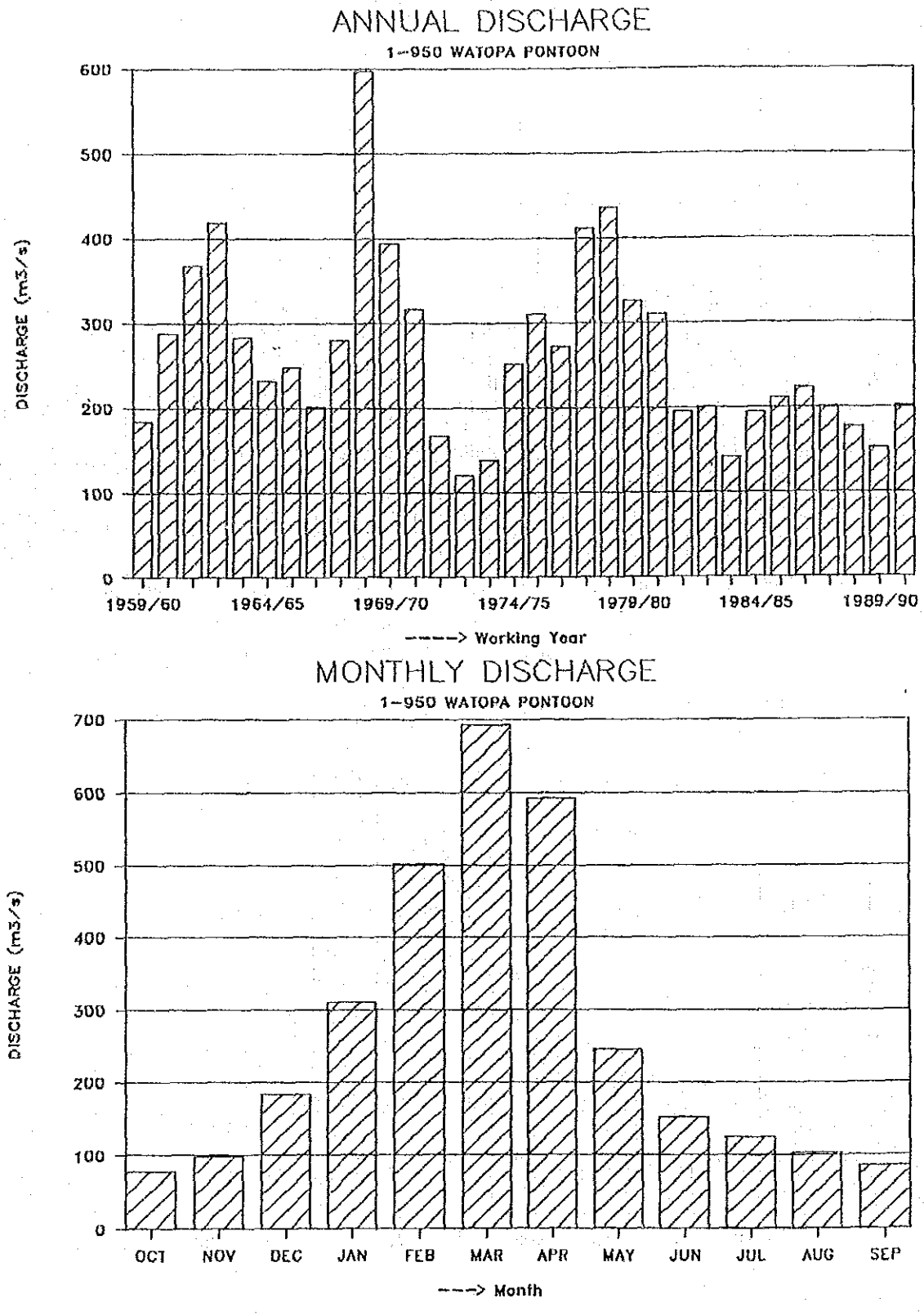

Fig.-5.42 Discharge Fluctuation (1-950 /Watopa Pontoon)

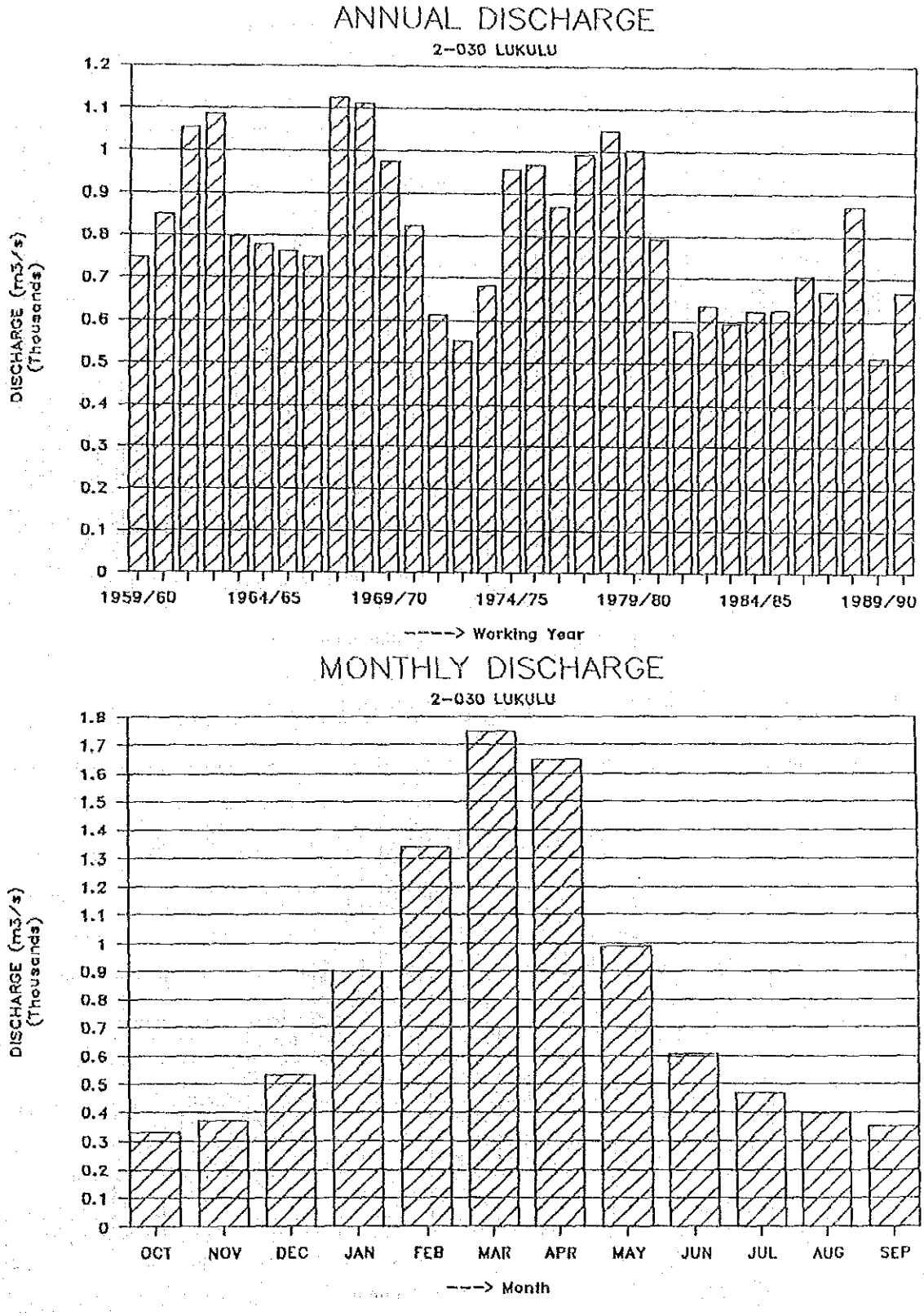

Fig.-5.43 Discharge Fluctuation (2-030 / Lukulu)

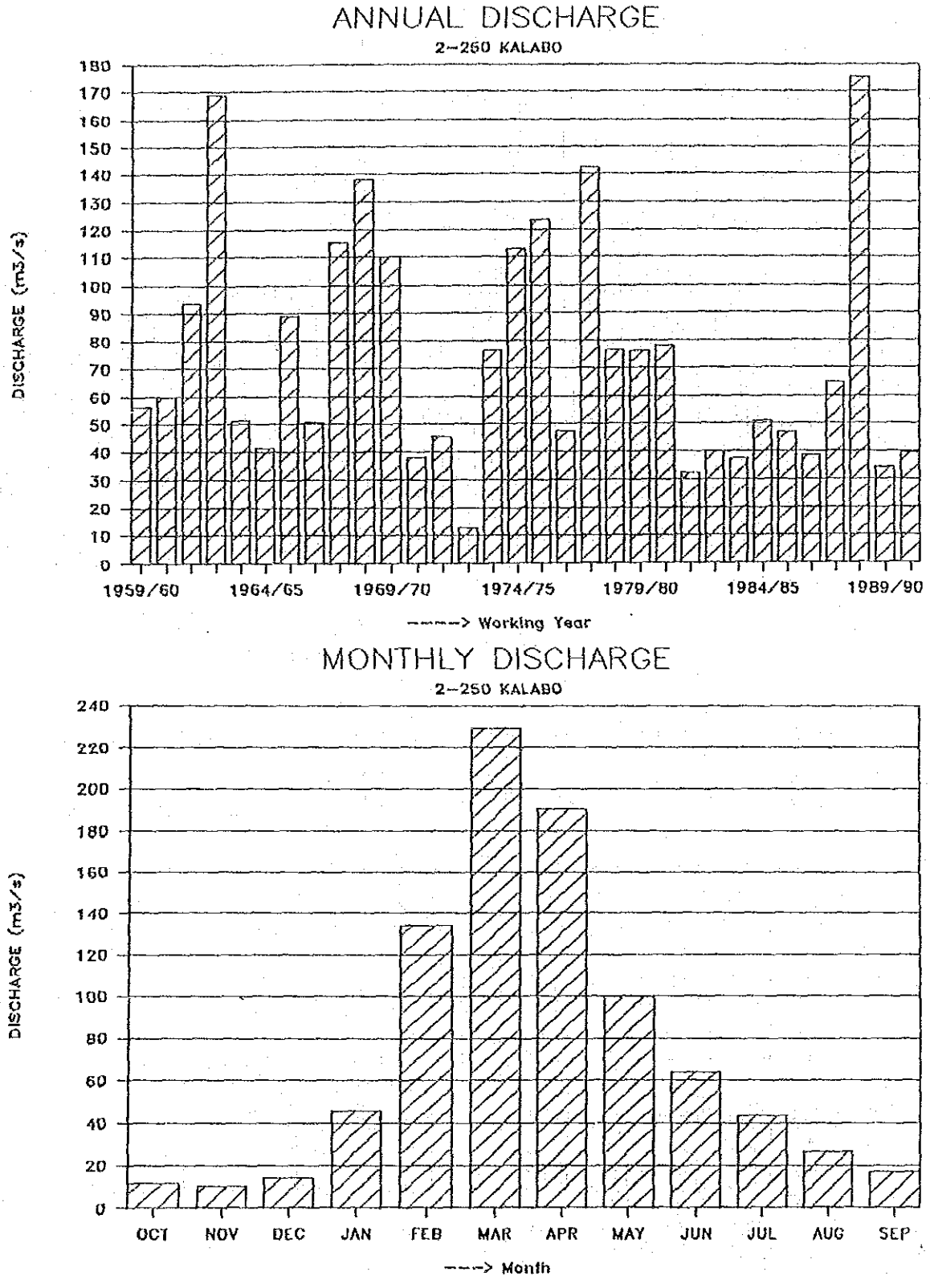

Fig.-5.44 Discharge Fluctuation (2-250 / Kalabo)

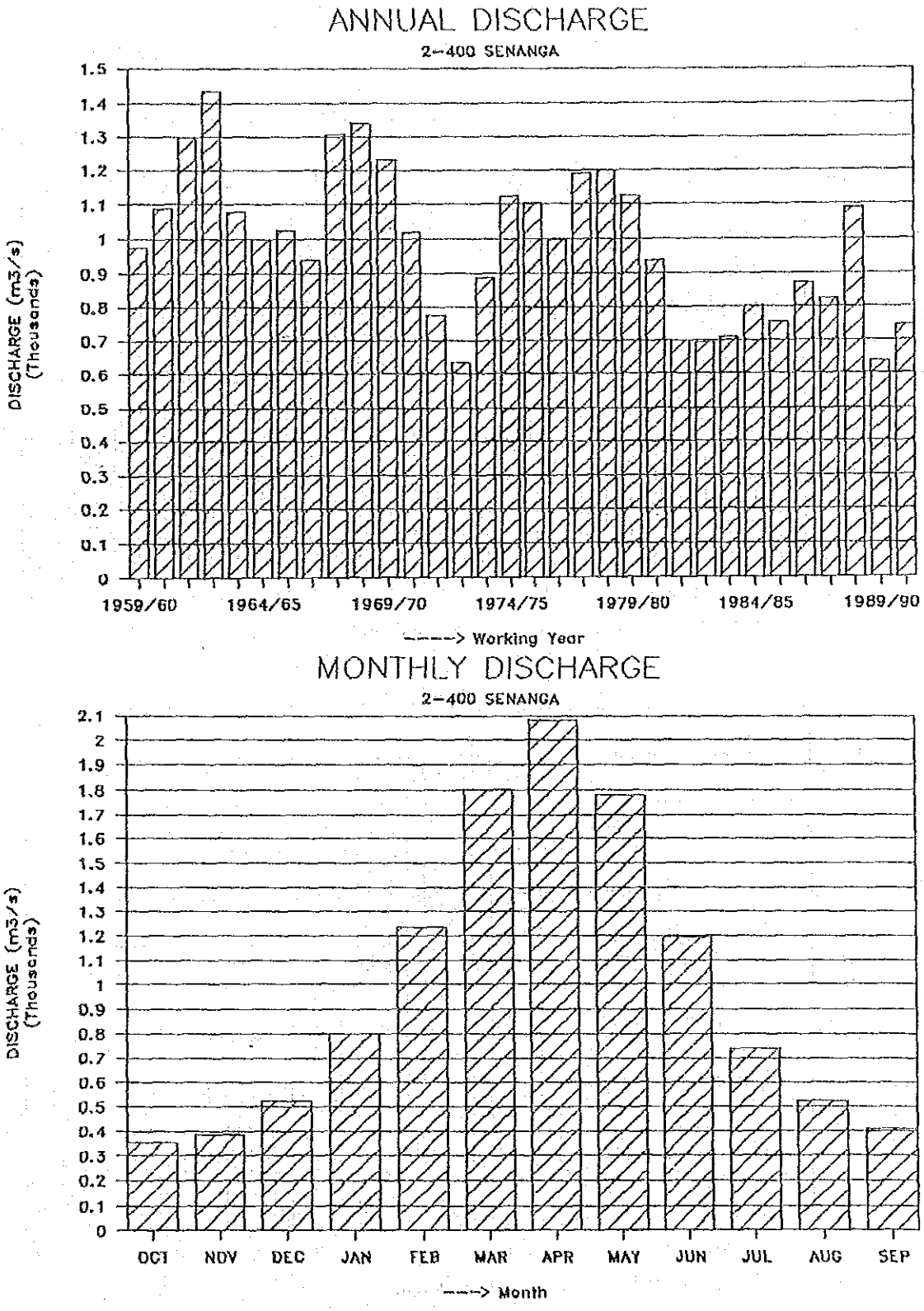

Fig.-5.45 Discharge Fluctuation (2-400 / Senanga)

