REPUBLIC OF ZAMBIA
MINISTRY OF ENERGY AND WATER DEVELOPMENT

FINAL REPORT
SUMMARY

THE MASTER PLAN STUDY ON HYDROLOGIC OBSERVATION SYSTEMS OF THE MAJOR RIVER BASINS IN ZAMBIA

MARCH, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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Preface

In response to a request from the Government of the Republic of Zambia, the Government of Japan decided to conduct a Master Plan Study on Hydrologic Observation Systems of the Major River Basins in Zambia, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Zambia a study team headed by Mr.Yoshio Nakagawa, Yachiyo Engineering Co.,Ltd., five times between December 1989 and March 1992.

The team held discussions with the officials concerned of the Government of Zambia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the Project and to the enhancement of the friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Zambia for their close cooperation extended to the team.

Tokyo, March 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

THE MASTER PLAN STUDY ON HYDROLOGIC OBSERVATION SYSTEMS
OF THE MAJOR RIVER BASINS IN ZAMBIA

FINAL REPORT
S U M M A R Y

<< CONSTITUTION OF FINAL REPORT >>

(1) S U M M A R Y
(2) M A I N
(3) S U P P O R T I N G
(4) D A T A B O O K

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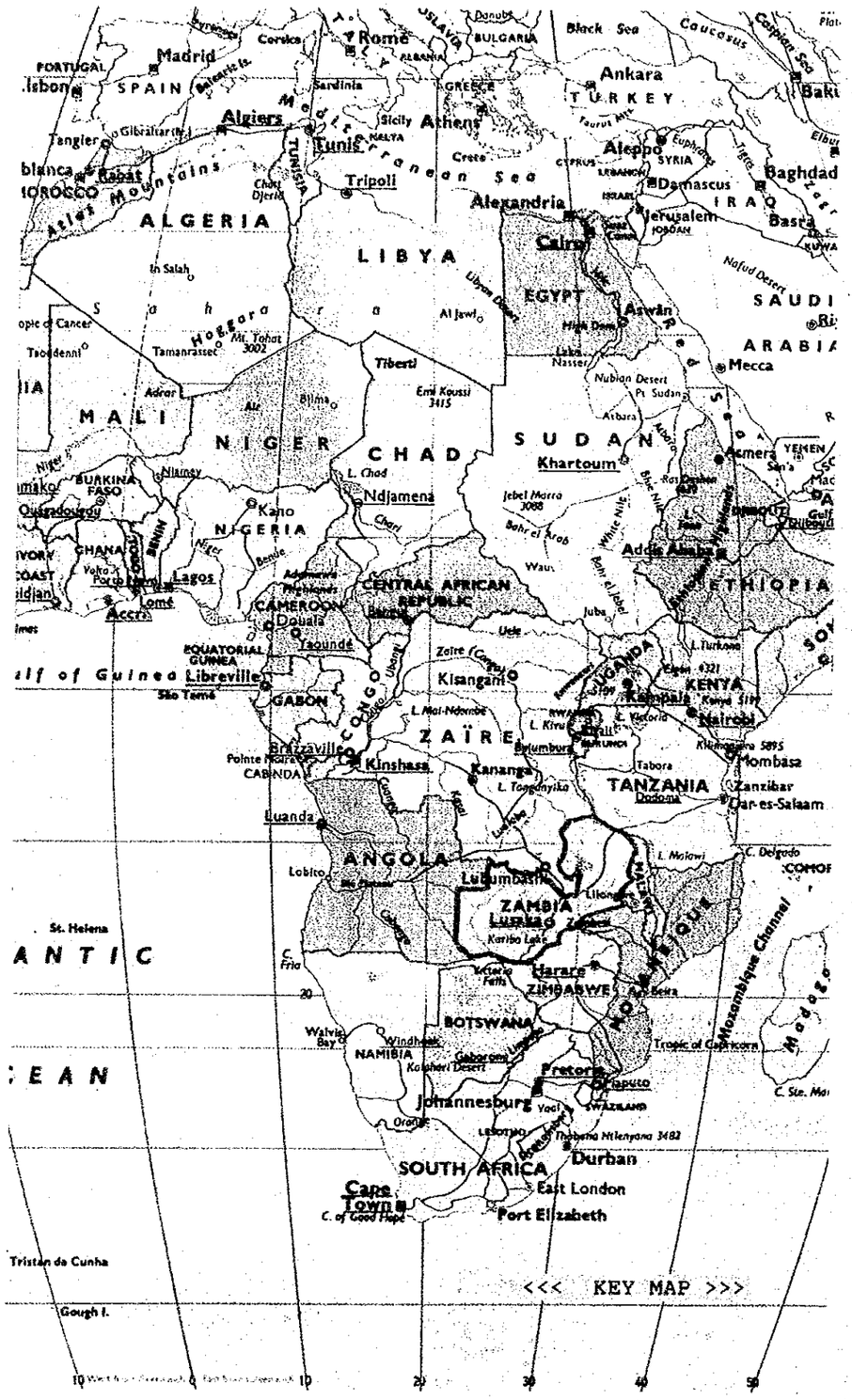
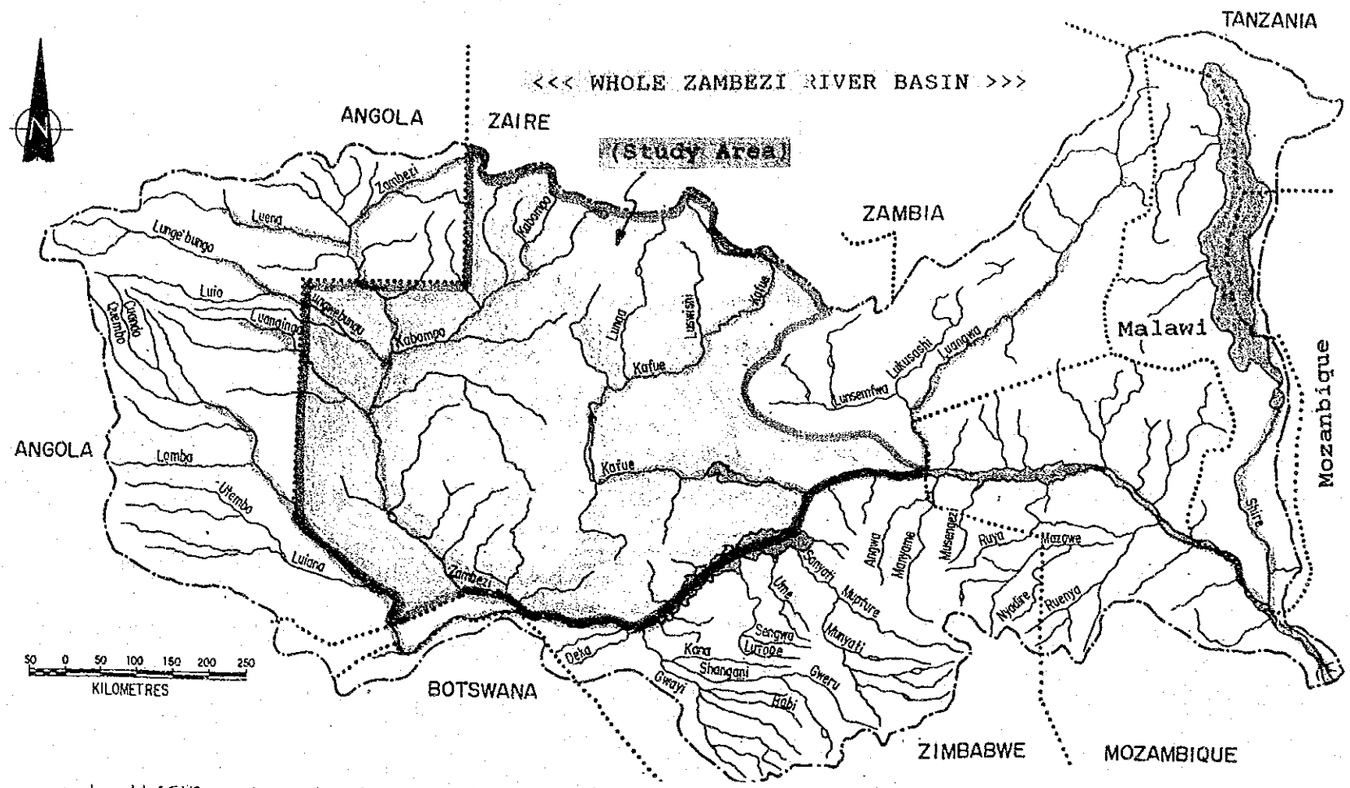
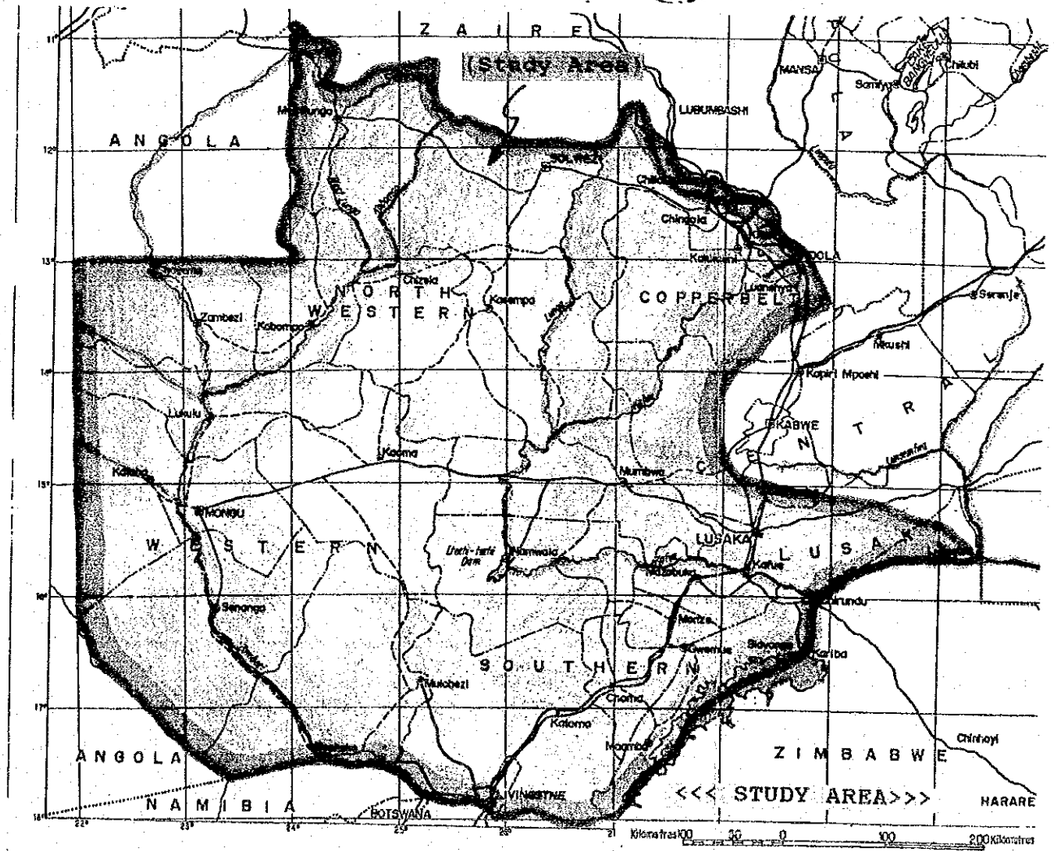
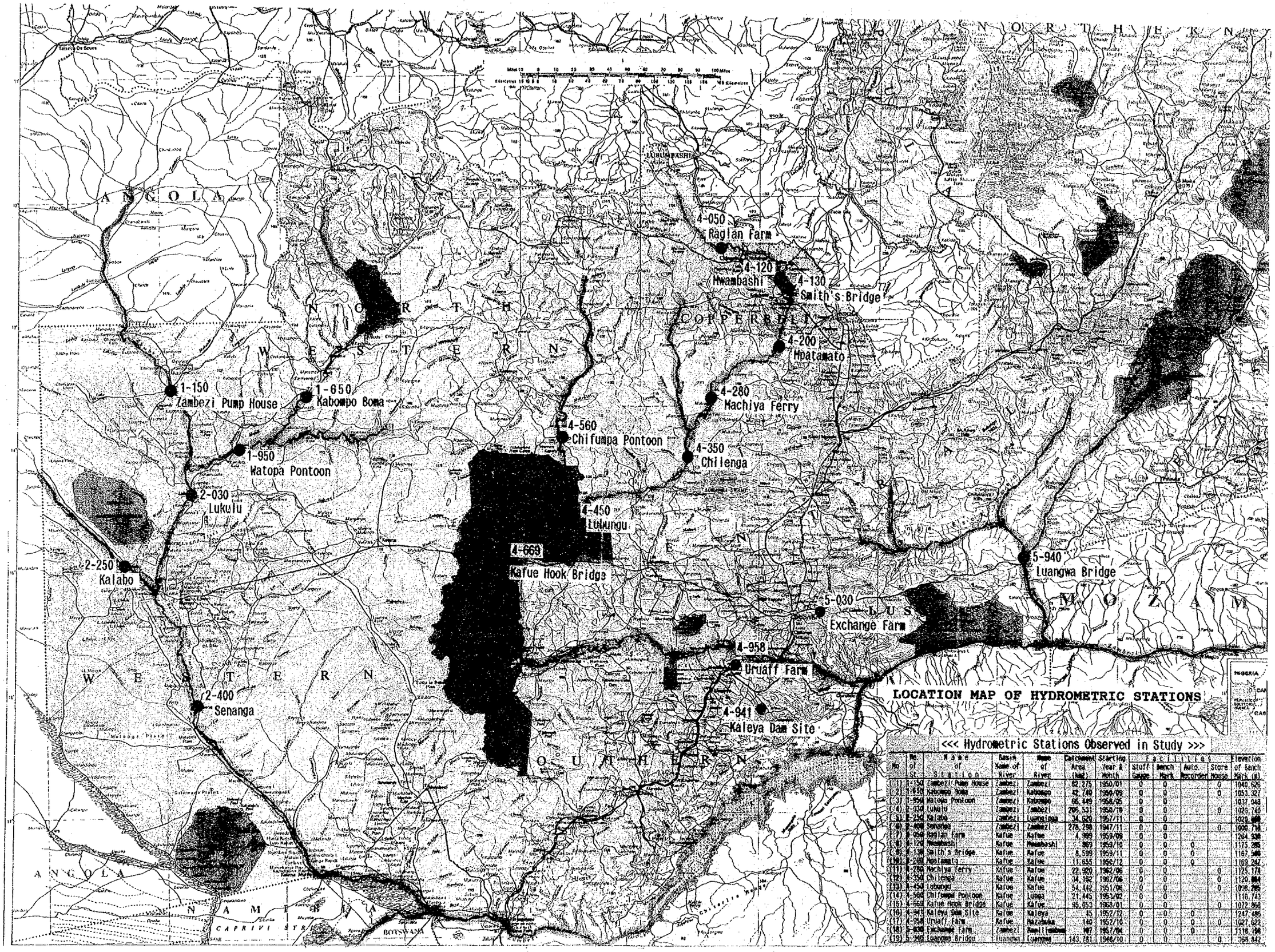


