APPENDICES

Observation Report for the Hydroelectric Power Stations

OBSERVATION REPORTS

FOR

THE HYDROELECTRIC POWER STATIONS

(AUGUST, 1994)

CONTENTS

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This observation reports had been prepared according to the site reconnaissance by a study member(Hydro-Power Development) during May to August 1994 in the study period.

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1. MUSONDA FALLS POWER STATION

(1) **Date visited:** 9th July 1994, 9:00-13:00

(2) **Access:** The access to power station and downstream dam located near main road was no objective. The access to upstream dam located 10km from downstream dam was slightly difficult.

(3) **Upstream dam:** The upstream dam was designed by the foreign consultant and constructed by Zambia 20 years ago. This dam existed in order to store the flow and formulated as follows:

1) Spill way and outlet made by concrete with about 300m long.
2) Both bank of dam was made by earth fill dam.
3) Dam height was about 5m.
4) Discharge to the downstream dam was controlled by the slide-gate mounted on outlet.

The water reservoir area of reservoir was very broad (Probably 3-5 km^2) and the height of reservoir was low, so that reserve capacity was not so large. Accordingly, the reservoir shall be dried-up in dry season. At the observation, the water was filled in reservoir from upstream flow.

The concrete dam had thickness of only 1m so that defect of structure existed. In the fact, the cracks existed in everywhere so that water was leaked. The repair and reinforcement of dam shall be required, otherwise the dam shall be collapsed in near future.

(4) **Downstream dam:** The traffic road ran on the crest which length was 200m. The water intake for generation existed on the right bank of the dam. The fall existed at 100m from downstream of the dam.

(5) **Water conduction channel:** A water conduction channel between the water intake and storage tank was open channel and 1km long. The water level inside water conduction channel was almost full. The maintenance condition was excellent.

(6) **Storage tank:** A storage tank and a spill way existed. The maintenance condition was excellent.

(7) **Penstock:** Five penstocks existed. The maintenance was excellent.

(8) **Power station:** Five hydro-machines existed in a building.

Unit No.	Type	Capacity (MW)	Comm. Year
1	HF	1	1960
2	"	1	1960
3	"	1	1973
4	"	1	1973
5	"	1	1984
Total		5	

HF: Horizontal Francis

The design data and available data were as follows.

Item	Design	Available	Remarks
Discharge (m^3/s)	21	16	See Note
Effective head (m)	30	30	See Note

(Note): Available discharge of $16m^3/s$ existed in June 1994. Available discharge was $0m^3/s$ during the past September to November in every year so that no electricity was generated.

The maintenance condition was excellent . The space area existed for future building.

(9) **Substation:**

The generated voltage was stepped-up to 33kV in the substation. A 33kV line ran to 66kV substation located in the opposite bank of the river.

This power station was interconnected to the national network throughout 33/66 kV substation.

(10) **Availability of as built drawings and design data:** Not available.

(11) **Prospects for renovation plan:**

1) In order to increase capacity in the reservoir, the new dam will be proposed at the intermediate between upstream dam and downstream dam. Consequently, the capacity will be increased to 3 or 5 times from original dam. In this case, the upstream dam shall be under the water.

2) The existing power station will generate the rated capacity to utilise previous design discharge ($21m^3/s$) from the existing intake.

3) The existing civil structures such as downstream dam, intake, channel, tank, penstock and power house will be used without any modifications.

2. **CHISHIMBA FALLS POWER STATION**

(1) **Date visited:** 10th July 1994, 9:00 - 12:00

(2) **Access:** No objection to power station and dams.

(3) **Upstream dams:** The upstream dam was constructed for new 4 x 1, 200kW generation. The water intake for generation existed on the left bank the dam.

(4) **Downstream dam:** The down stream dam constructed for original 4 x 300 kW generation. The water intake for generation existed on the left bank of the dam. The Chishimba Falls as a national monument existed between the downstream dam and the power station.

(5) **Water conduction channel:** A 2m diameter conduit pipe for new generation existed and its length was 1.4 km between the upstream dam and the surge tank. An open trench with 2.5m width for original generation existed and it's length was 1.2 km between the downstream dam and storage tank. The maintenance condition for both channels were excellent.

(6) **Surge tank and storage tank:** Not observed

(7) **Penstock:** Four penstock existed. The maintenance condition was excellent.

(8) **Power station:** Eight hydro-machines existed in a building.