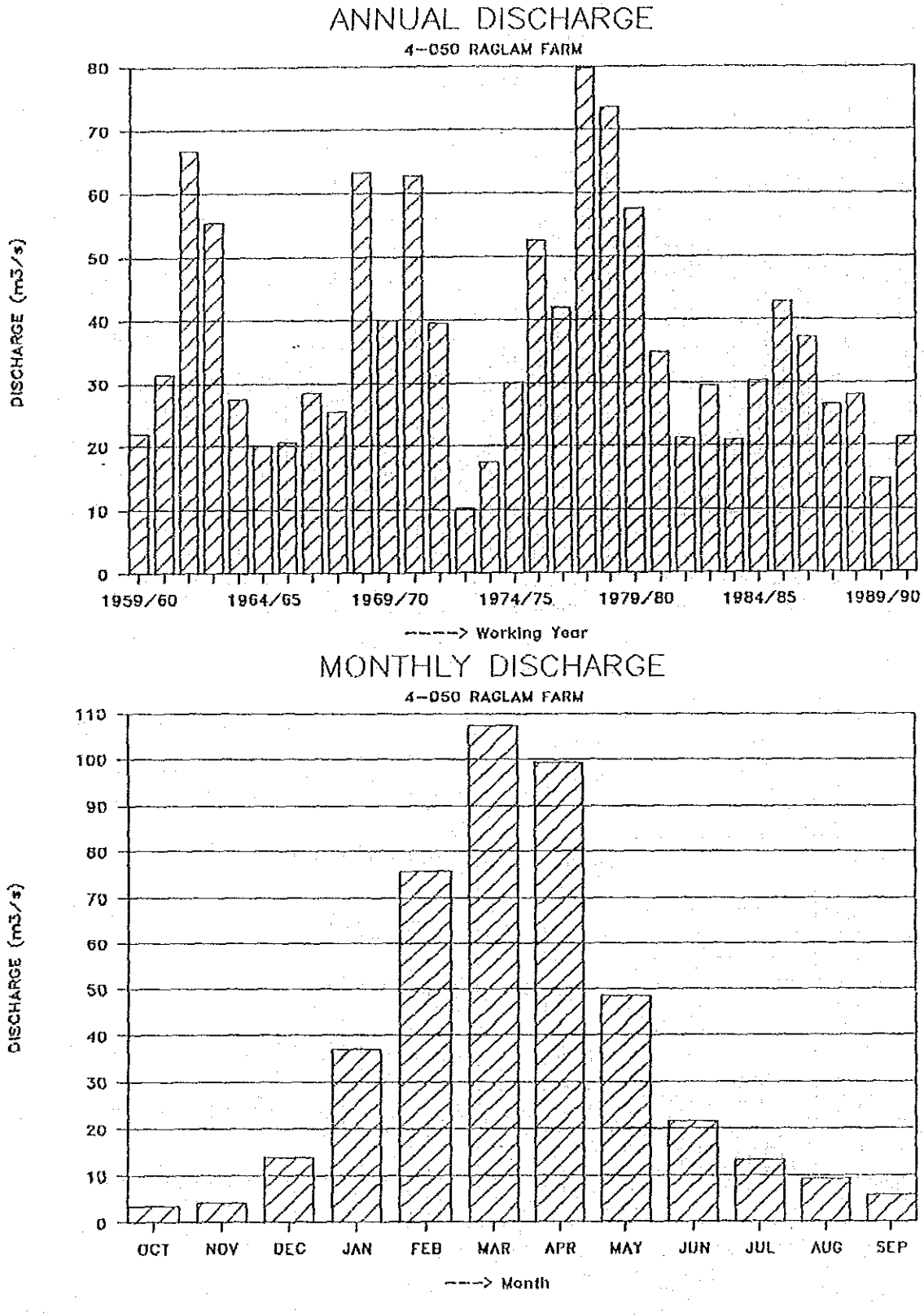

Fig.-5.46 Discharge Fluctuation (4-050 / Raglam Farm)

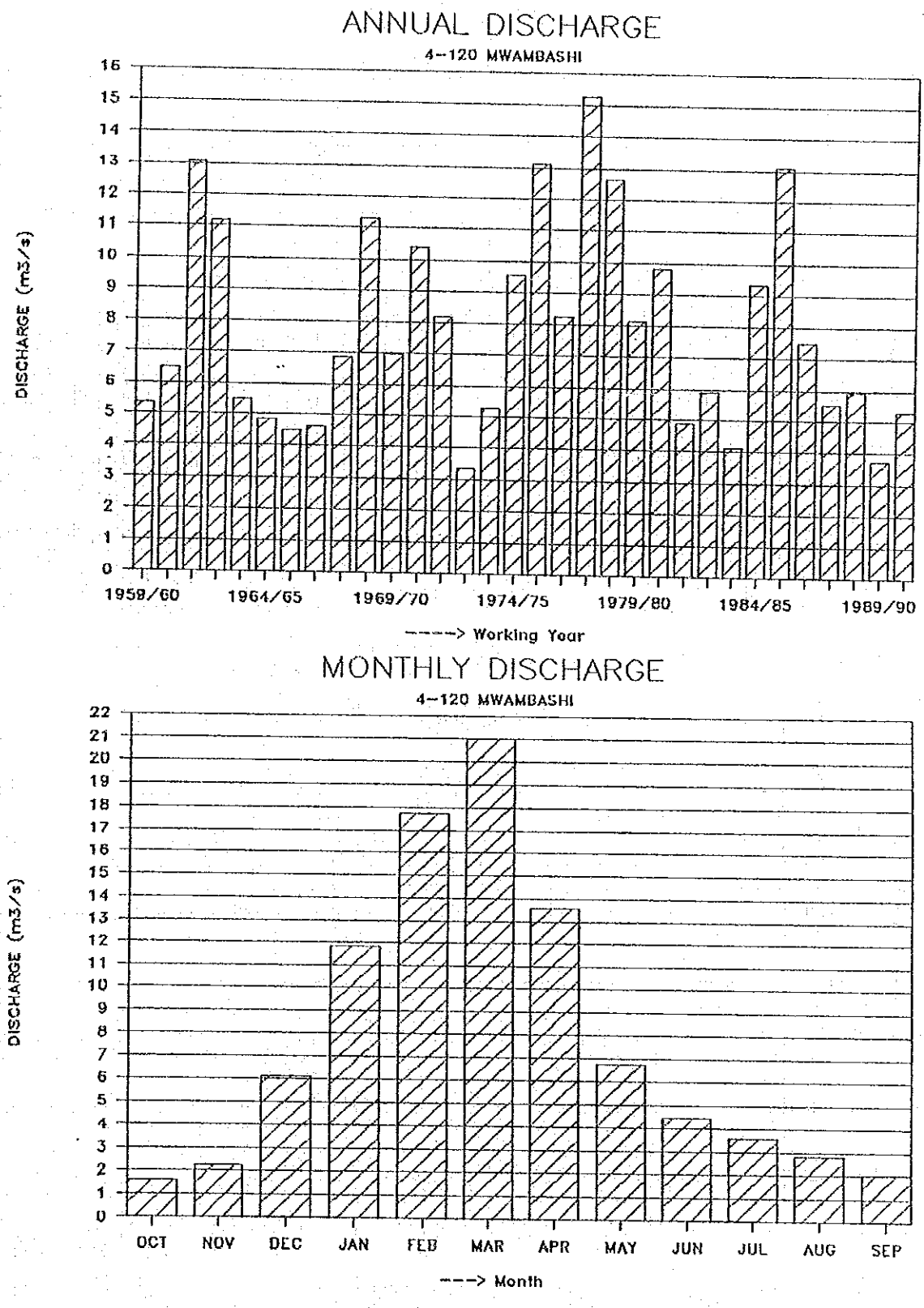

Fig.-5.47 Annual and Monthly Discharge (4-120 / Mwambashi)

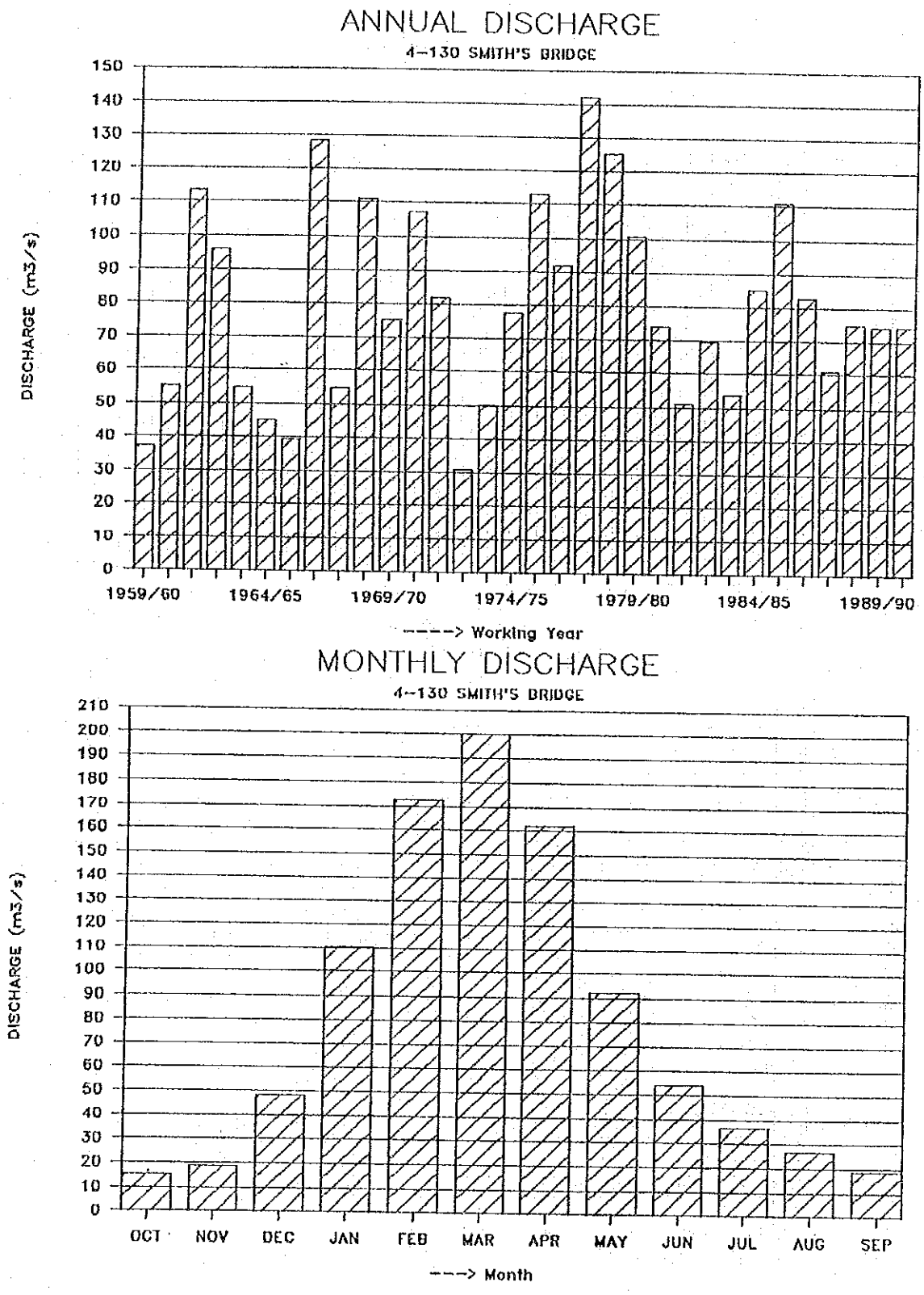

Fig.-5.48 Discharge Fluctuation (4-130 / Smith's Bridge)

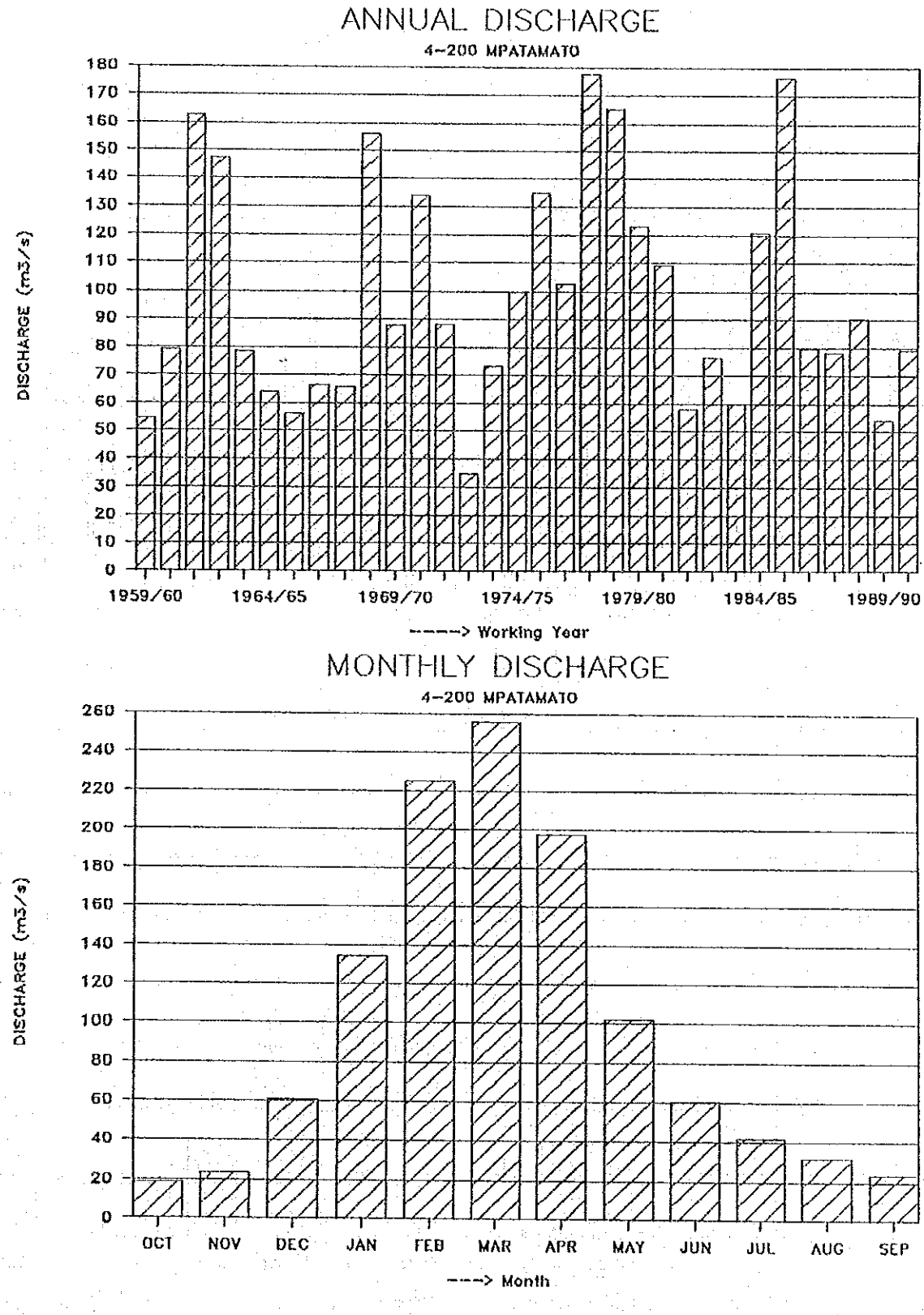

Fig.-5.49 Discharge Fluctuation (4-200 / Mpatamato)

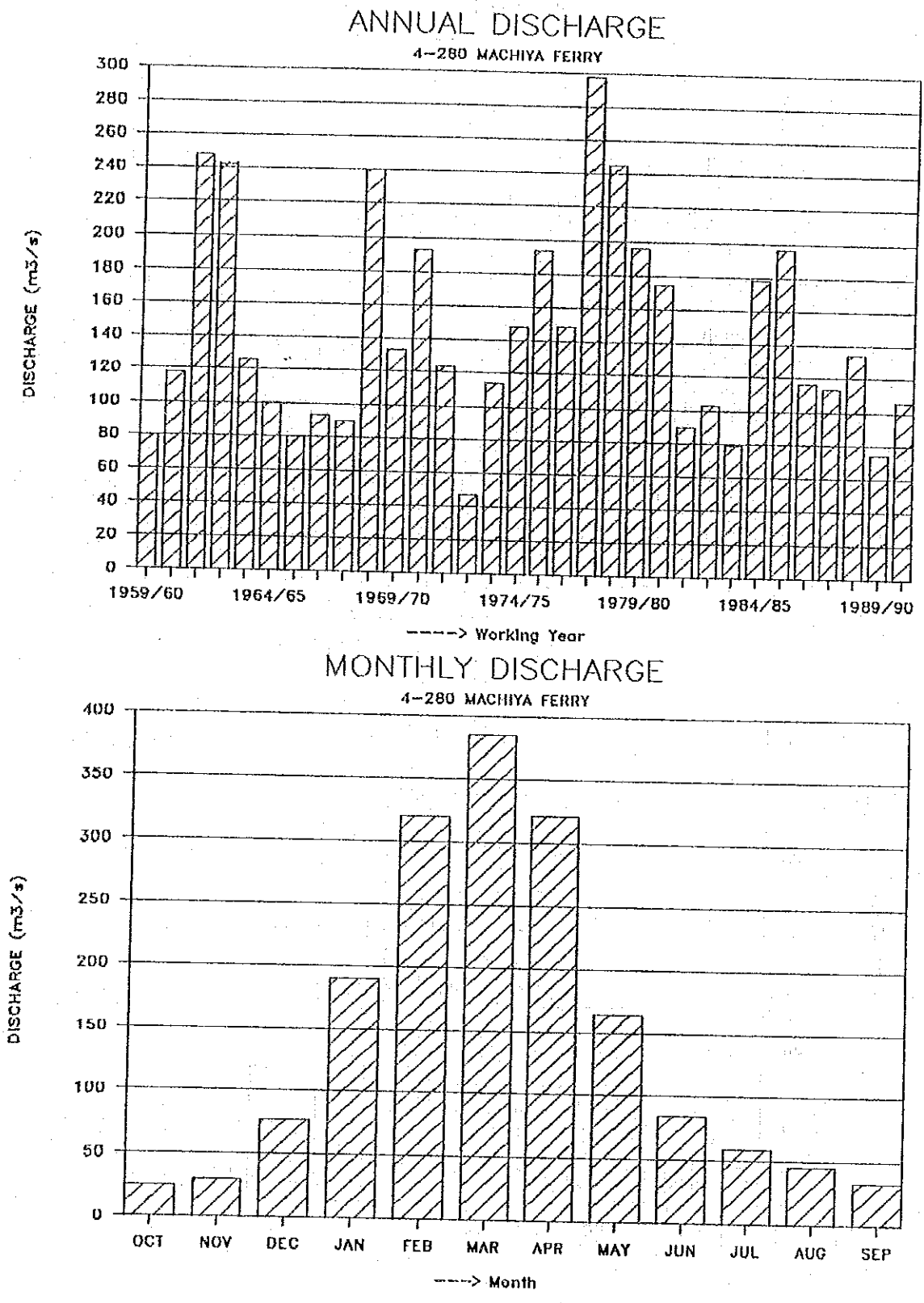

Fig.-5.50 Discharge Fluctuation (4-280 / Machiya Ferry)