MAP OF STUDY AREA







<<< Hydrometric Stations Observed in Study >>>

No.	No. of St.	Name of Station	Basin Name of River	Name of River	Catchment Area (km²)	Starting Year & Month	Facilities: Staff Gauge	Bench Mark	Auto. Recorder	Store House	Elevation of Bench Mark (ft)
(1)	1-150	Zambezi Pump House	Zambezi	Zambezi	82,275	1950/01	0	0		0	1040.626
(2)	1-650	Kabompo Boma	Zambezi	Kabompo	42,749	1950/05	0	0		0	1053.327
(3)	1-950	Watopa Pontoon	Zambezi	Kabompo	66,449	1958/05	0	0			1037.948
(4)	2-030	Lukulu	Zambezi	Zambezi	295,531	1950/10	0	0		0	1026.749
(5)	2-250	Kalabo	Zambezi	Luanginga	34,920	1957/11	0	0			1020.668
(6)	2-400	Senanga	Zambezi	Zambezi	276,758	1947/11	0	0		0	1008.716
(7)	4-050	Raglan Farm	Kafue	Kafue	4,995	1959/09	0	0			1284.538
(8)	4-120	Mwambashi	Kafue	Mwambashi	869	1959/10	0	0	0		1175.285
(9)	4-130	Smith's Bridge	Kafue	Kafue	8,599	1959/11	0	0	0		1167.949
(10)	4-200	Mpatamato	Kafue	Kafue	11,655	1956/12	0	0	0		1169.247
(11)	4-280	Machiya Ferry	Kafue	Kafue	22,920	1962/06	0	0		0	1125.178
(12)	4-350	Chilenga	Kafue	Kafue	34,162	1962/06	0	0		0	1120.864
(13)	4-450	Lukwngu	Kafue	Kafue	54,442	1951/06	0	0		0	1098.295
(14)	4-560	Chifumpa Pontoon	Kafue	Lunga	21,445	1953/02	0	0			1116.743
(15)	4-669	Kafue Hook Bridge	Kafue	Kafue	95,053	1958/01	0	0		0	1072.956
(16)	4-941	Kaleya Dam Site	Kafue	Kaleya	45	1952/12	0	0	0		1247.486
(17)	4-958	Uruaff Farm	Kafue	Nazabuka	140	1952/10	0	0	0	0	1027.623
(18)	5-030	Exchange Farm	Zambezi	Kawilimbwa	987	1957/04	0	0	0		1118.184
(19)	5-940	Luangwa Bridge	Luangwa	Luangwa	143,761	1948/10	0	0		0	783.942

CHAPTER - 1 OUTLINE OF STUDY

(1) Outset of Study

Zambia has been dependent on copper production since the discovery of copper ore deposits. The country, however, now faces a nationwide economic difficulties due to a significant drop in copper prices in international markets since 1975. To overcome this situation, the country is seeking to diversify its domestic industries and has chosen agriculture to be the center of a national development plan. On the other hand, the population growth rate, more than three (3) percent per annum, is high and increasing rapidly. This growth rate is among the highest in the world. Such population increase will cause further serious shortage of urban and rural water. This situation requires urgent development of water resources. Existing plans of water resource development have emphasized single purpose which has been limited in scope, such as hydraulic power generation, urban water supply and irrigation. An overall scheme for developing water resources, taking into account differences in river basins, has never been produced. Regarding the hydrological observation to collect, process and archive the hydrological data for the base of water resources development plan of Zambia, the installation of hydrometric stations was started mainly from 1950's in technical cooperation with the foreign agencies led by the England. At the moment, more than 240 hydrometric stations are registered in Zambia. In fact, basic hydrologic data, essential to an overall scheme for water resource development, has not been sufficiently collected and analyzed, especially in a recent decade.

With this as a background, Zambia sought technical cooperation from Japan in February of 1987, to study the water resources potential in the major rivers and to prepare a master plan for developing these resources. In response to the Zambia's request, the Japan International Cooperation Agency (JICA) sent the preliminary study team to Zambia in November of 1988 to perform a preliminary survey, and the scope of work (S/W) of this study was discussed and agreed upon by the two countries. In December 1989, JICA dispatched the study team for " The Master Plan Study on Hydrologic Observation Systems of the Major River Basins in Zambia" (Study Team and Study respectively) according to the scope of work, and commenced the Study in conjunction with the counterpart agency, Department of Water Affairs (DWA), Ministry of Water, Lands and Natural Resources (present Ministry of Energy and Water Development).

(2) Objectives of Study

The Study, the first step in preparation of the overall plan for water resources development in Zambia, is designed to achieve the following objectives.

1) To strengthen the hydrologic observation systems in Study Area to utilize the data for future planning of water resources development.

2) To make a rough estimation of water resources potential through the study of river flow based on existing and new hydrologic data.

In addition, this study is also designed to transfer technology to the Zambian counterparts through the execution of study.

(3) Study Area

The areas covered by Study (Study Area) are the western parts of Zambia. The total catchment area of Study Area amounts about 340,000 km2 consisting of:

1) Catchment area of some 787,000 km2 along the mainstream of the Zambezi River (Area of 602,000 km2 is out of Zambia, this area is out of scope) as far as the confluence point with one of its tributaries, the Luangwa River, and

2) Catchment area of some 155,000 km2 along the Kafue River, another tributary of the Zambezi River.

The Zambezi River originates at the northwest corner of the county and, after passing through Angolian territory, flows southward in the western part of the Zambia. After forming a great flooding area (190 km in length and 40 km in average width), it reaches the boundary with Namibia. It then turns east, giving the great valley and Victoria falls (utilized for generating hydraulic power of 108 MW), flows into the Kariba Lake (big artificial lake with a total volume of 160 billion cubic meters and formed by the construction of Kariba Dam which generates as much as 1266 MW of electric power in Zasmbia and Zimbabwe and joins with its tributary, Kafue River, at Kafue Gorge. At Luangwa it accompanies another tributary, Luangwa River which originates at the country's east boundary with Tanzania and after passing through Mozanbique, flows into the Indian Ocean. The Zambezi River is an international river and its total catchment area is about 1.2 million km2. Other countries: Angola, Namibia, Botswana, Zimbabwe and Mozanbique all contain parts of the Zambezi River basin.

The Kafue River, originating from the copper belt on the boundary with Zaire, flows through the middle west portion of the country and has a total area of about 155,000 km2 and a total length of about 1,200 km. Its whole area is contained within Zambian territory. Its catchment area contains political, economic and cultural centers of the country. One third of the whole population is concentrated in this area. The Kafue river has two big dams (the Itezhi-tezhi Dam in the middle and the Kafue Gorge Dam on its lower course) to utilize the river's water resources for hydroelectric power generation. The Itezhi-tezhi Dam is a regulation reservoir for Kafue Gorge Dam. The Kafue Gorge Dam can generate 900 MW of electric power which is distributed to the capital, Lusaka, or cities in the Copperbelt to operate urban facilities.

(4) Scope and Contents of Study

The scope of this study includes systemizing and reinforcing a hydrologic observation network throughout the Study Area and clarifying the water resources potential of the Study Area.

The Study is divided into three (3) phases comprising each phase's targets as shown below. Refer to Fig.- 1.1.

<<< Phase 1 >>>
Period : Dec. 1989 - Mar. 1990

1) To establish the hydrometric reference points and hydrologic observation network.
2) To repair and/or install observation stations covered by the network. After putting facilities into place, actual observation should be made using those facilities.
3) To prepare a hydrologic database to be used for planning water resource development in the future, and feed it the necessary data.
4) To prepare a progress report (1)

<<< Phase 2 >>>
Period : May 1990 - Mar. 1991

1) To continue hydrologic observations and to transfer hydrologic techniques to Zambian counterparts. (training level)
2) To investigate water quality.
3) To analyze existing materials and observation data to comprehend the flow regime at each reference point and to study water balance of existing reservoirs.
4) To prepare an interim report summarizing the interim results, and discuss with the Zambian side.
5) To prepare a progress report (2)

<<< Phase 3 >>>
Period : May 1991 - Mar. 1992

1) To continue hydrologic observations and work to transfer hydrologic techniques to Zambian counterparts (mastery level).
2) To analyze the existing materials and observation data to reveal river flow classified by different basins so that potential water resources can be roughly estimated.
3) To prepare a master plan for hydrologic observation systems.
4) To prepare Draft Final Report summarizing the above results, and discuss Study results with Zambian side.
5) To prepare Final Report after receiving the comments on the report from the Zambian side and submit it to Zambia.