Unit No.	Type	Capacity (MW)	Comm. Year
1	HF	0.3	1960
2	"	0.3	1960
3	"	0.3	1960
4	"	0.3	1960
5	"	1.2	1970
6	"	1.2	1970
7	"	1.2	1970
8	"	1.2	1970
Total		6	

HF: Horizontal Francis

The design and available data were as follows: The maintenance condition was excellent.

Item	Unit No.	Design	Available	Remarks
Discharge (m^3/s)	1 - 4	2.0	1.7	See note
	5 - 8	6.5	3.4	
Effective Head (m)	1 - 4	66	66	
	5 - 8	76	76	

Note: Available discharge was at the peak generation as of 9th July, 1994.

(9) **Substation:** The generation voltage was stepped-up to 33kV and delivered to Kasama substation. Also a 66kV substation existed, but it was not connected to the generation. This power station was not interconnected to national net work.

(10) **Availability of as-built drawings and design data:** Not observed

(11) **Prospect for extension plan:**

1) As Chishimba Falls is one of Zambia's significant natural monuments, the generating extension plan is not considered at this stage.

2) In the upstream of river, to construct a dam with large capacity and high crest is difficult because the ridge of both bank was low. Accordingly, the expansion of power generation is not realistic.

3) As Chishimba Falls Power Station is not interconnected to National network, I recommend to develop the interconnection throughout the existing 66kV substation located in the power station.

3. LUSIWASI POWER STATION

(1) **Date visited :** 22nd and 23rd July1994

(2) **Access:** The access road (distance 52 km) and the bridge rehabilitation work has not yet been carried out so that access was very bad. The access from the storage tank to the power station along to penstock (about 500m fall) was used by a 10 ton trolley. Another access did not exist to power station.

(3) **Upstream dam (Lusiwasi dam):** Lusiwasi dam was located at about 81km upstream from the existing power station. This dam completed in 1970 have main dam (crest length: 300m, height: 7m) made by rock fill and concrete and coffer dam made by earth. Five manual operated gates existed and any time closed so that water was not flowing into Lusiwasi river. In the dry season, the water level of the dam was down 5m.

(4) **Downstream dam (weir dam):** This weir dam completed in 1969 was located about 5km upstream from the existing power station. The crest length was 42m. The crest height was not enough so that the water was spilled way. ZESCO is studying about the 1.5m tall-up. The water intake for generation existed on the left bank of the dam. The intake gate was remote controlled from power station.

(5) **Water conduction channel:** An open trench (W: 2.5m, D: 2.5m) water conduction channel ran from water intake to storage tank and it's length was 1.5m. A flow gauge existed but not calibrated. The water level was one third in every dry season. The maintenance condition was excellent.

(6) **Storage tank:** A storage tank and a spill way existed. The capacity of storage tank was small so that the water was spilled way.

(7) **Penstock:** Two penstock existed. The length was 2.5km and diameter was 1m. The maintenance condition was good. In order to pass a valley (Length : 300m, Height : 30m),the penstocks were laid on the bridge.

(8) **Power station:** Four Hydro-machines existed in a building.

Unit No.	Type	Capacity (MW)	Comm. Year
1	P	3	1970
2	P	3	1970
3	P	3	1975
4	P	3	1975
Total		12	

P: PELTON

The design data and available data were as follows:

Item	Design	Available	Remarks
Discharge (m^3/s)	0.719/Unit	1.5, 3	See note
Effective head (m)	500	500	

(Note) 1.5: four units in dry season 3: four units in rainy season

No.1 and No.4 units were stopped due to lack of water. The maintenance conditions was very excellent. The installed capacity of the power station 12 MW, was unable to meet the Lusiwasi system peak demand and some load shedding was carried out during every dry season .

At the present, the above problem was solved since Serenje (Pensulo) 330/66kV substation was commissioned in 1994. Because, the Lusiwasi power station was interconnected to national network throughout this substation.

(9) **Substation:** The generated voltage was stepped-up to 66kV. Two lines of 66kV national grid from Pensulo 330/66kV substation were connected. One line of 66kV to Msoro and Chipata was connected. One line of 132kV to Msoro commissioned in 1992 was connected and it was used in 66kV for the time being. The maintenance condition was excellent.

(10) **Availability of as built drawings and design data:** Not observed.

(11) **Observation of proposed new dam:** We could not observe the exactly site of the proposed new dam which is located in few km downstream a confluence of Lusiwasi and Luangala Rivers, which was mentioned in the FINNIDA power system master plan (1984 - 2004) as we could not fined the access. However, we could observe the site which was a confluence of two rivers, Lusiwasi and Luangala. Even in the dry season, the flow in the Lusiwasi and Luangala river was rich.