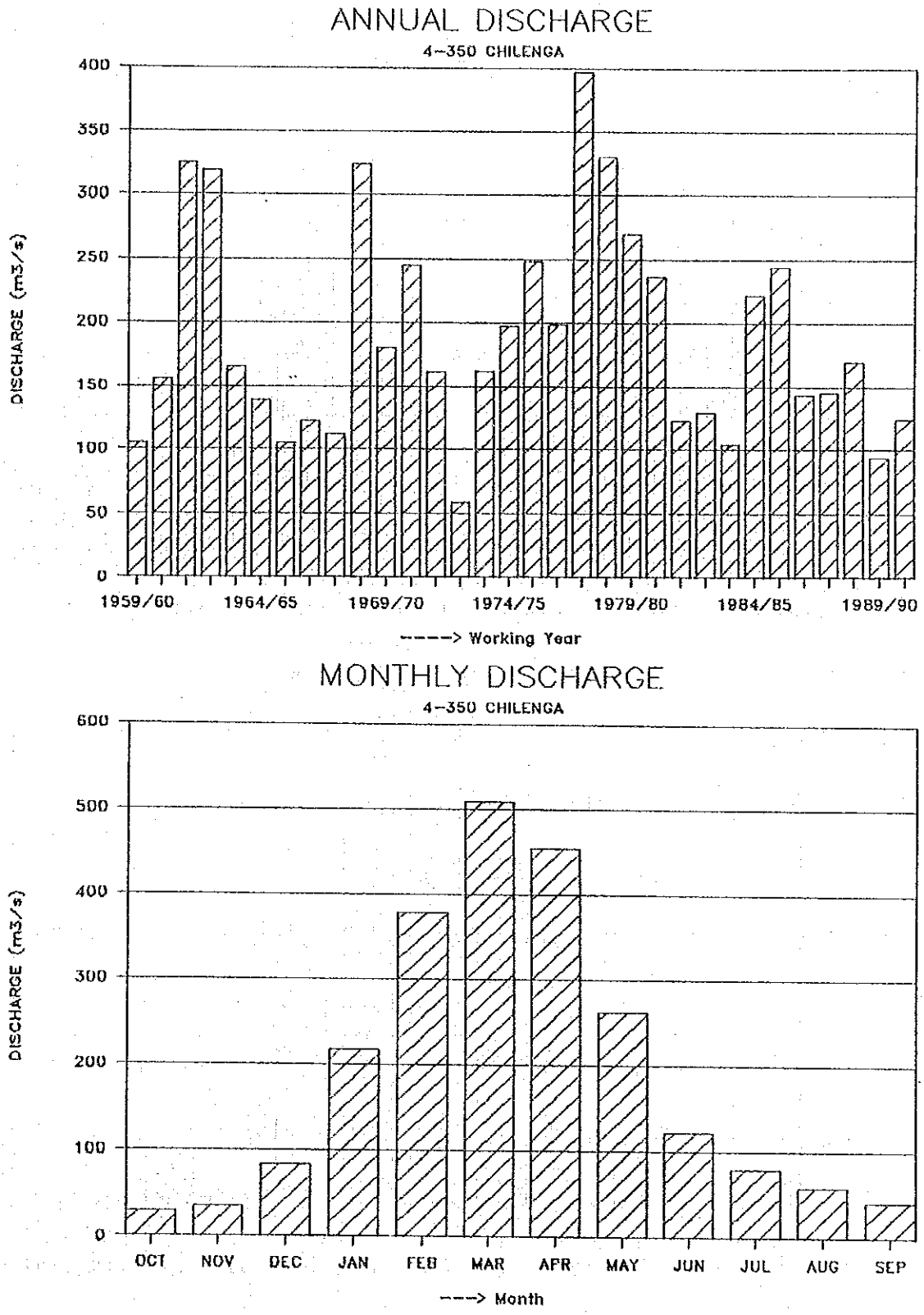

Fig.-5.51 Discharge Fluctuation (4-350 / Chilenga)

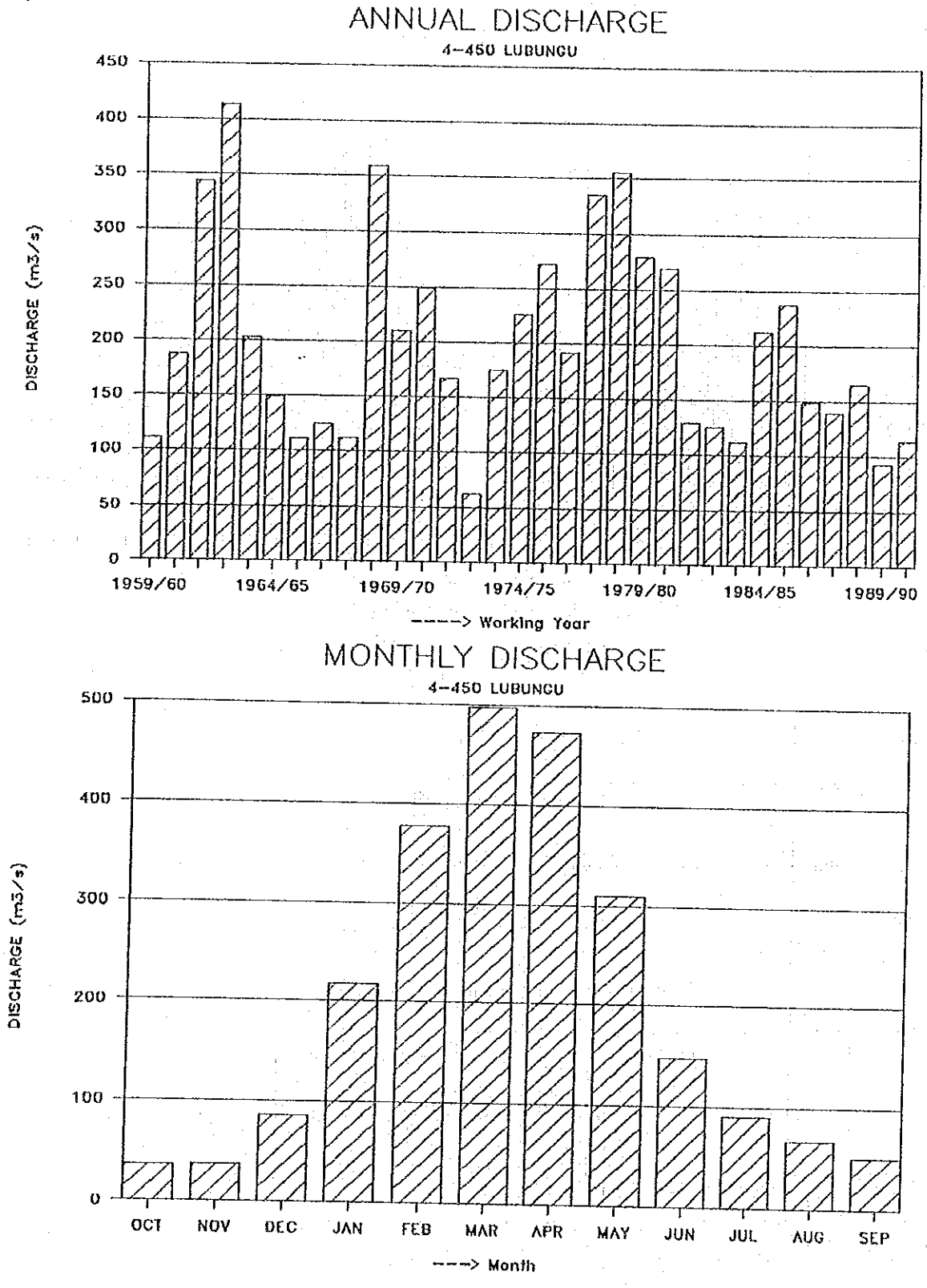

Fig.-5.52 Discharge Fluctuation (4-450 / Lubungu)

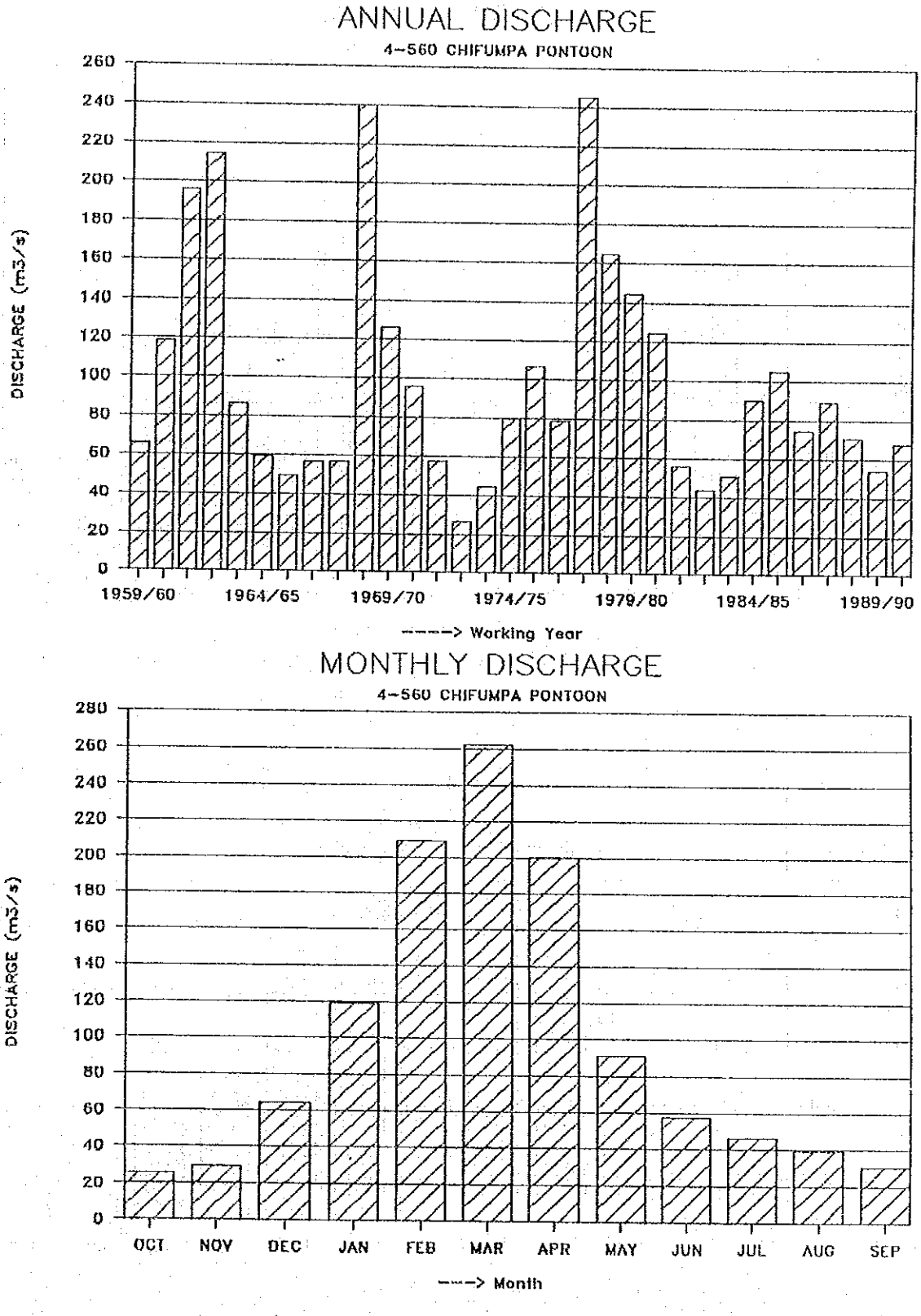

Fig.-5.53 Discharge Fluctuation (4-560 Chifumpa Pontoon)

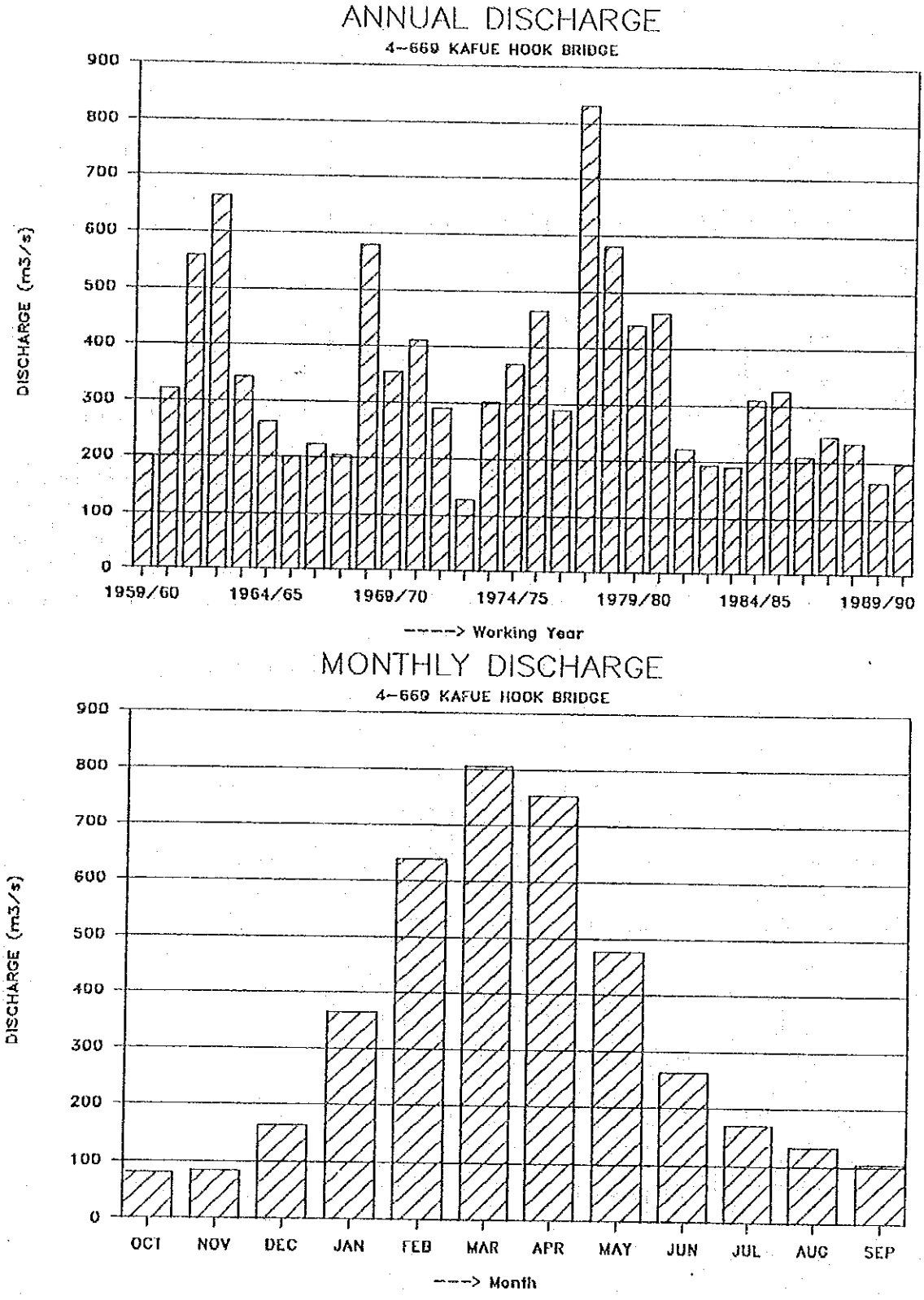

Fig.-5.54 Discharge Fluctuation (4-669 / Kafue H. Bridge)