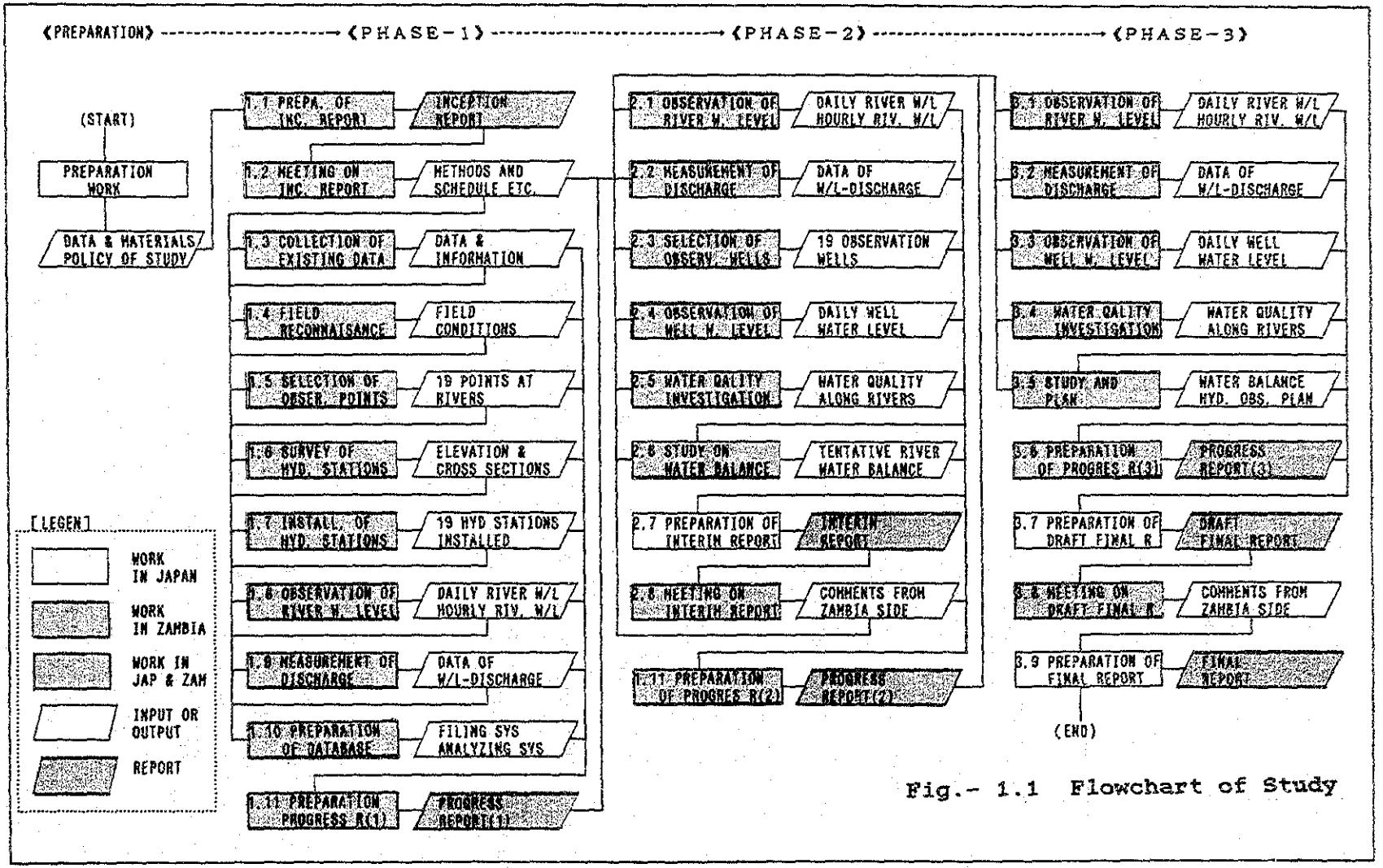


Fig.- 1.1 Flowchart of Study

(5) Work Schedule

The Study was carried out as shown in Table- 1.1.

Table-1.1 Work Schedule of Study

WORK ITEMS	'89 N	D	'90 J	F	M	A	M	J	J	A	S	O	N	D	'91 J	F	M	A	M	J	J	A	S	O	N	D	'92 J	F	M
PHASE-1	*	*	*	*	*	*	*	*	*	*																			
1.1 Inception Report	J	J	Z	Z																									
1.2 Meeting on Inc.Report			Z																										
1.3 Collection of Existing Data			Z	Z	Z	Z	Z	Z	Z																			
1.4 Field Reconnaisance			Z	Z																									
1.5 Selection of Observation Points			Z	Z																									
1.6 Survey of Hydrometric Stations				Z	Z	Z	Z	Z	Z																				
1.7 Installation of Hydrometic Stations			Z	Z	Z	Z	Z	Z	Z																				
1.8 Observation of River Water Level			Z	Z	Z	Z	Z	Z	Z																				
1.9 Flow Measurement			Z	Z	Z	Z	Z	Z	Z																				
1.10 Preparation of Database			Z	Z	Z	Z	Z	Z	Z																				
1.11 Progress Report(1)						Z	Z																						
PHASE-2								*	*	*	*	*	*	*	*	*	*	*	*	*									
2.1 Observation of River Water Level								Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z									
2.2 Flow Measurement								Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z									
2.3 Selection of Observation Wells								Z	Z	Z	Z																		
2.4 Observation of Well Water Level								Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z									
2.5 Water Quality Investigation								Z	Z	Z	Z																		
2.6 Hydrologic Analysis								Z	Z	Z	Z	Z	J	J															
2.7 Interim Report													J	J															
2.8 Meeting on Int.Report														Z	Z														
2.9 Progress Report(2)																	Z	Z											
PHASE-3																					*	*	*	*	*	*	*	*	*
3.1 Observation of River Water Level																					Z	Z	Z	Z	Z	Z			
3.2 Flow Measurement																					Z	Z	Z	Z	Z	Z			
3.3 Observation of Well Water Level																					Z	Z	Z	Z	Z	Z			
3.4 Water Quality Investigation																						Z	Z	Z					
3.5 Analysis and Plan																					Z	Z	Z		J	J	J		
3.6 Progress Report(3)																						Z							
3.7 Draft Final Report																											J	J	J
3.8 Meeting on D/F/Report																													Z
3.9 Final Report																													

<Note> JJJ:Work in Japan ZZZ:Work in Zasmbia

(6) Organization of Study

The organization of Study is as shown in Fig.-1.2.