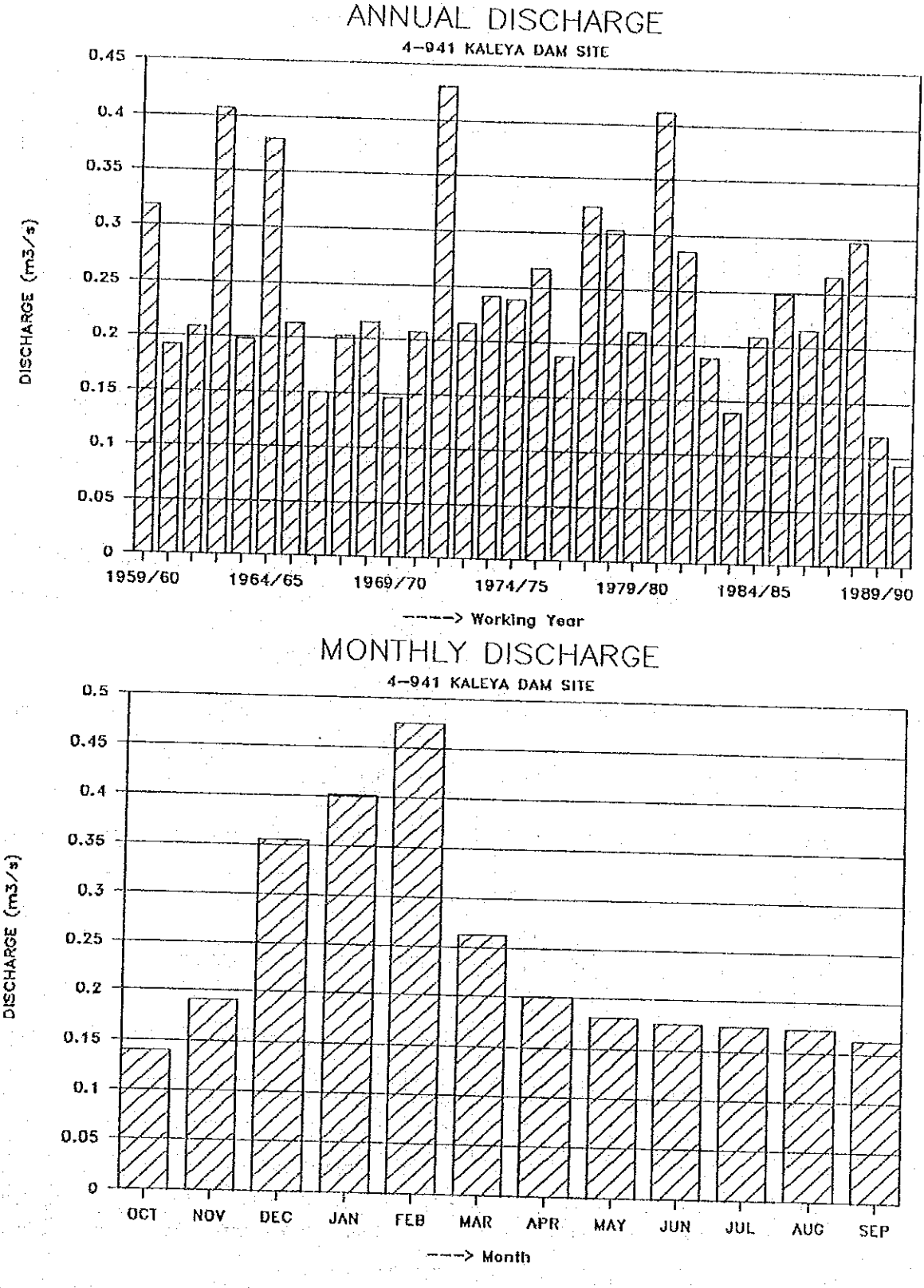

Fig.-5.55 Discharge Fluctuation (4-941 / Kaleya Dam Site)

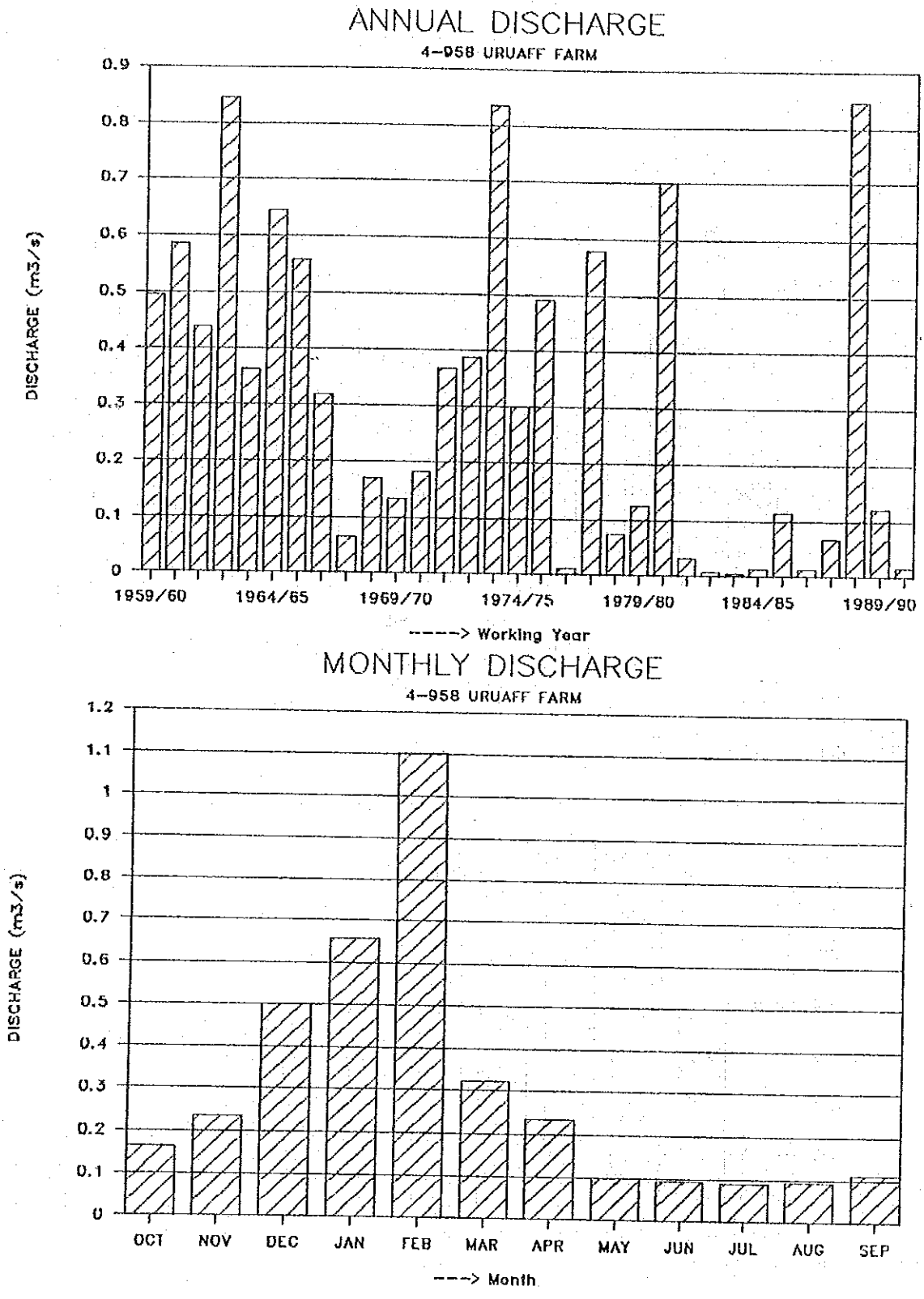

Fig.-5.56 Discharge Fluctuation (4-958 / Uruaff Farm)

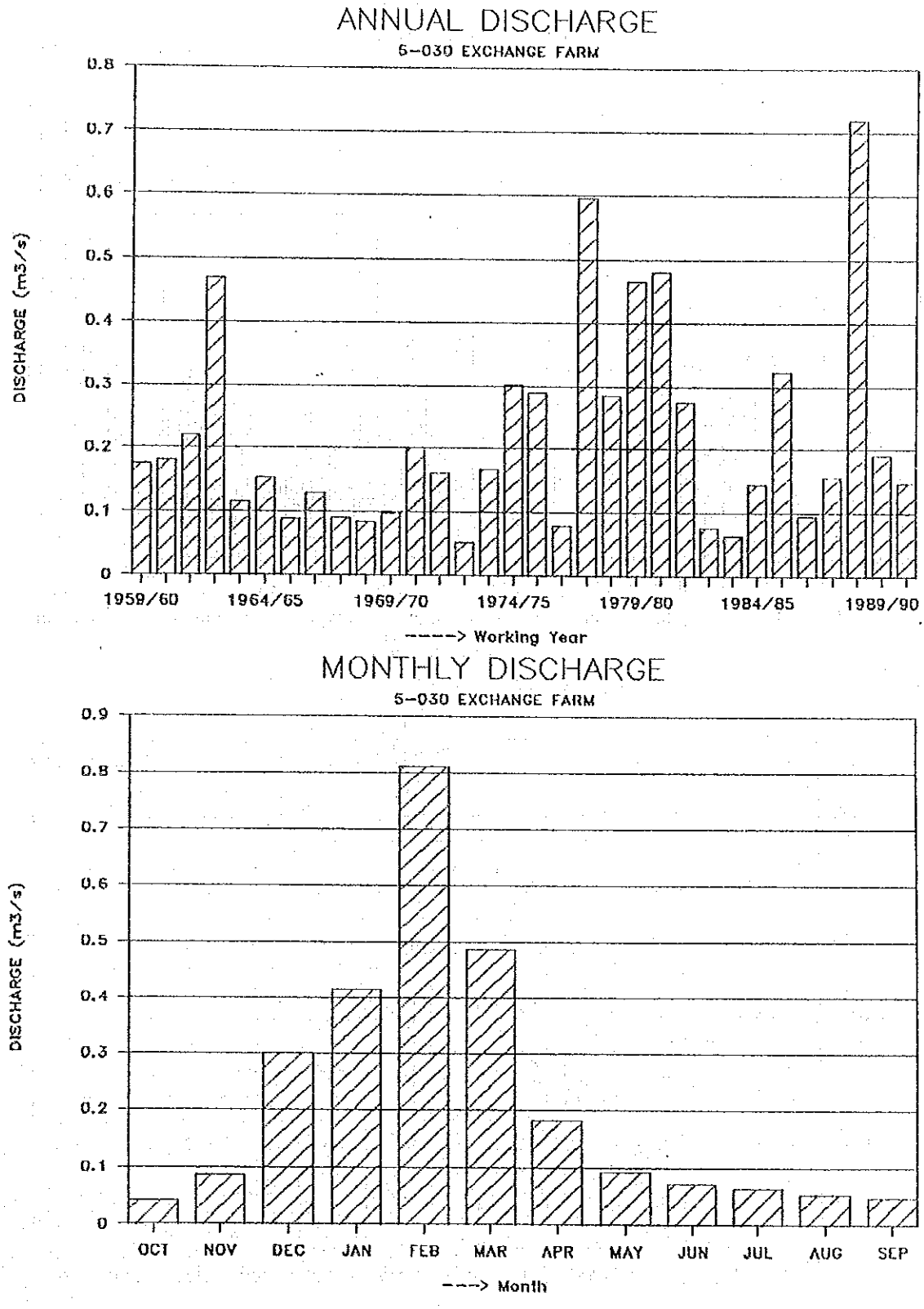

Fig.-5.57 Discharge Fluctuation (5-030 / Exchange Farm)

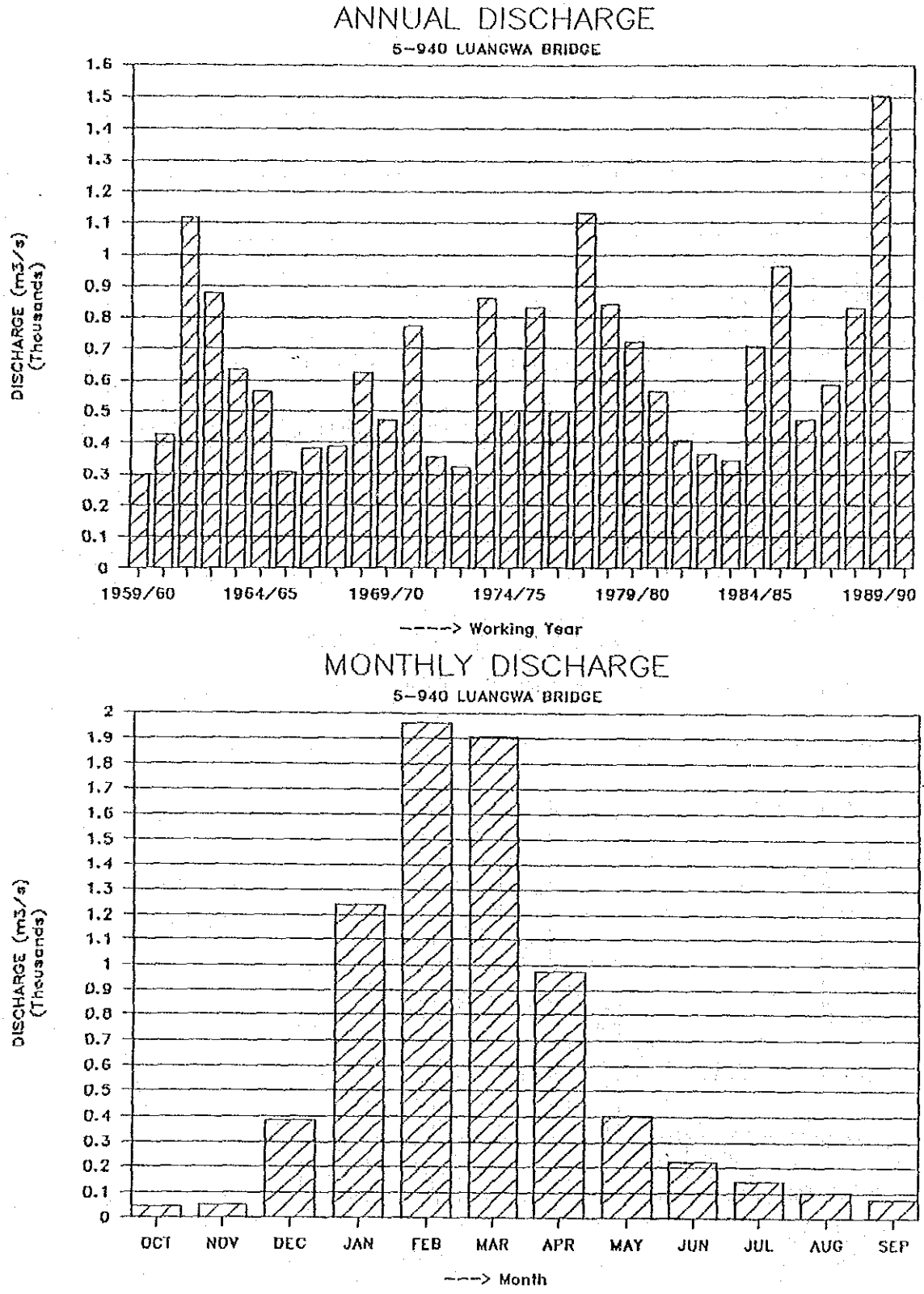

Fig.-5.58 Discharge Fluctuation (5-940 / Luangwa Bridge)

(2) Flow Regime

The flow regime of each station selected in the Study is as shown in Table-5.24.

Table-5.24 Flow Regime at Hydrometric Station Unit: m3/s

Stations No. and Name	High Q(95)	Normal Q(185)	Low Q(275)	Drought Q(355)	Annual Mean
1-150 Zambezi Pump House	978.2	258.0	121.1	77.4	692.9
1-650 Kabompo Boma	289.7	150.6	98.9	60.5	218.7
1-950 Watopa Pontoon	354.6	155.1	104.9	73.9	264.2
2-030 Lukulu	1,101.9	543.3	385.1	315.2	807.6
2-250 Kalabo	103.7	33.8	13.4	9.1	73.9
2-400 Senanga	1,459.4	722.1	443.8	336.7	986.1
4-050 Raglam Farm	56.0	17.0	6.9	2.8	36.5
4-120 Mwambashi	10.8	4.4	2.5	1.2	7.8
4-130 Smith's Bridge	124.1	49.7	23.1	11.0	79.5
4-200 Mpatamato	148.5	56.2	28.4	15.3	97.5
4-280 Machiya Ferry	221.4	75.7	38.6	21.1	144.5
4-350 Chilenga	296.7	98.3	46.6	25.3	189.2
4-450 Lubungu	324.1	109.2	53.5	28.1	199.2
4-560 Chifumpa Pontoon	141.6	70.2	42.0	23.8	98.1
4-669 Kafue Hook Bridge	480.2	186.6	107.8	67.2	336.2
4-941 Kaleya Dam Site	0.21	0.18	0.14	0.01	0.24
4-958 Uruaff Farm	0.16	0.10	0.08	0.00	0.31
5-030 Exchange Farm	0.15	0.07	0.04	0.02	0.22
5-940 Luangwa Bridge	863.3	205.7	82.4	37.1	626.2

[Remarks] Period of Discharge Data: 32 years (1959/60 - 1990/91)

(3) Locality of Discharge

Regarding the locality of discharge in the Study Area, the simulation results (recent 12 years, 1979/80 - 1990/91) are compiled in Table-5.25 and illustrated in Fig.-5.59 and 5.60. These data reveal the followings;

1) The specific discharge of the Zambezi River main stream is 2 - 3 times larger than that of the Kafue River main stream.

2) The specific discharge of the Zamabezi River tributary, the Kabompo River, is same as that of the Kafue River main stream. The specific discharge of the Kabompo River is smaller than that of the Kafue River main stream.

3) The specific discharge of the Kafue River in Upper areas such as Mwambashi and Raglaam Farm, is smaller than that of the Kafue River Main Stream.

Table-5.25 Specific Discharge at Reference Points

Name of Reference Points	Basin Area (km2)	Area Ratio (%)	Annual Discharge (m3/s)	Dis. Ratio (%)	Specific Dis.(m3/s /1000km2)
<<<Zambezi River>>>					
(1-150) Zambezi P/H	87,275	11.09	510	38.03	5.84
(1-650) Kabompo B.	42,740	5.43	185	13.80	4.33
(1-950) Watopa P.	66,449	8.45	211	15.73	3.18
(2-030) Lukulu	206,531	26.25	691	51.53	3.35
(2-250) Kalabo	34,621	4.40	60	4.47	1.73
(2-400) Senanga	278,298	35.38	824	61.45	2.96
Livingstone	466,324	59.28	1,003	74.79	2.15
Kariba Dam In	608,634	77.37	1,259	93.89	2.07
Zambezi River Portion	786,686	100.00	1,350	100.00	1.70
<<< Kafue River >>>					
(4-050) Raglam Farm	4,999	0.64	30	2.24	6.00
(4-120) Mwambashi	869	0.11	7	0.52	8.06
(4-130) Smith's Br.	8,599	1.09	76	5.67	8.84
(4-200) Mpatamato	11,655	1.48	92	6.86	7.89
(4-280) Machiya Ferry	22,920	2.91	130	9.69	5.67
(4-350) Chilenga	34,162	4.34	167	12.45	4.89
(4-450) Lubungu	54,442	6.92	168	12.53	3.09
(4-560) Chifumpa P.	21,445	2.73	110	8.20	5.13
(4-669) Kafue H/B	95,053	12.08	263	19.61	2.77
Iteshi-tezhi Dam In	105,672	13.43	261	19.46	2.47
Kafue Gorge Dam In	151,576	19.27	282	21.03	1.86
Kafue R. x Zambezi R.	154,882	19.69	250	18.64	1.61
<<< Luangwa River >>>					
(5-940) Luangwa Br.	143,781		652		4.53

[Remarks] Period of Discharge Data: 12 years (1979/80 - 1990/91)

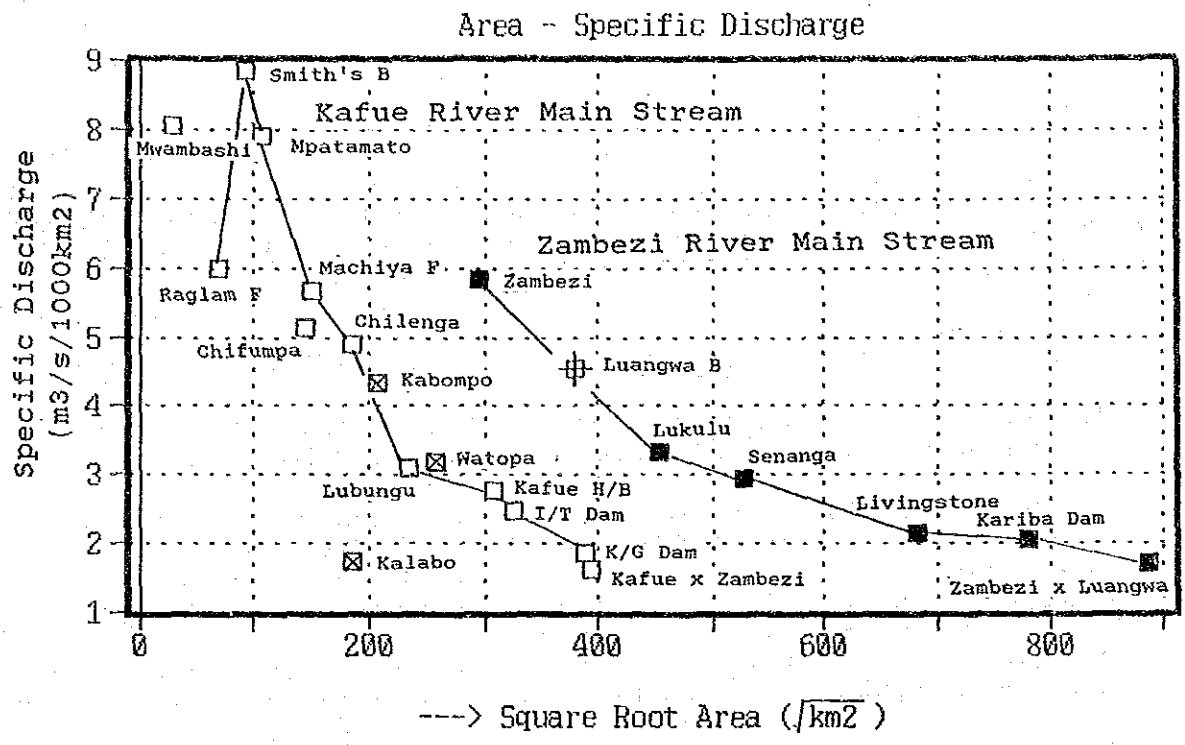

Fig.-5.59 Specific Discharge

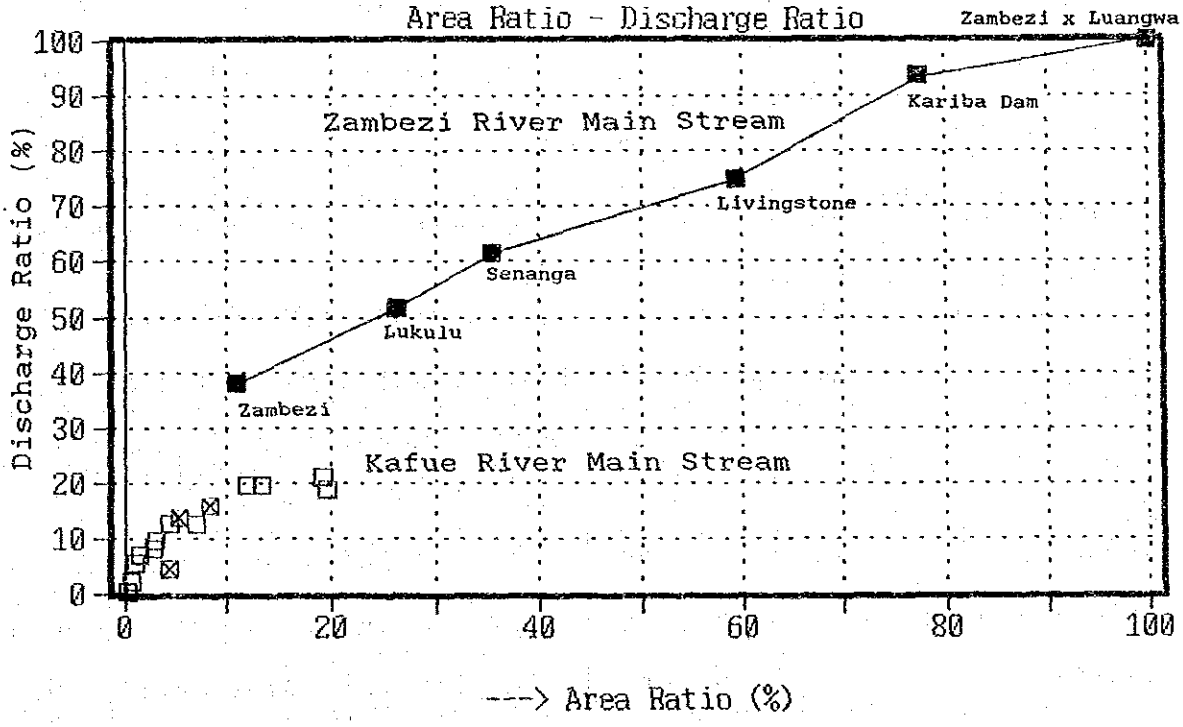

Fig.5.60 Area Ratio and Discharge Ratio

(4) Runoff Coefficient of Kafue River Basin

Table-5.27 shows the estimation of average runoff coefficient of the Kafue River basin, of which the whole area is included in the Study Area and annual mean rainfall can be calculated. The conditions of this estimation are as follows.

1) Rainfall data:
   Average rainfall of recent 10 years (1979/80 -1988/89)

2) Calculation method of mean rainfall: Thiessen method
   Thiessen coefficients are as shown in Table-5.26

Table-5.26 Thiessen Coefficient and annual rainfall at each station for Kafue River Basin

Rainfall Stations	Annual Rain-F (mm)	(4-050) Ragram Farm	(4-200) Mpata-mato	(4-450) Lubungu	I/T Dam	K/G Dam	River Mouth
Solwezi	1301	0.659	0.276	0.090	0.161	0.113	0.111
Kafilonda	1257	0.341	0.577	0.262	0.135	0.095	0.093
Ndola	1185		0.147	0.183	0.094	0.066	0.065
Kasempa	1071			0.036	0.215	0.151	0.148
Mumba	884			0.219	0.191	0.224	0.219
Kabwe	875			0.210	0.108	0.076	0.074
Kaoma	884				0.096	0.067	0.065
Lusaka	824					0.039	0.059
Magoye	729					0.073	0.072
Choma	800					0.096	0.094
Mean Rainfall(mm)	1,286	1,259		1,078	1,069	992	989

3) Discharge Data:
   Average discharge of recent 10 years (1979/80 -1988/89)

Table-5.27 Runoff Coefficient of Kafue River Basin

Name of Points	Basin Area (km2)	Annual Mean --Discharge- (m3/s)	(bcm)	Annual Mean --Rainfall-- (mm)	(bcm)	Runoff Coeff. (%)
(4-050) Raglam Farm	4,999	33	1.04	1,286	6.43	16.2
(4-200) Mpatamato	11,655	97	3.06	1,259	14.67	20.9
(4-450) Lubungu	54,442	181	5.71	1.078	58.69	9.7
Iteshi-tezhi Dam In	105,672	279	8.80	1,069	112.96	7.8
Kafue Gorge Dam In	151,576	301	9.49	992	150.36	6.3
Kafue River Mouth	154,882	268	8.45	989	153.18	5.5

5.5 Consideration on Analysis Results

(1) Discharge Rating Curve

The Study Team has established nineteen (19) discharge rating curves in this study. Especially, regarding such stations as Zambezi, Kabompo, Lukulu and Senanga, the rating curves were obtained firstly by the Team. Those curves obtained in the Study correspond well with the measured discharge data.

However, regarding the stations in the Mongu flooding areas along Zambezi River as shown in Table-5.28, the established rating curves express the discharge in river channel. The discharge in the flooding zone can not be obtained with these curves. See Fig-5.61.

Table-5.28 Flooding Water Level and Discharge

Stations	Approximate Flooding Water Level	Approximate Flooding Discharge	Average Flooding Months
(1-150) Zambezi	over 8.0 m	over 2,100 m3/s	1 months
(2-030) Lukulu	over 4.0 m	over 1,200 m3/s	3 months
(2-250) Kalabo	over 3.0 m	over 100 m3/s	3 months
(2-400) Senanga	over 2.2 m	over 1,500 m3/s	3 months

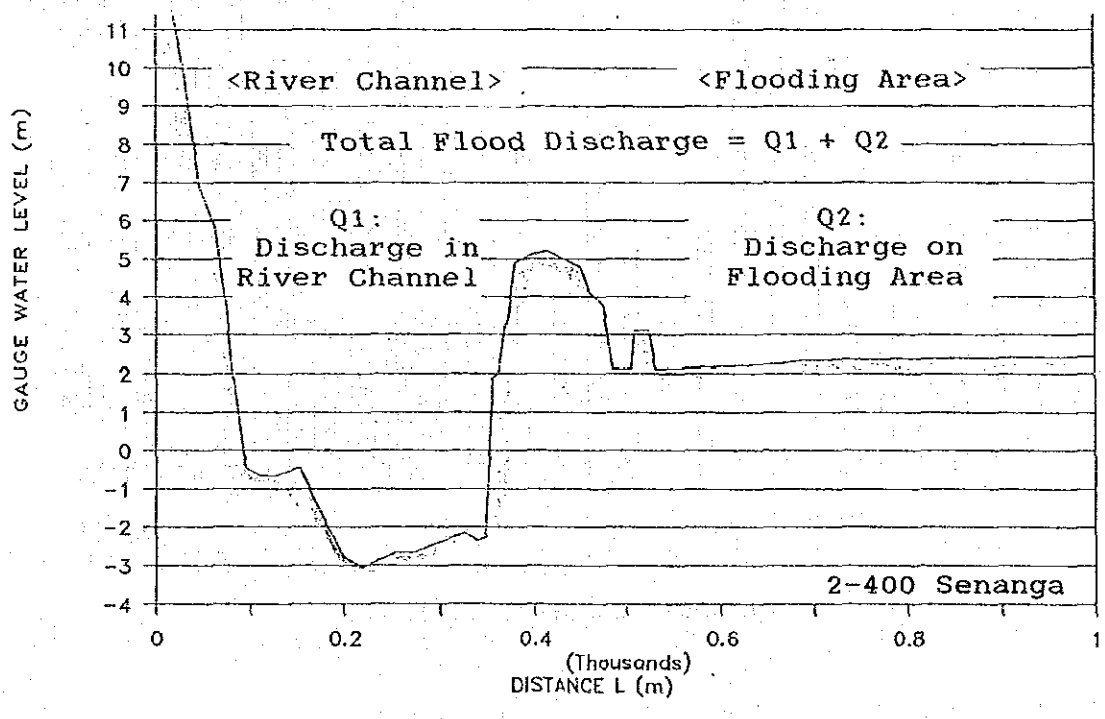

Fig.-5.61 River Channel and Flooding Area

(2) Reservoir Operation of Existing Dams

Itezhi-tezhi Dam is a regulation reservoir for Kafue Gorge Dam that is facilitated with hydropower generation of 900 MW. Kariba Dam is facilitated with hydropower generation of 1200MW.

The reservoir simulation result shows that Itezhi-tezhi Dam is operated effectively for hydropower generation at Kafue Gorge Dam. Fig.-5.62 shows the annual ratio of hydropower generation (= 100 x (Discharge for generation / Total outflow discharge)). Regarding the last 10 years, full outflow from both dams has been used for hydropower generation, except for 4 years (1985/86 - 1988/89). During that period, hydropower generation at Kafue Gorge Dam was stopped due to the failure of facilities.

Considering those facts, it is recognized that the water resources for hydropower at each dam site are effectively utilized. If the demand for new hydropower generation is required, it is recommended to find another new sites instead of reinforcing facilities at the existing sites.

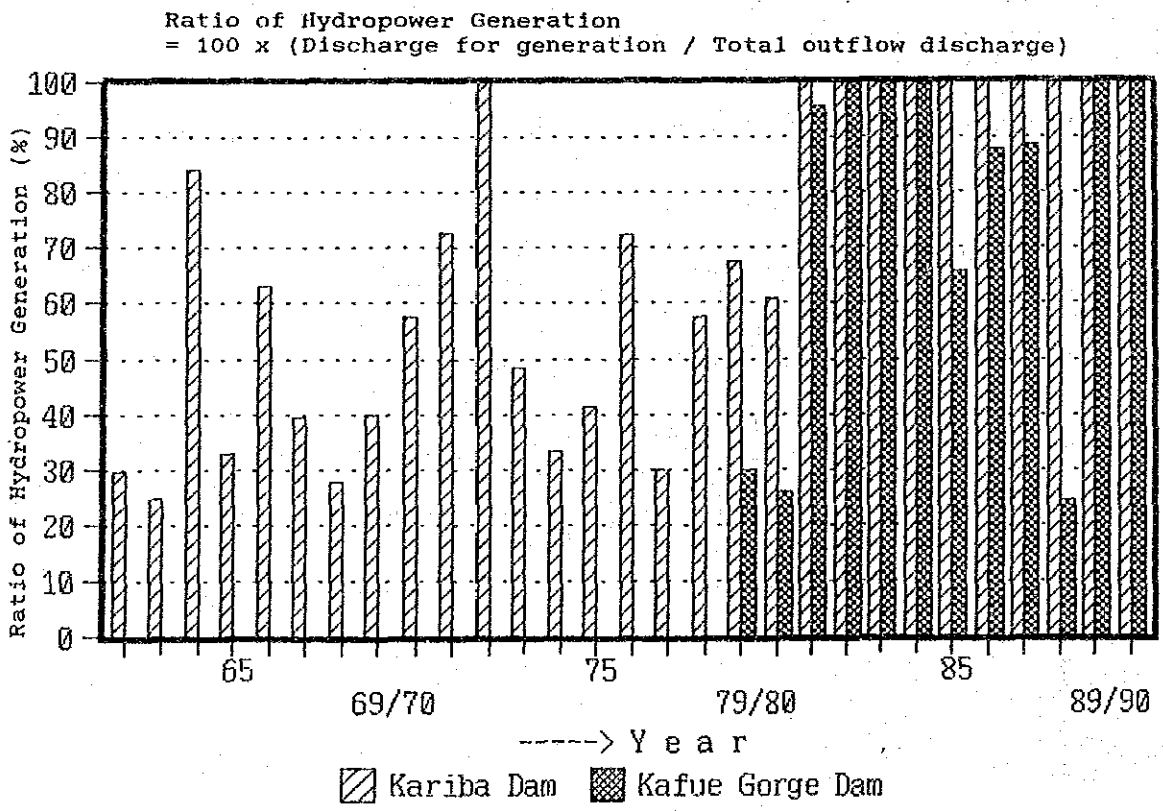

Fig.-5.62 Ratio of Hydropower Generation

(3) River Flow Balance in Flooding Areas

Along the main stream of upper Zambezi River there exists an extensive flood plain. Including the flood discharge, the river flow balance in this flooding area is estimated as shown in Table-5.29. Refer to Fig.-5.63. The values of discharge on the flooding area at Zambezi and Kalabo are assumed to be 5% and 20% of the channel discharge respectively. For the estimation of discharge from the areas (a, b and c in Table-5.26) where no measurement is done, the specific discharge of each area is assumed considering that of Kalabo Station.