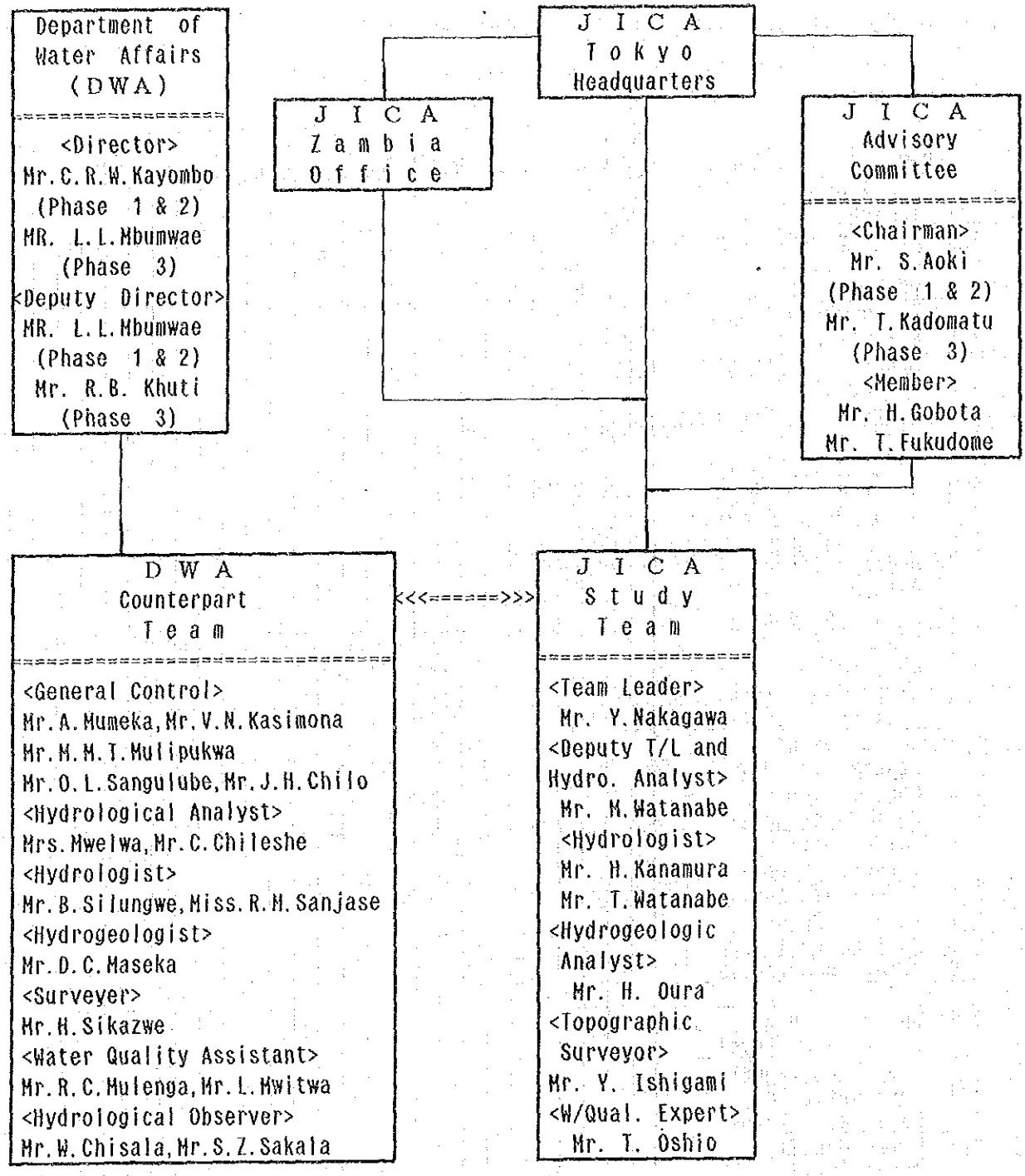


Fig.-1.2 Organization of Study

CHAPTER - 2 HYDROLOGIC OBSERVATION

2.1 Installation of Hydrometric Stations

(1) Selection of Hydrometric Observation Points

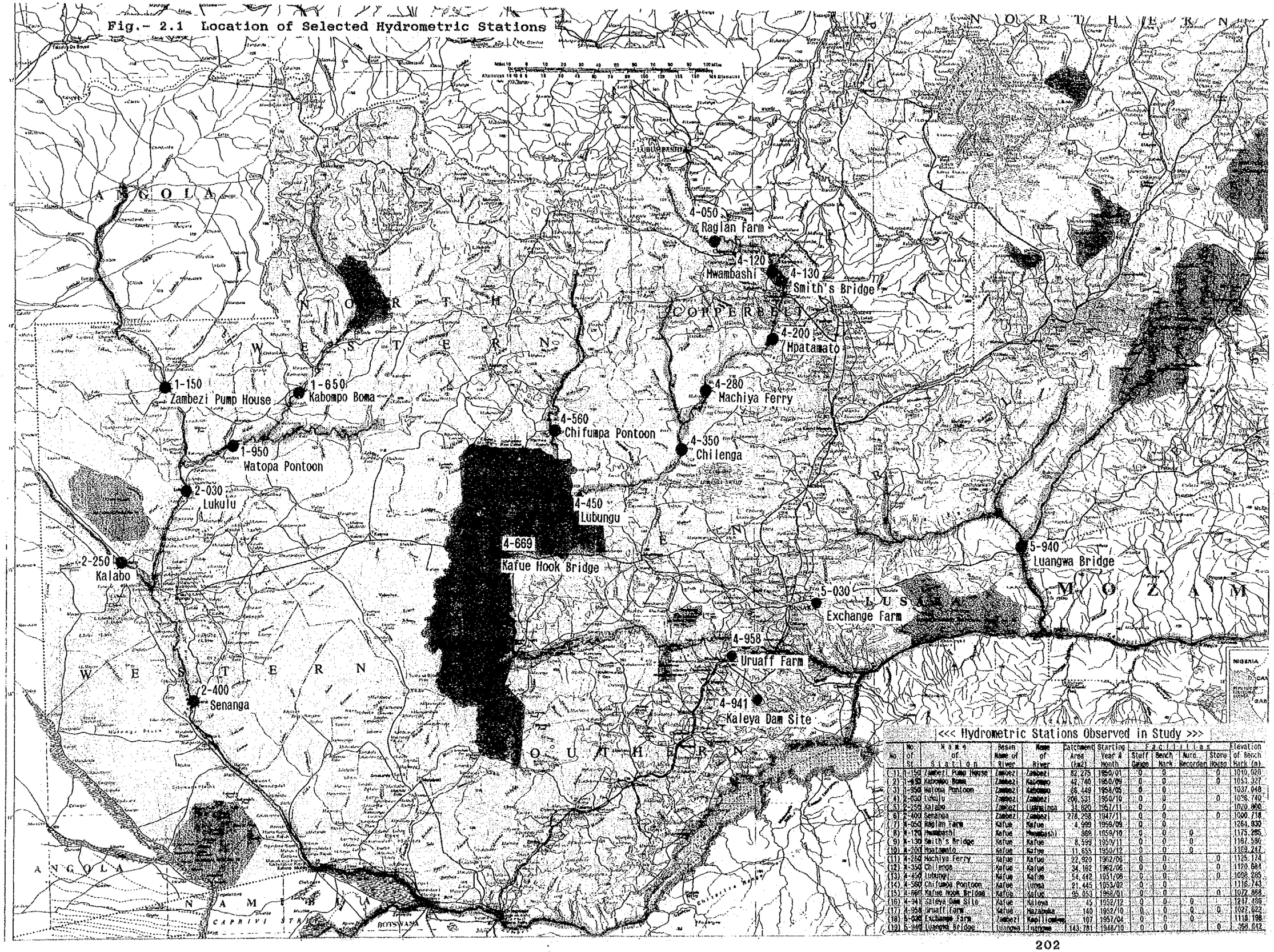
The Study Team and DWA selected the 19 hydrometric stations to be observed in this Study as shown in Table- 2.1. and Fig.- 2.1. The main points of selection criteria are as follows.

1) The stations are well located so as to comprehend uniformly the river flow pattern throughout Study Area, also the stations have long term observation data so that the long term flow pattern is estimated.
2) Kariba Dam, Itezhi-tezhi Dam, Kafue Gorge Dam, Sesheke, Victoria Falls and Luangwa should be reference points. However, no observation will be done at these points in the Study. This is because periodic data such as reservoir water level and gate operation etc. are recorded at each dam, and at the other three points flow measurement is difficult due to the reason that the international boundary lies on the river.
3) Water level recorders should be set at promising exploitation points having small catchment area, .
4) To estimate the discharge at the confluence (Zambezi and Luangwa River), observation will be carried out at St. Luangwa Bridge, though it is out of the Study Area.