Table-5.29 River Flow Balance on Mongu Flooding Area

Discharge Points	Catchment Area (km2)	Specific Dis (m3/s/ /1000km2)	Total Discharge (m3/s)	Discharge in Channel (m3/s),(%)	Discharge on F/Area (m3/s),(%)
St.Zambezi	87,275		698	665(95%)	33(5%)
Zambezi R	90,353		722	689(95%)	33(5%)
Kabompo R	72,347		275	275	0
Confluence	162,700		997	964(97%)	33(3%)
Area (a)	48,831	(1.5)	73	-	-
St.Lukulu	206,531		1,070	808(76%)	262(24%)
Area (b)	26,090	(2.5)	65	-	-
Luanginga R	41,233		113	93(82%)	20(18%)
Confluence	269,309		1,248	961(77%)	287(33%)
Area (c)	10,910	(3.0)	33	-	-
St.Senanga	278,298		1,281	986(77%)	295(33%)
Livingstone	466,324		1,324	1,324	0

[Note] Period of Discharge Data: 32 years (1959/60 - 1990/91)

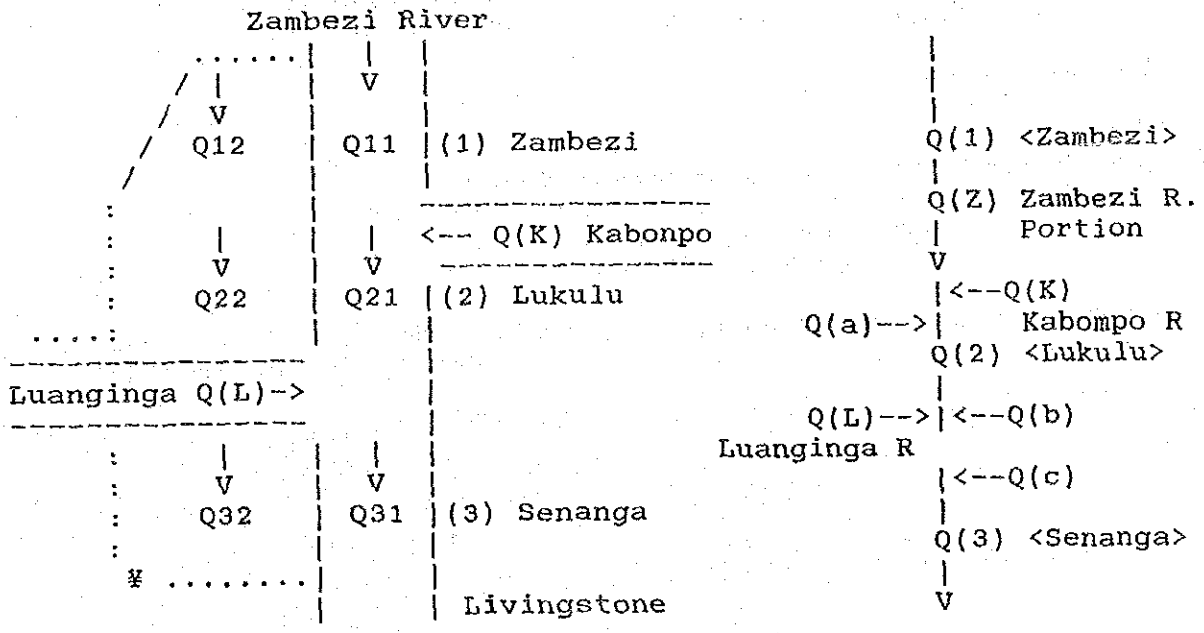

Fig.-5.63 Flooding Model in Mongu Plain

(4) Hydrologic Water Balance

The objective of this Study is not to obtain hydrologic water balance of Study Area. However, preliminary estimation of the hydrologic water balance in Kafue River basin is done because some factors such as rainfall, evaporation from reservoirs and surface runoff have been noted.

Generally, the hydrologic water balance is expressed with the following equations.

$$dS = I + O$$
$$I = R + Qi + Gi$$
$$O = Qo + Ev + Go + C$$

Where,

- dS: Variation of storage
- I : Input of water
- O : Output of water
- R : Rainfall
- Qi: Inflow of surface runoff
- Qo: Outflow of surface runoff
- Gi: Inflow of groundwater
- Go: Outflow of groundwater
- Ev: Evaporation and transpiration
- C : Consumption

In the case of Kafue River basin that is a closed basin, such figures as Qi (surface runoff inflow), Gi (groundwater inflow), Go (groundwater outflow) and C (Consumption) are negligible, comparing with the values of Qo (Surface runoff from Kafue River mouth) and Ev (Evaporation and transpiration). Also, it can be said that there is no storage variation over long term periods. Therefore, the above equations can be rewritten as follow.

$$R = Qo + Ev$$

Where,

- R : Rainfall on Kafue River basin
- Qo: Surface runoff from Kafue River mouth
- Ev: Evaporation and transpiration from Kafue River basin

Table-5.30 gives the hydrologic water balance of Kafue River basin over the last 10 years (1979/80 - 1988/89). Refer to Fig.-5.64.

Table-5.30 Hydrologic Water Balance of Kafue River Basin

Items	Value			Ratio
Catchment Area	154,882 km2			
1) Rainfall :R	989 mm/year	: 153.2	bcm/year	100.0 %
2) Surface Runoff :Qo	268 m3/s	: 8.5	bcm/year	5.5 %
3) Evaporation & Transpiration :Ev		144.7	bcm/year	94.5 %
(Ev from Reservoirs)	(46.3 m3/s)	:(1.5	bcm/year)	(1.0 %)
(Other Ev)		(143.2	bcm/year)	(93.5 %)

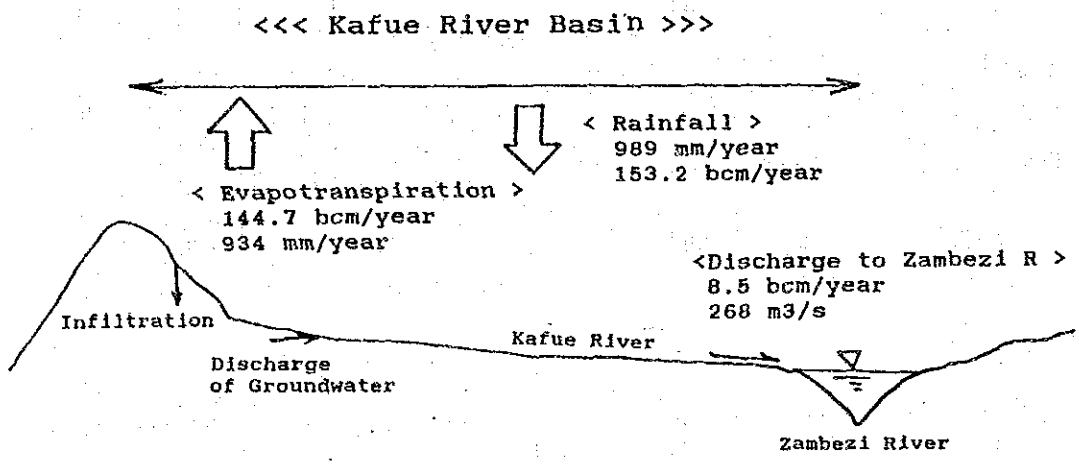

Fig.-5.64 Hydrologic Water Balance of Kafue River Basin

(5) Annual Fluctuation of Rainfall and Discharge

Annual volumes of rainfall and discharge change periodically due to the global climatological variation. One example is shown in Fig.-5.65 that illustrates the annual fluctuation of rainfall (at Solwezi) and discharge (at Kafue Hook Bridge) in the Kafue River Basin. Regarding the index "fluctuation coefficient" that shows the degree of fluctuation, The fluctuation coefficient of annual mean discharge is bigger than that of annual rainfall. This is because the runoff coefficient is changed in proportion to the amount of rainfall.

The discharge of river, objective of water resources development, has a characteristics of annual fluctuation as well as seasonal variation. On the other side, the discharge developed by the plan is designed to secure constant volume every season and year. That is why dam and reservoir are employed in the water resources development plan.

Fig.-5.66 shows the fluctuation coefficients of annual discharge at the main points covered by the Study. These coefficients are distributed from 0.2 - 0.6, showing larger values according to larger catchment area. This is because the storage and control effect of the area (for example, temporal storage of groundwater and its discharge to river) become larger in proportion to the catchment area.

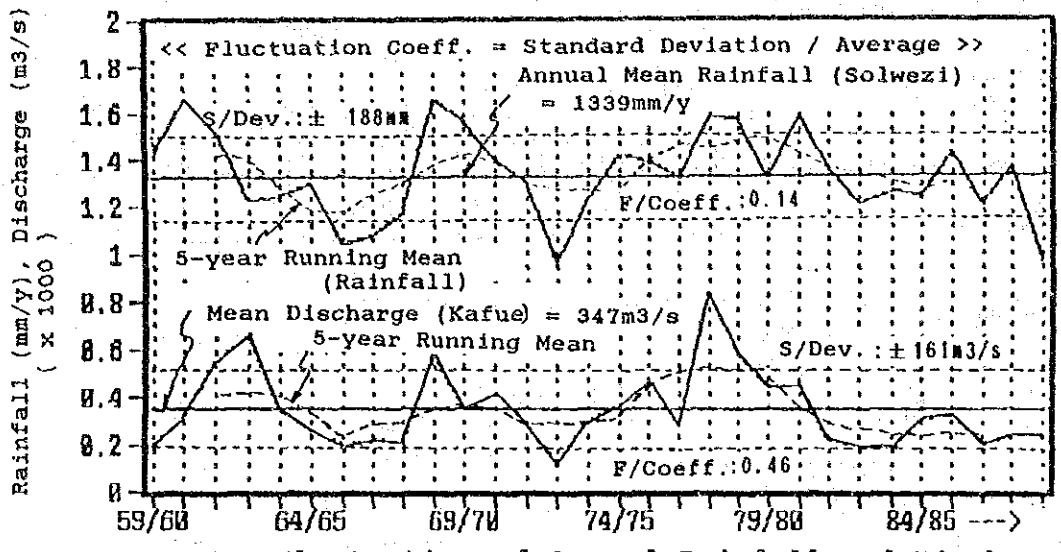

Fig.-5.65 Fluctuation of Annual Rainfall and Discharge

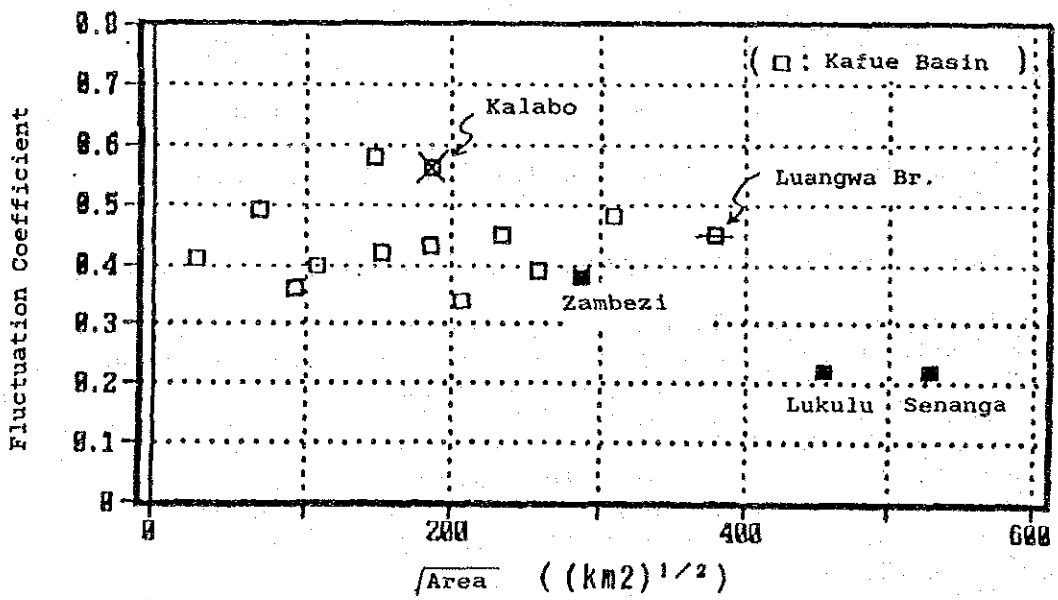

Fig.-5.66 Fluctuation Coefficient of Annual Mean Discharge

(6) Development Potential of River Water

Water resources development is a kind of arrangement between human need to rivers and water resources potential of rivers by employing some measures of facilities.

For example, kinds of human need to rivers are supply of drinking and industrial water, irrigation, hydroelectric power generation, water quality conservation, navigation and so on. These kinds of need request necessary amount, quality, location, time and so on to rivers. On the other hand, river water has not only regional distribution but also annual and seasonal variation. The facilities to arrange the need and potential of these characteristics are dam and reservoir, intake and channel, pump station, hydroelectric power station, water treatment works, water conveyance works etc.

The development potential of river water, decided depending on the type of water resources development facilities, is assumed at this stage as follow. The maximum and minimum development potential of river water are low discharge (275 days discharge) and drought discharge (355 days discharge) respectively at each point of river. These values at each hydrometric station are as shown in Table-5.22. The low discharge is a discharge to secure for 275 days a year in average. The drought discharge is a discharge to secure for 355 days a year in average. Table-5.31 shows the development potential of river water at the main points. See Fig.-5.67. The potential includes the obligation discharge to downstream.

Table-5.31 Development Potential of River Water

Basin	Development Point (Hydro. Station)	Catchment Area (km2)	Max.Potential <Low Dis.> (m3/s)	Max.Potential <Low Dis.> (bcm/y)	Min.Potential <Drought Dis.> (m3/s)	Min.Potential <Drought Dis.> (bcm/y)
Zambezi Main Channel	1-150 Zambezi	82,275	117	3.69	75	2.37
	1-650 Kabompo	42,740	99	3.12	61	1.92
	1-950 Watopa	66,449	105	3.31	74	2.33
	2-030 Lukulu	206,531	385	12.14	315	9.93
	2-250 Kalabo	34,620	13	0.41	9	0.28
	2-450 Senanga	278,298	444	14.00	337	10.63
Kafue	4-130 Smith B	8,599	23	0.73	11	0.35
	4-200 Mpatamato	11,655	28	0.88	15	0.47
	4-280 Machiya	22,920	39	1.23	21	0.66
	4-350 Chilenga	34,162	47	1.48	25	0.79
	4-450 Lubungu	54,442	54	1.70	28	0.88
	4-560 Chifumpa	21,445	42	1.32	24	0.76
Luangwa	5-940 Luangwa B	143,781	82	2.59	37	1.17

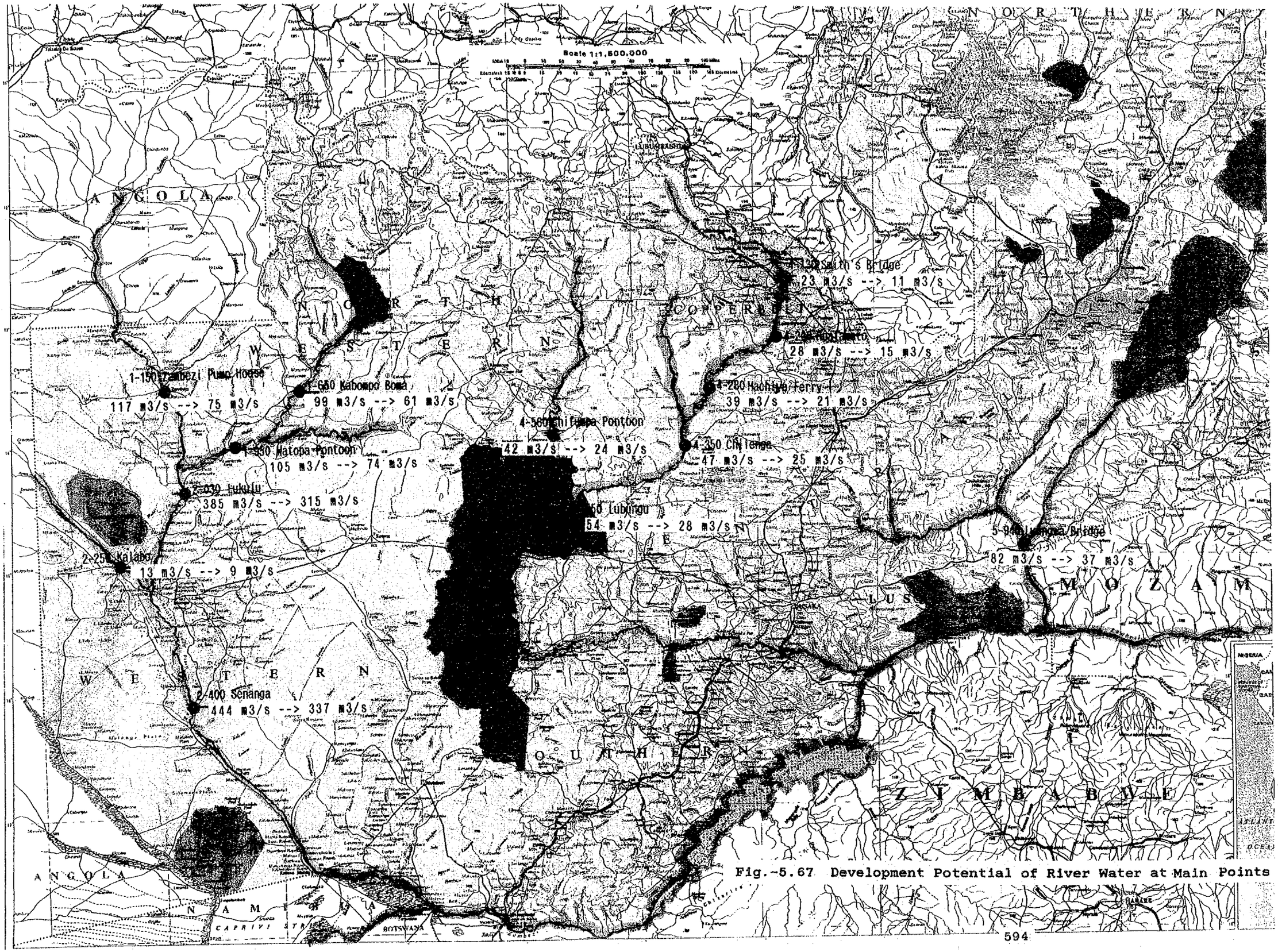

Fig.-5.67 Development Potential of River Water at Main Points

6 HYDROLOGIC OBSERVATION PLAN

6.1 Present Observation System

(1) Authorities Responsible for Hydrologic Observation

In Zambia, the following hydrologic items are regularly observed by the government bodies respectively.

- Rainfall and other meteorological data:
  Department of Meteorology,
  Ministry of Transport and Communication

- River water level and discharge:
  Department of Water Affairs, (DWA)
  Ministry of Energy and Water Development (Ministry of W.L.NR)

(2) Organization of DWA

In Zambia, the body responsible for collecting river hydrologic data is DWA. In Fig.-6.1, the organization of DWA is shown. DWA consists of the headquarters in Lusaka and 9 provincial offices. DWA's main activities are 1) water supply 2) hydrological investigation 3) drilling and 4) dredging. The main activities of each section are as shown in Table-6.1. The hydrological section, in charge of hydrologic observation, is responsible for 1) Hydrologic data collection 2) Data processing and archiving 3) Hydrologic analysis.

In the organization of the hydrological section, the principal (or senior) hydrologist is the head of section. After the principal hydrologist come the hydrologists. The officer-in-charge is the top among the hydrologists. In each provincial office, there is a provincial hydrological officer (RHO) or engineer (RHE) who is responsible for hydrological work in the province. At each hydrometric station, a gauge reader is employed by DWA. The daily water level gauging is carried out this gauge reader. The flow measurement is to be conducted by RHO or RHE.

Table-6.1 Main Activities of DWA by Section

Section Office	Location of Office	Water Supply	Hydro-logy	Drilling	Dred-ging
Headquarter	Lusaka	O	O	O	X
Lusaka	Lusaka	O	O	O	X
Central	Kabwe	O	O	O	O
Copperbelt	Ndola	O	O	O	X
North-Western	Solwezi	O	O	O	X
Western	Mongu	O	O	O	O
Southern	Choma	O	O	O	X
Eastern	Chipata	O	O	O	X
Northern	Kasama	O	O	O	O
Luapula	Mansa	O	O	O	O

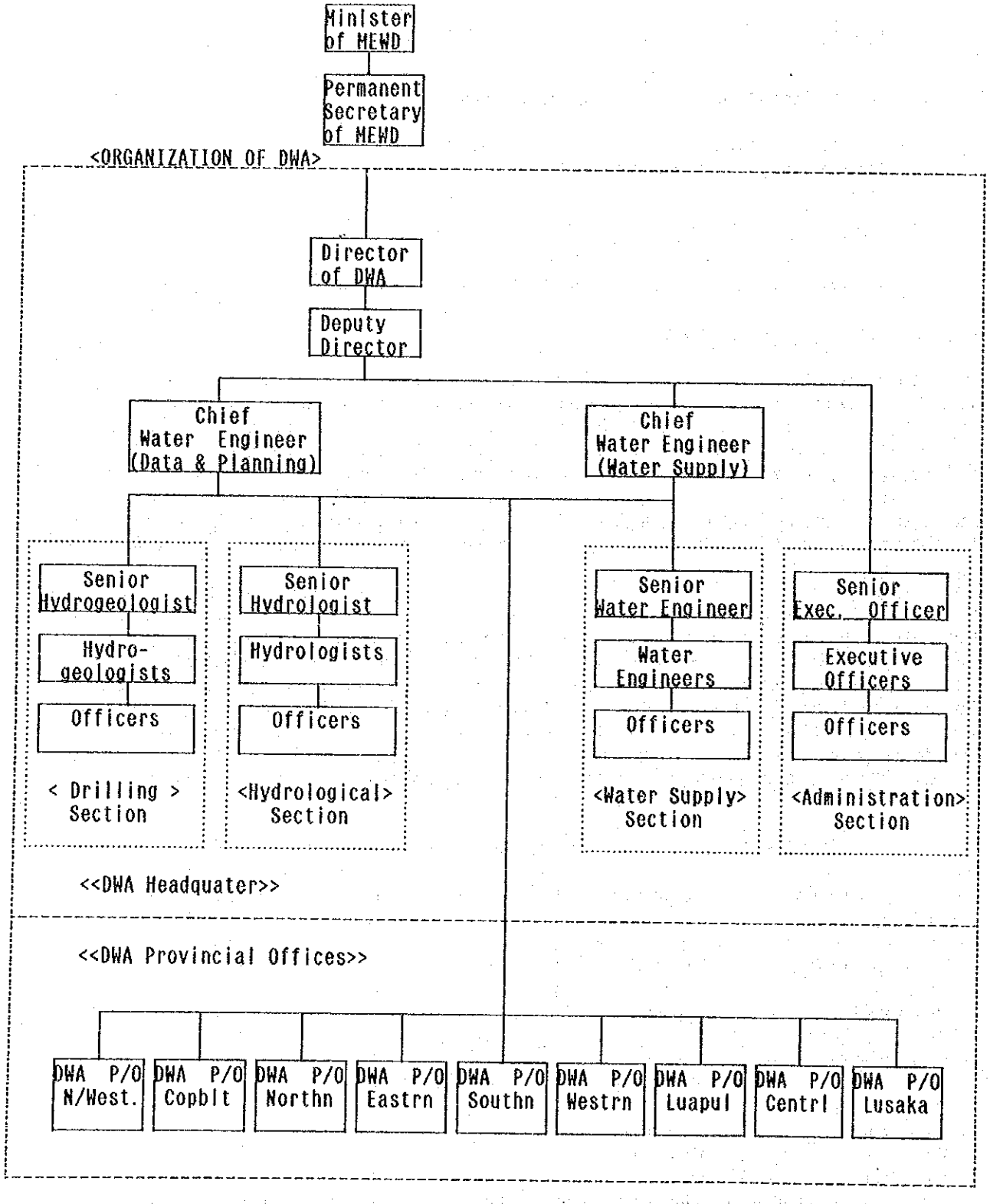

Fig.-6.1 Organization of DWA

(3) Observation Network

The Provincial Office of DWA has Regional Hydrological Offices. There are eight (8) Regional Hydrological Offices. The hydrological activities of Luska Province and Central Province are covered by Lusaka Regional Hydrological Office. Each office is headed by RHO (or RHE) who is responsible for hydrological observation in the region.

In Table-6.2, the stations covered by each Regional Hydrological Office are shown. A total number of 190 hydrometric stations are currently maintained by the Regional Hydrological Offices. In some of the stations mentioned above, meteorological equipment for rainfall, evaporation, temperature, humidity, wind speed etc. is installed.

Table-6.2 Present Hydrometric Stations

Regional Hydrological Office	Location of Office	Working Stations	Temporally Closed Stations	Total
(1) < Lusaka >	Lusaka	20	13	33
(2) < Copperbelt >	Kitwe	16	17	33
(3) < North Western >	Solwezi	15	21	36
(4) < Western >	Mongu	11	6	17
(5) < Southern >	Mazabuka	11	24	35
(6) < Eastern >	Chipata	18	2	20
(7) < Northern >	Kasama	31	3	34
(8) < Luapula >	Kawamba	24	11	35
[T o t a l]		146	97	243

(4) Observation Team

<Manpower>
Each regional hydrological office has an observation team to conduct flow measurement. Also, the hydrological section in the Headquarters has extra observation teams led by hydrologists who are responsible for the designated river basins. These teams go out to the respective regions to check the work being performed by the regional observation team.

The Hydrological Section of DWA recognizes that there is a critical shortage of manpower, especially in professional and technical staff regarding hydrological observation as shown in Table-6.3.

Table-6.3 Staff Level in Hydrological Observation

Post	Present Number	Number Required by Hydrological Section
(1) Professional (Hydrologist)	4 persons (include of Officer in Charge)	11 persons - 8 persons (one/each region) - 1 officer-in-charge (in H/Q) - 1 deputy o-i-c (in H/Q) - 1 for data processing (in H/Q)
(2) Technical (Regional Hydrological Officer)	8 persons	8 persons 6 persons are need to be trained to technical level (diploma) so as to assist hydrologists.
(3) Technicians (Data Processing in Head/q.)	8 persons	8 persons All persons are required to have some form of training to fulfill their duties.
(4) Other Staff	enough	Good mechanic staffs are required to maintain hydrologic equipment.

<Equipment>

At present in almost all Regional Hydrological Offices, there is no full set of equipment to execute hydrological activities. There is a general lack of observation equipment, transport, camping set and so on.

Regarding transport for hydrologic observation throughout the whole country, only two (2) vehicles are available at the moment. At least, eight (8) vehicles for the regional hydrological offices and three (3) vehicles for headquarters are required to execute sufficient hydrologic activities.

There is also a need to replace the boats that are equipped at the stations due to decrepitude.

<Maintenance of Observation Equipment>

Due to lack of funds, no major maintenance has been done on the equipment for hydrological observation. The conditions of some of the boats, winches, current meters etc. are not satisfactory. Hydrological structures like weirs have not been maintained for the last 10 to 15 years.

Calibration of current meters has not been done since 1968. In short, almost all equipment apart from the relatively new need maintenance and reparation. In some cases, it is difficult to trust the accuracy of the equipment.

(5) Frequency of Hydrological Observation

The frequency of discharge measurement has gradually reduced from 1975. No discharge measurement has been made at some stations for some years. This is mainly caused due to lack of funds allocated to hydrologic observation. The quantities of hydrological activities in 1990 by catchment are shown in Table-6.4.

Table-6.4 Hydrological Activities in 1990

Catchment	(1)Water Level Gauging (times)	(2)Level Checking of S/G (times)	(3)Sediment Sampling & Analysis (samples)	(4)Flow Measurement (times)
(1)Zambezi R.	(82%)	(47%)	(5%)	(1.3%)
- Actual	464	28	15	4
- Expected	564	60	312	312
(2)Kafue R.	(84%)	(31%)	(2%)	(4.9%)
- Actual	393	24	5	14
- Expected	468	78	288	288
(3)Luapula R.	(78%)	(17%)	(6%)	(3.0%)
- Actual	235	9	10	5
- Expected	300	52	168	168
(4)Luangwa R.	(85%)	(35%)	(0%)	(0.0%)
- Actual	214	14	0	0
- Expected	252	40	192	192
(5)Chambesi R.	(81%)	(86%)	(2%)	(17%)
- Actual	203	43	5	36
- Expected	252	50	216	216
(6)Tanganyika L.	(82%)	(21%)	(67%)	(1.7%)
- Actual	69	3	8	2
- Expected	84	14	12	12
T o t a l	(82%)	(32%)	(3%)	(5.5%)
- Actual	1578	94	37	61
- Expected	1920	294	1118	1118

(6) Training

Recently, there is no training program for hydrologists and technical staff intentionally organized by DWA, although some technical training programs are prepared by individual assistance projects by the other countries.

(7) Data Filing and Analyzing System

The present data filing and analyzing system conducted in the hydrological section Lusaka, DWA is as shown in Fig.-6.2.

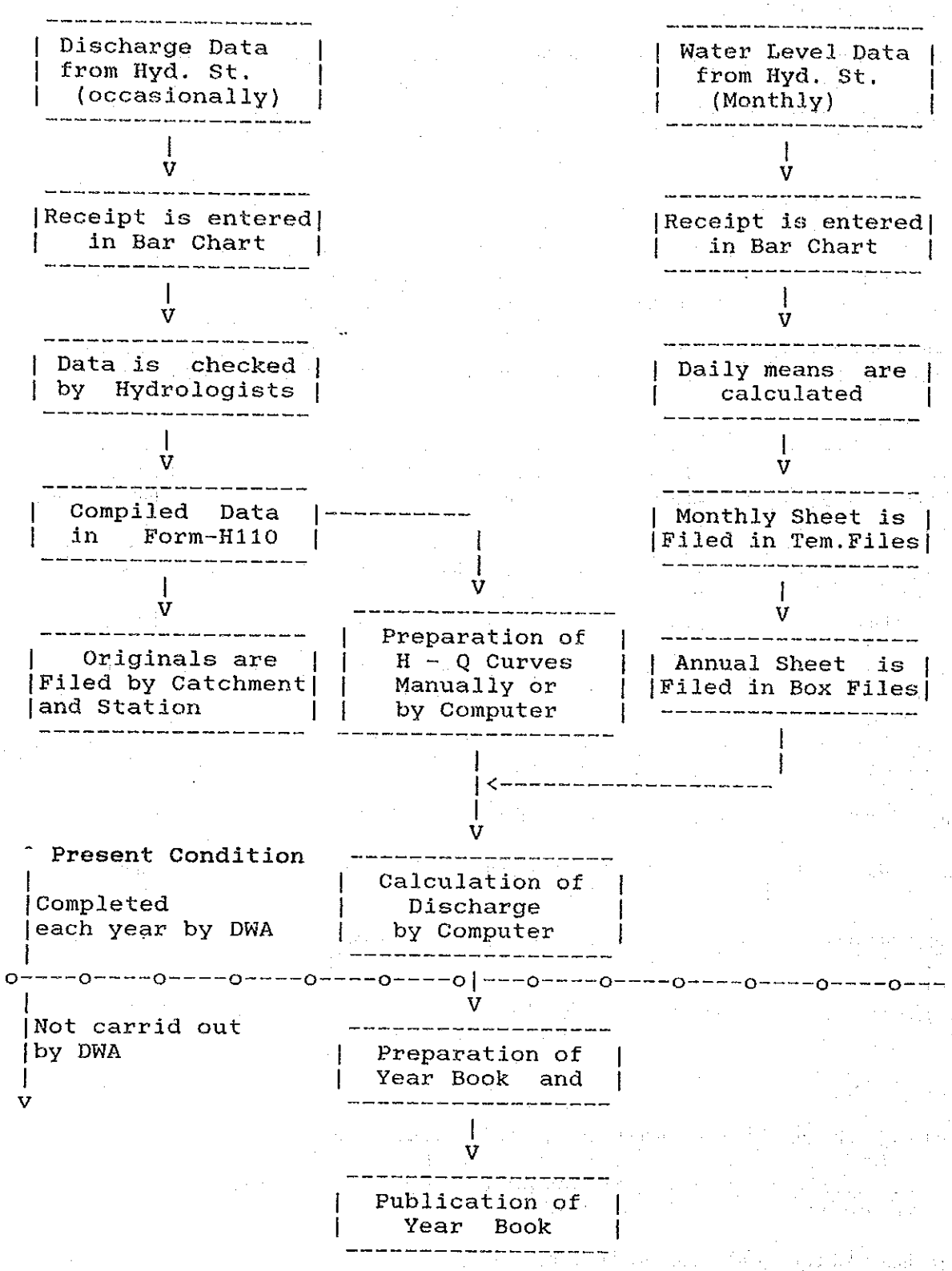

Fig.-6.2 Hydrological Data Filing and Analyzing System

(8) Recognition of Present Problems

At the moment. Hydrological Section of DWA recognizes the following problems in improving the present situation of hydrologic observation.

1) Training

The hydrological section would like to update all the rating curves, and to improve the collecting system of hydrologic data. To achieve this, it is necessary to give staff training both in-house and institutionally etc.