Table-2.1 Hydrometric Stations Selected and Installed in Study

Hydrometric Stations	Catchment Area (km2)	Starting Year & Month	Facilities Set in Study: Stuff Gauge	Bench Mark	W/Level Recorder	Store House
1-150 Zambezi P/H	82,275	1950/01	O	O		O
1-650 Kabompo B.	42,740	'50/09	O	O		O
1-950 Watopa Pon.	66,449	'58/05	O	O		
2-030 Lukulu	206,531	'50/10	O	O		O
2-250 Kalabo	34,620	'57/11	O	O		
2-400 Senanga	278,298	'47/11	O	O		O
4-050 Raglam Farm	4,999	'59/09	O	O		
4-120 Mwambwashi	869	'59/10	O	O	O	
4-130 Smith's Br.	8,599	'50/08	O	O	O	
4-200 Mpatamato	11,655	'50/12	O	O	O	
4-280 Machiya F.	22,920	'62/06	O	O		O
4-350 Chilenga	29,008	'62/06	O	O		O
4-450 Lubungu	54,442	'51/06	O	O		O
4-560 Chifumpa P.	21,445	'53/02	O	O		
4-669 Kafue H/B	95,053	'68/01	O	O		O
4-941 Kaleya D/S	45	'52/12	O	O	O	
4-958 Uruaff Farm	140	'52/10	O	O	O	O
5-030 Exchange F.	67	'57/04	O	O	O	
5-940 Luangwa Br.	143,781	'48/10	O	O		O

Fig.- 2.1 Location of Selected Hydrometric Stations



<<< Hydrometric Stations Observed in Study >>>

No	No. of St	Name of Station	Basin Name of River	Name of River	Catchment Area (km²)	Starting Year & Month	Facilities: Staff Gauge	Bench Mark	Auto. Recorder	Store House	Elevation of Bench Mark (m)
(1)	1-150	Zambezi Pump House	Zambezi	Zambezi	82,275	1950/01	0	0		0	1010.028
(2)	1-650	Kabompo Boma	Zambezi	Kabompo	42,740	1950/09	0	0		0	1053.327
(3)	1-950	Watopa Pontoon	Zambezi	Kabompo	66,149	1956/05	0	0			1037.948
(4)	2-030	Lukulu	Zambezi	Zambezi	206,531	1950/10	0	0		0	1026.740
(5)	2-250	Kalabo	Zambezi	Luanginga	34,620	1957/11	0	0			1020.900
(6)	2-400	Senanga	Zambezi	Zambezi	278,258	1947/11	0	0		0	1000.718
(7)	4-050	Raglan Farm	Kafue	Kafue	4,999	1959/09	0	0			1264.830
(8)	4-120	Mwambashi	Kafue	Mwambashi	869	1959/10	0	0	0		1175.285
(9)	4-130	Smith's Bridge	Kafue	Kafue	8,599	1959/11	0	0	0		1161.590
(10)	4-200	Mpatamato	Kafue	Kafue	11,855	1959/12	0	0	0		1109.247
(11)	4-280	Machiya Ferry	Kafue	Kafue	22,920	1962/06	0	0		0	1125.174
(12)	4-350	Chilenga	Kafue	Kafue	34,192	1962/06	0	0		0	1120.684
(13)	4-450	Lubungu	Kafue	Kafue	54,442	1951/09	0	0		0	1092.285
(14)	4-560	Chifumpa Pontoon	Kafue	Lunsa	91,445	1955/02	0	0			1116.743
(15)	4-669	Kafue Hook Bridge	Kafue	Kafue	95,053	1968/01	0	0		0	1072.868
(16)	4-941	Kaleya Dam Site	Kafue	Kaleya	45	1952/12	0	0	0		1247.880
(17)	4-958	Uruaff Farm	Kafue	Nazabuka	140	1952/10	0	0	0	0	1027.622
(18)	5-030	Exchange Farm	Zambezi	Kapiflimbwa	107	1957/04	0	0	0		1119.198
(19)	5-940	Luangwa Bridge	Luangwa	Luangwa	143,781	1948/10	0	0		0	358.842

(2) Installation of Hydrometric Stations

The selected 19 stations installed by the Study Team and the following facilities were constructed. Refer to Table-2.1

1) Automatic water level recording station ..... 6 Stations
2) Water Level Gauge and bench bark..... 19 Stations
3) Store house ..... 10 Stations

(3) Topographic Survey

The topographic survey for the selected 19 stations was carried out. The survey includes the following:

1) Leveling Survey for Establishment of Bench Mark
2) Cross Sectional Survey of River
3) Relative Position Survey between Bench Mark & Base Point
4) Leveling Survey for Water Level Gauge

The results of leveling survey between the national Bench Mark and the new bench mark installed at each station are summarized as shown in Table- 2.2. The cross sections of the selected 19 hydrometric stations are shown in Fig.-5.9 in Chapter 5. The item 3) and 4) above were done during the construction of stations.

Table- 2.2 Result of Leveling Survey

Hydrometric Stations	National Bench Mark		Length of Leveling (km)	Elevation of River Bench Mark (m)
	Name	Elev.(m)		
1-150 Zambezi P/H	T=P6	1056.230	41.0	1040.626
1-650 Kabompo B.	T=TP28	1128.980	7.2	1053.327
1-950 Watopa Pon.	T=TP30	1110.380	62.0	1037.048
2-030 Lukulu	T=P7	1032.430	5.4	1026.740
2-250 Kalabo	B=H89	1046.000	7.9	1020.800
2-400 Senanga	B=17F7	1009.392	0.1	1000.718
4-050 Raglam Farm	B=14M30	1321.953	18.1	1264.930
4-120 Mwambwashi	B=KITWE	1205.831	12.0	1175.285
4-130 Smith's Br.	B=RM88CL	1200.269	5.0	1167.580
4-200 Mpatamato	B=E7M165	1208.594	28.0	1169.247
4-280 Machiya F.	B=E7M120	1196.963	28.0	1125.174
4-350 Chilenga	B=E7M75	1161.896	21.0	1120.684
4-450 Lubungu	B=12M120	1120.492	0.4	1098.285
4-560 Chifumpa P.	B=43M81A	1079.549	0.8	1116.743
4-669 Kafue H/B	B=19/19	1147.963	36.0	1072.868
4-941 Kaleya D/S	B=19F1	1136.021	13.8	1247.486
4-958 Uruaff Farm	B=9/19	1125.102	0.3	1027.622
5-030 Exchange F.	B=12/63	1097.606	0.1	1118.198
5-940 Luangwa Br.	B=TS289	944.570	12.0	368.289

2.2 Observation and Flow Measurement

(1) Observation Team

To collect data at the 19 stations, the following three observation teams for the Study were established: 1) Mongu Team to cover the western part of the Study Area 2) Kitwe Team to cover the northern part 3) Lusaka Team to cover the southern part.

(2) Water Level Observation and Discharge Measurement

The daily water level observation was carried out at every stations by the employed observer. The gauge reading was made twice a day, every morning (6:00) and evening (18:00). The continuous water level data was recorded at the six (6) recording stations during rainy seasons. In this Study all the flow measurement were done with the current meter method. Flow measurement with current meter was done by wading or from bridge or from boat.

(3) Observation and Measurement Data

The Study Team executed successfully the hydrologic observation mentioned above and obtained the daily water level data of 19 stations and the recording water level data of 6 recording stations. These data was converted into discharge using the rating curves established in the Study. Flow measurement data obtained in this Study is summarized as shown in Table-2.3.

Table-2.3 Number of Flow Measurement Data

Stations	Before Study	<-- During Study Period --> 1989/90	1990/91	1991/92	Total	Team in Charge
1-150 Zambezi P/H	0	5	7	2	14	Mongu
1-650 Kabompo Boma	0	5	7	2	14	Mongu
1-950 Watopa Pontoon	173	7	7	2	16	Mongu
2-030 Lukulu	0	5	7	2	14	Mongu
2-250 Kalabo	45	5	6	1	12	Mongu
2-400 Senanga	2	4	8	2	14	Mongu
4-050 Raglam Farm	127	2	8	2	12	Kitwe
4-120 Mwambashi	186	4	8	2	14	Kitwe
4-130 Smith's Bridge	226	3	8	2	13	Kitwe
4-200 Mpatamato	368	3	8	2	13	Kitwe
4-280 Machiya Ferry	261	3	7	2	12	Kitwe
4-350 Chilenga	220	2	6	2	10	Kitwe
4-450 Lubungu	216	3	7	2	12	Lusaka
4-560 Chifumpa Pont.	54	3	5	2	10	Lusaka
4-669 Kafue Hook Br.	75	3	7	2	12	Lusaka
4-941 Kaleya Dam/S	15	2	5	2	9	Lusaka
4-958 Uruaff Farm	11	1	4	2	7	Lusaka
5-030 Exchange Farm	22	2	5	2	9	Lusaka
5-940 Luangwa Bridge	133	3	7	2	12	Lusaka
< Total >	2134	65	127	37	229	

CHAPTER - 3 WELL OBSERVATION

3.1 Selection of Observation Wells

To clarify the relationship between the river water level and shallow groundwater level, 19 observation wells shown in Table-3.1 were selected near the hydrometric stations.

One well was designated near hydrometric station, but around 2 hydrometric stations: St. Lubungu and St. Luangwa Bridge, there is no available well. The locations of wells are shown in Fig.-3.1.

Table-3.1 List of Observation Wells

Observation Well	Hydrometric Stations	Diameter(m)	Depth (m)	Distance btw Well & St.
(1) Kanylilaba	1-150 Zambezi	1.30	11.77	8.50 km
(2) Kanyayibma	1-650 Kabompo B	1.30	14.00	6.00 km
(3) Watopa	1-950 Watopa P	1.30	11.79	0.80 km
(4-1) Luanchama	2-030 Lukulu	1.40	3.66	7.00 km
(4-2) Lishawa	2-030 Lukulu	1.30	4.20	30.00 km
(5) Machatanga	2-250 Kalabo	1.40	3.29	4.20 km
(6-1) Milne Farm	2-400 Senanga	1.30	2.21	4.10 km
(6-2) Litoya	2-400 Senanga	1.30	4.35	20.00 km
(7) Kansofu	4-050 Raglam Farm	1.30	7.99	9.10 km
(8) Mwambashi	4-120 Mwambashi	1.00	4.82	0.07 km
(9) Kabulanda	4-130 Smith's B.	1.00	5.36	0.70 km
(10) Mpatamato	4-200 Mpatamato	0.50	1.60	0.54 km
(11) Machiya	4-280 Machiya F	0.98	6.33	0.35 km
(12) Chilenga	4-350 Chilenga	1.30	2.25	1.50 km
(14) Lupemba	4-560 Chifumpa P	1.20	10.81	30.00 km
(15) Kafue H/B	4-669 Kafue F/B	5.15	7.54	0.50 km
(16) U Kaleya Dam	4-941 Kaleya D/S	1.40	10.50	6.50 km
(17) Uruaff Farm	4-958 Uruaff Farm	1.20	4.50	1.60 km
(18) Mutamina	5-030 Exchange F	1.20	3.90	0.60 km

3.2 Observation of Well Water Level

The well water level is measured two times a day, every morning and evening by the observer employed at each observation well. Measurement time in morning is fixed at 6:00 hour and evening at 18:00 hour.

Table-3.2 shows the monthly mean well water level and river water level at the hydrometric station .

Well No.	NAME	Dia.(m)	Depth(m)	Elo.(m)	Hydrometric St.	Dis.(km)
1	Kanyilaba	1.30	11.77	1068.55	1-150 Zambezi	8.50
2	Kanyayimba	1.30	14.00	1074.33	1-650 Kabompo	6.00
3	Watopa	1.30	11.79	1038.96	1-950 Watopa P.	0.80
4-1	Luanchama	1.40	3.66	1046.90	2-030 Lukulu	7.00
4-2	Lishawa	1.30	4.20	1062.00	2-030 Lukulu	30.00
5	Machatanga	1.40	3.2	1031.92	2-250 Kalabo	4.20
6-1	Milne Farm	1.30	2.21	1024.21	2-400 Senanga	4.10
6-2	Litoya	1.30	4.35	1038.21	2-400 Senanga	20.00
7	Kansofu	1.30	7.99	1305.96	4-050 Raglan F.	9.10
8	Hwambashi	1.00	4.82	1179.51	4-120 Hwambashi	0.07
9	Kabulanda	1.00	5.36	1176.10	4-130 Smith's B.	0.70
10	Hpatamato	0.50	1.60	1170.80	4-200 Hpatamato	0.54
11	Machiya F.	0.98	6.33	1128.65	4-280 Machiya F.	0.35
12	Chilenga	1.30	2.25	1120.65	4-350 Chilenga	1.50
14	Lupemba	1.20	10.81	1147.00	4-560 Chifumpa	30.00
15	Kafue H/B	5.15	7.54	1075.48	4-660 Kafue H/B	0.50
16	U.kaleya Dam	1.40	10.50	1319.40	4-941 Kaleya D/S	6.50
17	Urnaff Farm	1.20	4.50	1031.12	4-958 Urnaff F.	1.60
18	Mutamina	1.20	3.90	1120.27	5-030 Exchange F	0.60