2) Transportation

At present, there are only two vehicles for hydrologic observation in the whole area of Zambia. This make it practically impossible to get good discharge data. One vehicle is essential at each regional hydrological office, and three (3) vehicles at the headquarters for hydrological observation. The vehicles should be 4X4 vanettes and station wagons, complete with double fuel tanks and winches.

3) Extensive Flow Measurement

The frequency of flow measurement has decreased recently due to budgetary conditions, lack of transport and so on. However, it is desirable to execute the program for extensive discharge data collection for at least two (2) years although five (5) years would be preferred. This will allow the rating curves to be updated or checked.

4) Maintenance of Equipment

It is necessary to improve the present situation as far as observation equipment is concerned. Sufficient equipment for flow measurement with spare parts should be provided to all hydrological offices. It is also impossible to repair or calibrate the equipment due to lack of skilled mechanical staff.

6.2 Master Plan for Hydrologic Observation

Through the Study, JICA Study Team has recognized that the activities of hydrological observation should be greater. To improve the present activities of hydrological observation in Zambia, we proposed a plan as described below.

In preparation of the plan, we employed the implementable or realizable methods. With some input and modification of present system according to the proposed plan, the hydrologic observation system in Zambia will work more effectively.

6.2.1 General

(1) Objectives

The objective of this Plan is to facilitate the effective execution of hydrological observation in Zambia by clarifying the activities and organization. The targets of hydrological observation specified in this Master Plan are to obtain river water data such as water level and discharge throughout Zambia on regular basis, and to store these processing data for the use of river water resources development.

Water resources development brings various benefits such as supply of drinking water and industrial water, generation of hydroelectric power, flood control and so on. Moreover, through water resources development, the essential items for living are conserved such as groundwater (closely related to the river water), environment (becoming a serious matter from a global view point) and water quality (important for drinking). The essential data for preparation of plan for such development is hydrological data observed continuously for the long period.

(2) Contents

This Plan discusses the following four (4) items: 1) Activities 2) Organization and responsibilities 3) Observation frequency 4) Observation stations.

The contents of each item are the standard for hydrological observation and related work. The contents will be modified according to the social and technical conditions if necessary.

(3) Application

This Plan is employed in the Hydrological Section, DWA and applied to the regular work of hydrological observation.

6.2.2 Activities

The work of hydrological observation comprises the following activities:

1) Hydrological Observation
   - Observation of river water level
   - Measurement of discharge
   - Sediment Sampling and Analysis
   - River Water Quality
   - Others (according to request of other authorities)
2) Data processing and archiving
3) Basic hydrological analysis
4) Maintenance of equipment and station
5) Training
6) Reporting
   - Activity results for current year
   - Activity plan for following year

7) Publication of Hydrological Year Book

(1) Hydrological Observation

The regular observation items are river water level, discharge, sediment and river water quality. Regarding the observation requested by the other agencies and projects, activities will be executed according to each plan. The observation should be done continuously with no lack of data using well maintained equipment and stations. For the continuous observation of daily water level, personnel to back up the gauge reader should be employed, if necessary.

< Observation of River Water Level >

To collect continuous river water level, daily river water level should be observed at the stations registered by DWA. Daily observations are done two (2) times a day, in morning and in evening. The average of these two data is recorded as a daily water level. This observation is done by the observer living near the station and employed by DWA. At the stations where the water level recorder is installed, the recording river water level is obtained. These observed water level data are converted into discharge through the discharge rating curve established with flow measurement data.

< Measurement of Discharge >

To establish the discharge rating curve, flow measurements should be carried out regularly at the selected hydrometric station.In one measurement, one relationship between a water level and a discharge is obtained. To get reliable rating curve, measurement should cover the full range of water level and discharge as much as possible. In case of the river where the river bed fluctuation is small, the established rating curve will be used long term with annual checking and with few measurement. In case of remarkable fluctuation of river bed, the rating curve should be modified with many calibratior measurements. The regular flow measurement is carried out by the team belonging to the Regional Hydrological Office.

< Sediment Sampling and Analysis >

To establish the sediment discharge rating curve, the sediment sampling and analysis should be carried out at the selected hydrometric stations. The river flow transports sediments, generally in three types : 1) bed-material Load 2) suspended load and 3) wash load. These analyses clarify the relationship between the discharge and the transport sediment amount consisting of suspended load and wash load. The regular sampling and analysis are carried out by the team belonging to the Regional Hydrological Office.

<Investigation of Water Quality>

The water quality investigation for river water should be carried out at the selected hydrometric stations and other problematic points according to the following programs.

1) Investigation by Regional Hydrological Office
Water temperature, turbidity, pH, electrical conductivity and dissolved oxygen are measured using the water checker at the time of discharge measurement by the observation team belonging to the Regional Hydrological Office.

2) Investigation by Hydrological Section
The river water is sampled and tested for copper, manganese etc. in the laboratory. This investigation is carried out by the team belonging to the Hydrological Section in Lusaka.

(2) Data Processing and Archiving

The observed data, such as river water level and flow measurement data should be processed and stored at the offices concerned. The Regional Hydrological Office should keep the original of data and send copies to the Hydrological Section of Headquarter DWA. The DWA Hydrological Section should process all the data sent from the regional offices and store all the processed data. The main items of data processing are as follows:

- Daily and hourly river water level data
- Flow measurement data
- Sediment sampling and analysis data
- Others

(3) Basic Hydrological Analysis

The following analyses will be done at the DWA Hydrological Section using computer.

- Preparation of discharge rating curve
- Preparation of sediment discharge rating curve
- Calculation of discharge by station
- Calculation of annual flow regime by station
- Calculation of annual river flow in main channels

(4) Maintenance of Equipment and Station

All the equipment used for observation and hydrometric stations shall be maintained by each Regional Hydrological Office.

(5) Training

To maintain and improve the hydrological observation, DWA Hydrological Section is responsible for training given to the staff inside the section and to staff in the Regional Hydrological Office. The training to gauge readers is given by the Regional Hydrological Office.

(6) Reporting

< Activity Results for Current Year >

The Regional Hydrological Office shall report the annual activities to DWA Hydrological Section. DWA Hydrological Section shall report the annual activities including the result of hydrological analysis.

< Activity Plan for Following Year >

To arrange and settle the budgetary condition for hydrological observation, DWA Hydrological Section and each Regional Hydrological Office shall prepare the following year's activity plan. The Hydrological Section shall compile the plans sent from the Regional Hydrological Office and report them to DWA Headquarters.

(7) Publication of Hydrological Year Book

All the observation data and analysis results in a fiscal year should be published in the Hydrological Year Book. DWA Headquarters is responsible for this publication. The material for this book is prepared by DWA Hydrological Section.

6.2.3 Organization and Responsibilities

(1) General Organization

DWA is responsible for hydrological observation in Zambia. In DWA, the Hydrological Section has substantial responsibility for hydrological observation. The principal hydrologist heads the Hydrological Section.

The Regional Hydrological Offices, belonging to DWA Provincial Offices, execute actual field observation in each Province. The Regional Hydrological Officer heads this office. The activities of this office are coordinated and supervised by DWA Hydrological Section. The gauge readers belong to each Regional Hydrological Office. Refer to Fig.-6.3 and Fig.-6.4.

(2) Responsibilities of Organization and Staff

The responsibilities of the organization and staff regarding hydrological observation are as shown in Table-6.5.

(3) Number of Staff

To fulfill the responsibilities of each organization the necessary number of main staff is as shown in Table-6.5.

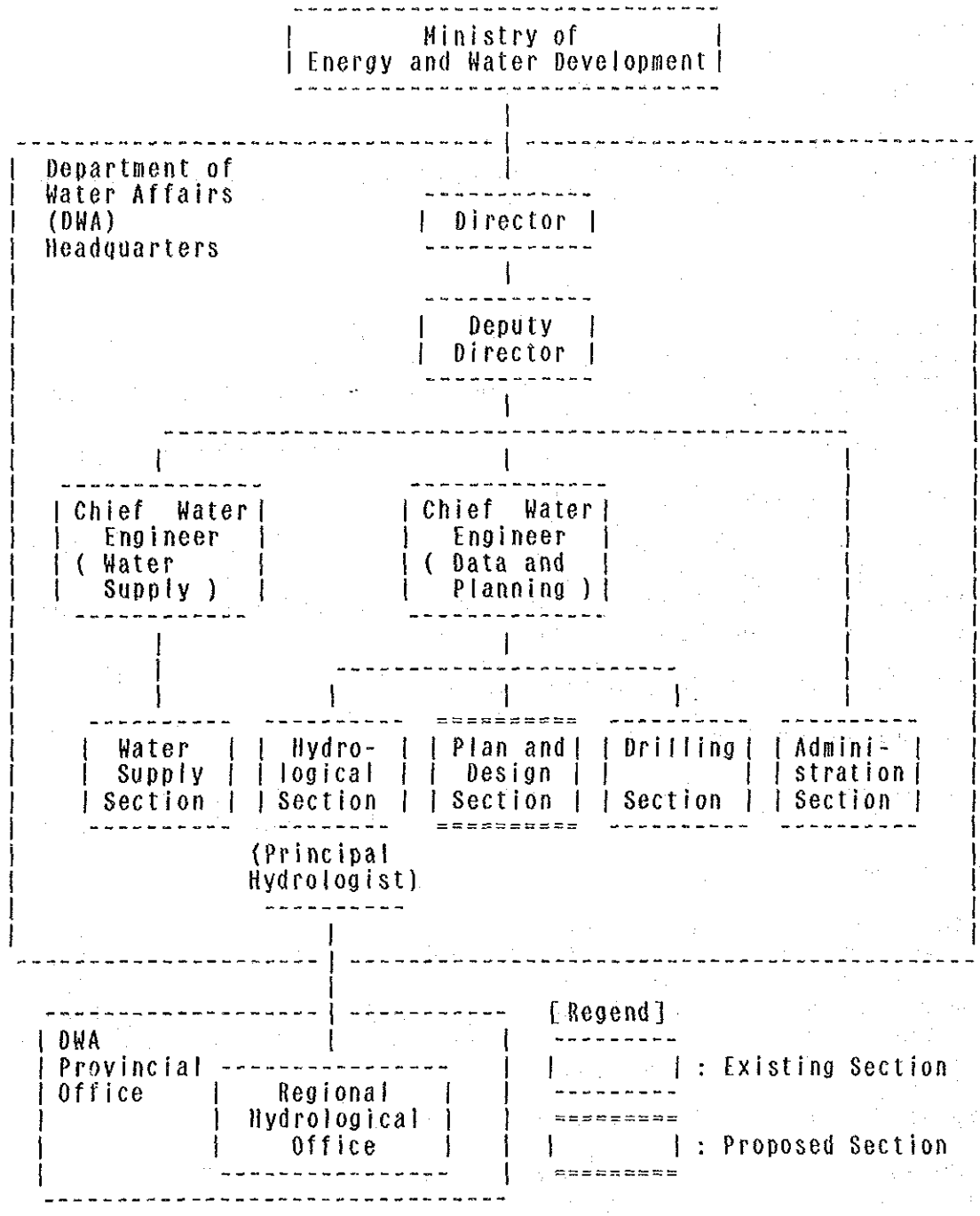

Fig.-6.3 General Organization for Hydrological Observation

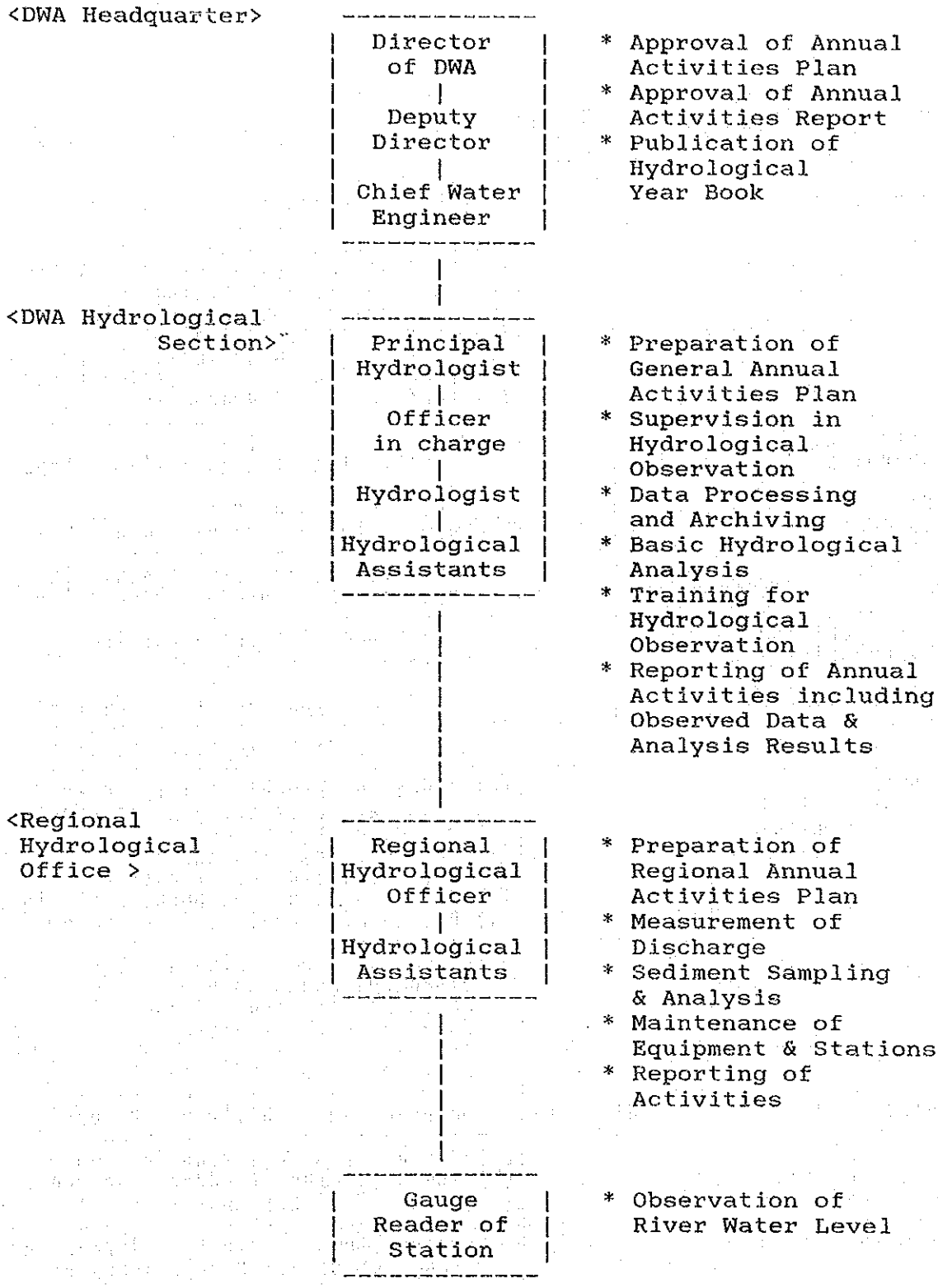

Fig.-6.4 Responsibilities of Organization

Table-6.5 Responsibilities of Organization and Staff

Organization and Staff	Num. of Staff		Responsibilities
	Plan	Now	
<Dep/Water Affairs>			Approval of Annual Report & Plan
<Hydrological Section >			(a) Preparation of Annual Plan (b) Guidance of Hydrologic Observation (c) Water Quality Investigation (d) Data Processing and Archiving (e) Basic Hydrologic Analysis (f) Training for Hydrologic Observation (g) Prepa. of Annual Activities Report (h) Publication of Hydro. Year Book
(1) Prinsipal Hydrologist	1	1	- General Supervision - Finalization of Annual Plan & Report
(2) Officer in Charge	1	1	- Prepa. of Annual Plan and Report - Supervision of Hydrologic Analysis
(3) Hydrologist	5	3	- Execution of Hydrologic Analysis - Supervision of hydro. observation
(4) Assistant for Hydrologist	10	8	- Data Processing and Archiving - Assistance for hydrologist
(5) W/Quality Spec.	1	1	- Plan/Execution/Report of W/Q/Invest.
(6) Assistant for(5)	1	1	- Assistance for W/Quality Specialist
<Regional Hydrological Offices>			(a) Prepa. of Annual Activity Plan (b) Observation of Daily Water Level (c) Discharge Measurement (d) Sediment Sampling Analysis (e) Water Quality Investigation (f) Maintenance of Equipment & Stations (g) Prepa. of Annual Activity Report
(1) Hydrologist	8	0	- Prepa. of Annual Plan and Report - Discharge Measurement - Sediment Sampling and Analysis - Maintenance of Equipment & Stations
(2) Assistant	16	8	- Assistance for Hydrologist
(3) Gauge Reader	1 / Station		- Observation of Daily Water Level
<Plan & Design Section > (For reference)			(a) Prepa. of Annual Plan and Report (b) Investigation of W/Resources Dev. (c) Planning of W/Respurces Development
(1) Section Chief	1	-	- Supervision of Invest. and Planning - Prepa. of Annual Plan and Report
(2) Engineer	1	-	- Investigation of W/Resources Dev. - Planning of W/Respurces Development
(4) Assistant	2	-	- Assistance for Engineer