Fig.-3.1 Location Map of Observation Wells

Table-3.2 Monthly River Water Level and Well Water Level

No.	Stations			JUN'90	JUL	AUG	SEP	OCT	NOV	DEC	JAN'91	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	A/AVG
	1-150 Zambezi P/H	River	Mean	2.05	1.43	1.07	0.72	0.58	0.58	1.18	3.07	7.73	6.39	5.56	3.10	1.76	1.17	0.79	0.62	2.36
(1)	KANYILABA	Well	Morning	35.02	34.62	34.03	33.54	33.10	32.69	32.38	32.87	36.17	36.91	36.94	36.39	35.80	35.14	34.46	33.91	34.62
		Well	Evening	34.79	34.28	33.62	33.09	32.72	32.23	32.05	32.64	36.04	36.78	36.77	36.19	35.47	34.68	34.04	33.33	34.29
	1-650 Kabompo Boma	River	Mean	2.01	1.84	1.75	1.63	1.59	1.54	1.88	2.57	3.21	3.16	2.92	2.20	1.99	1.91	1.84	1.70	2.11
(2)	KANYAMBU	Well	Morning	15.56	THERE WAS NO SUFFICIENT PERSON FOR							15.36	15.76	15.74	15.51	15.37	15.21	14.98	14.78	13.83
		Well	Evening	15.56	READING TAPE.							15.30	15.57	15.43	15.36	15.13	14.77	14.53	14.10	13.57
	1-950 Matopa Pontoon	River	Mean	2.22	2.05	1.94	1.78	1.73	1.68	2.05	3.37	4.66	3.99	3.69	2.53	2.38	2.27	1.95	1.79	2.51
(3)	MATOPA PONTOON	Well	Morning	2.24	2.09	1.94	1.74	1.57	1.37	1.21	1.19	1.98	2.33	2.33	2.17	1.96	1.78	1.57	1.37	1.80
		Well	Evening	2.11	2.09	1.94	1.74	1.57	1.36	1.22	1.20	1.99	2.33	2.32	2.17	1.95	1.77	1.57	1.37	1.79
	2-030 Lukulu	River	Mean	1.48	1.05	0.83	0.62	0.58	0.57	0.99	2.34	4.96	4.48	3.68	2.65	1.61	0.90	0.71	0.53	1.76
(4-1)	LUANCHUMA	Well	Morning	27.19	27.11	26.98	26.74	26.66	26.55	26.71	27.88	28.28	28.19	27.94	27.64	27.46	27.36	27.25	27.05	27.31
		Well	Evening	27.19	27.10	26.97	26.70	26.53	26.36	26.62	27.85	28.23	28.11	27.85	27.50	27.34	27.28	27.16	26.98	27.24
(4-2)	LISHUWA	Well	Morning	42.08	41.96	41.84	41.69	41.44	41.36	41.48	42.11	42.73	42.56	42.39	42.11	41.99	41.78	41.67	41.42	41.91
		Well	Evening	41.26	41.15	41.00	40.94	40.76	40.68	41.08	41.79	42.36	42.21	42.10	41.71	41.44	41.40	41.13	41.06	41.38
	2-250 Kalabo	River	Mean	1.91	1.40	1.00	0.77	0.58	0.39	0.39	0.55	1.59	3.04	2.76	2.15	1.70	1.28	0.97	0.69	1.35
(5)	MUCHATANGA	Well	Morning	13.28	13.27	13.27	13.24	13.17	13.22	13.25	13.51	14.13	14.05	14.09	13.75	13.73	13.96	13.50	13.27	13.54
		Well	Evening	12.99	13.01	12.95	12.92	12.91	12.87	12.93	13.52	13.93	13.62	13.71	13.22	13.40	12.65	12.95	12.65	13.14
	2-400 Senanga	River	Mean	2.51	1.45	1.02	0.76	0.66	0.62	0.94	1.71	3.02	4.17	4.00	3.58	2.24	1.24	0.95	0.74	1.85
(6-1)	MILWE FARM	Well	Morning	23.02	23.01	22.99	22.92	22.85	22.80	23.01	23.09	23.45	23.37	23.29	23.23	23.22	23.21	23.18	23.08	23.11
		Well	Evening	23.02	23.01	22.98	22.91	22.84	22.79	23.01	23.08	23.44	23.37	23.29	23.23	23.22	23.21	23.18	23.08	23.10
(6-2)	LITOYA	Well	Morning		36.34	36.35	36.31	36.32	36.33	36.32	36.32	36.32	36.31	36.32	36.18	36.21	35.91	36.07	36.31	36.26
		Well	Evening		36.07	36.00	35.90	35.90	35.90	35.92	35.97	35.95	35.97	36.16	35.97	35.91	35.57	35.79	36.13	35.94
	4-050 Raglan Farm	River	Mean	1.33	0.89	0.69	0.51	0.42	0.40	0.55	1.37	3.00	3.24	3.02	2.01	1.27	0.93	0.76	0.56	1.31
(7)	KANSOFU	Well	Morning	41.66	41.55	41.31	41.10	40.84	40.59	40.59	41.49	42.70	42.73	43.50	42.89	42.40	42.16	41.90	41.77	41.92
		Well	Evening	41.67	41.50	41.25	40.99	40.71	40.40	40.44	41.38	42.70	42.74	43.52	42.88	42.38	42.13	41.92	41.73	41.77
	4-120 Mwambashi	River	Mean	1.02	0.91	0.86	0.78	0.69	0.67	0.96	2.23	2.66	2.63	2.13	1.36	1.04	0.97	0.96	0.87	1.30
(8)	MWAMBASHI	Well	Morning	7.15	6.82	6.58	6.38	6.19	6.02	5.97	7.82	8.61	8.45	8.32	7.92	7.61	7.34	7.34	6.76	7.20
		Well	Evening	7.14	6.81	6.57	6.38	6.18	6.03	5.93	7.83	8.60	8.44	8.31	7.94	7.61	7.34	7.34	6.76	7.20
	4-130 Smith's Bridge	River	Mean	2.76	1.51	1.24	1.04	0.91	0.86	1.27	3.45	4.81	5.01	4.44	3.13	2.15	1.72	1.45	1.15	2.31
(9)	KABALANDA	Well	Morning	10.30	10.22	9.90	9.73	9.42	9.39	9.89	11.35	12.79	12.32	12.07	11.12	10.58	10.35	10.11	10.03	10.60
		Well	Evening	10.26	10.16	9.86	9.69	9.39	9.39	9.87	11.37	12.77	12.31	12.05	11.10	10.56	10.34	10.07	10.00	10.57
	4-200 Mpatamato	River	Mean	1.42	1.02	0.75	0.61	0.53	0.49	1.20	3.62	5.09	4.45	3.74	2.42	1.66	1.26	1.03	0.76	1.88
(10)	MPATAMATO	Well	Morning	5.57	5.57	5.57	5.57	5.95	6.62	6.62	6.62	6.62	6.62	6.62	6.60	6.56	6.24	5.55	5.47	6.15
		Well	Evening	5.53	5.53	5.53	5.53	5.95	6.62	6.62	6.62	6.62	6.62	6.62	6.60	6.50	6.01	5.54	5.41	6.11
	4-280 Machiya Ferry	River	Mean	3.08	2.70	2.57	2.42	2.32	2.17	2.53	4.52	6.59	5.89	5.55	3.99	3.20	2.89	2.73	2.55	3.48
(11)	MACHIYA FERRY	Well	Morning	2.70	2.40	1.92	1.54	1.48	1.46	1.43	2.68	4.78	4.89	4.87	4.39	3.84	3.27	2.82	2.44	2.93
		Well	Evening	2.56	2.25	1.74	1.51	1.45	1.46	1.42	2.69	4.77	4.88	4.84	4.36	3.74	3.19	2.74	2.32	2.87
	4-350 Chilenga	River	Mean	2.18	1.63	1.36	1.17	1.03	0.94	1.27	3.37	5.38	5.42	5.19	3.66	2.39	1.96	1.61	1.28	2.48
(12)	CHILENGA	Well	Morning	5.82	5.62	5.22	5.20	4.99	4.74	5.67	6.31	6.55	6.85	6.68	6.33	6.06	5.82	5.61	5.36	5.80
		Well	Evening	5.79	5.59	5.22	5.17	4.95	4.72	5.66	6.31	6.66	6.85	6.66	6.32	6.04	5.79	5.59	5.34	5.79
	4-560 Chifunpa Pon.	River	Mean	0.72	0.62	0.55	0.45	0.40	0.34	0.49	1.30	2.37	1.83	1.43	0.87	0.69	0.60	0.53	0.45	0.85
(14)	LUPEMBA	Well	Morning		32.51	32.24	31.48	30.84	30.57	31.04	34.33	35.24	34.95	34.59	33.83	33.11	32.63	32.28	31.79	32.16
		Well	Evening		32.27	31.79	30.91	30.40	30.39	30.90	34.34	35.22	34.97	34.54	33.78	33.04	32.52	32.02	31.63	32.58
	4-669 Kafue Hook B.	River	Mean	1.99	1.81	1.72	1.63	1.55	1.49	0.49	0.73	3.02	3.01	2.82	2.34	2.02	1.84	1.77	1.67	1.87
(15)	KAFUE HOOK BRIDGE	Well	Morning		5.27	5.00	4.97	5.02	4.93	5.26	5.98	6.16	6.16	5.92	5.60	5.23	5.24	5.00	4.97	5.38
		Well	Evening		4.63	4.39	4.31	4.41	4.34	4.77	5.42	5.68	6.52	6.56	6.24	5.87	5.88	5.64	5.61	5.35
	4-941 Kaleya D/S	River	Mean	0.37	0.36	0.35	0.35	0.34	0.35	0.34	0.34	0.37	0.36	0.31	0.34	0.34	0.34	0.33	0.34	0.35
(16)	UPPER KALEYA DAM	Well	Morning	73.99	73.35	72.58	72.33	71.69	71.65	71.48	72.47	72.75	72.71	72.34	71.43	70.85	70.35	70.02	69.76	71.86
		Well	Evening	73.93	73.26	72.49	72.01	71.34	71.33	71.21	72.12	72.45	72.40	72.10	71.20	70.56	70.10	69.81	69.40	71.61
	4-958 Uruaff Farm	River	Mean	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
(17)	URUAFF FARM	Well	Morning	8.18	7.89	7.39	6.87	6.74	6.67	5.96	6.73	7.03	7.05	6.96	6.93	6.94	7.02	6.36	6.20	6.93
		Well	Evening	8.16	7.88	7.34	6.87	6.80	6.79	6.18	6.74	7.17	7.13	7.18	7.19	7.18	7.19	6.35	6.20	7.02
	5-030 Exchange Farm	River	Mean	0.09	0.07	0.06	0.02	0.07	0.00	0.05	0.45	0.40	0.26	0.18	0.11	0.09	0.09	0.09	0.05	0.13
(18)	MUTAMINA	Well	Morning	1.81	1.80	1.78	1.82	1.71	1.68	1.63	2.01	2.36	1.97	2.01	1.89	1.72	1.83	1.77	1.73	1.85
		Well	Evening	1.73	1.75	1.78	1.80	1.70	1.66	1.62	2.02	2.37	1.96	2.02	1.89	1.72	1.83	1.77	1.73	1.83

Water Level: Height from zero-point at each hydro. station