(12) **Prospect for extension plan:**

1) I have considered that the extension to the existing power station will be system reinforcement in the Eastern and Northern Provinces. That is, it is important to increase the capacity and improve the reliability of power supply in the Eastern and Northern provinces even though the network was already interconnected throughout Serenje 330/66kV substation.

2) I have supposed that the capacity of extension power plant will be addition 26MW at the present site if flow could be increased from 3 m^3/s to 6.5 m^3/s and the effective head could be 500m.

4. KARIBA NORTH POWER STATION

(1) **Date visited:** 29th July 1994, 9:30 - 12:30

(2) **Access:** No objection

(3) **Dam and intake:** The design data is as follows:

- Max. lake level: 489.2m
- Min. lake level: 475.5m

The lake level was about 480m. The water intake for generation was located in the left bank of the lake and four gates existed. The space of gates for future No. 5 and No. 6 generating unit existed.

(4) **Penstocks:** Four penstocks (one penstock per each generating unit) were installed under ground. According to the civil drawings, the design data was as follows.

- Nominal diameter: 6.75m
- Length: 250m

(5) **Power station:** The access to power station located in the underground was by car through tunnel. Four vertical Francis turbine existed. No.2 machine was proceeding periodical maintenance since one month ago and it will be completed after few days. The design data was as follows:

- Nominal head: 90m
- Nominal flow per unit: 186 m^3/s

The future space for No.5 and No. 6 units existed in an existing power station building. The excavation of No. 5 and No.6 turbines foundation was suspended. The maintenance condition was excellent.

(6) **Transformer bank:** 17.1/330kV and 167 MVA (3 phases) step-up transformers (one each generator) existed on the ground. The 330kV cables were connected to

330kV substation. The future space for No.5 and No. 6 units existed on the transformer bank.

(7) **Kariba North extension:** The further progress of the extension plan proposed by FINNIDA power system master plan (1984 - 2004) is suspended depending on the relationship between Zambia and Zimbabwe.

5. VICTORIA FALLS POWER STATIONS

(1) **Date visited:** 30th July 1994, 8:30 - 11:00

(2) **Access:** The access from storage tank to "A", "B" and "C" power stations along to penstock for "A" power station (about 100m fall) was used by 7.6 ton trolley. Another access did not exist to power stations.

(3) **Intake:** The method of generation was run-off river type. Dam or diversion weir did not exist. The flow was directly conducted from Zambezi river to the intakes located upstream 100m from Victoria Falls. Two intakes existed, one was for "A" and "C" power stations and another one was for "B" power station.

(4) **Water conduction channel:** For "A" and "C" power stations, a common covered channel (L: 261m, W: 8m) under the ground and two open channel (L: 195m, W: 2.7m for "A" power station and L: 586m, W: 2.7m "C" power station) existed. For "B" power station, a covered channel (L: 248m, W: 4.5m) and an open channel (L: 536m, W: 3.7m) existed.

(5) **Storage tanks:** Three storage tanks for "A", "B" and "C" power stations existed.

(6) **Penstocks:** For "A" power station, three penstocks existed. No. 1 and No. 2 hydro-machines used a common penstock. No.3 and No.4 hydro-machines used an each penstock. For "B" power station, three penstocks existed. Two hydro-machines used a common penstock. For "C" power station, four penstocks existed. One Hydro-machine used one penstock.

(7) **Power stations:** Three power stations "A", "B" and "C" existed. Total installed capacity was 108MW.

Item	"A"	"B"	"C"
Comm. Year	1937	1968	1972
Building	ON GROUND	UNDER GROUND	ON GROUND
Capacity (MW)	8 3MW x 2 UNITS 1MW x 2 UNITS	60 10MW x 6 UNITS	40 10MW x 4UNITS
Type	HF	HF	HF
Nominal Discharge (m^3/s)	10.5	63.9	42.8
Nominal Effective Head (m)	105.77	105.77	105.77

HF: Horizontal Francis

The hydro-machines No. 1 and No. 2 in "A" power station and No. 2 in "B" power station stopped due to repairing. Particularly the control panels in "A" power station are ancient, however the maintenance condition was excellent.

(8) **Substations:** Not observed

(9) **Prospect for extension plan:**

1) "A" power station is very old, past 60 years. Consequently, the machine availabilities is about 60% according to ZESCO Annual Report 1990/91. The installed capacity "A" power station is 8MW. At the present, the capacity is decreased to 4.8MW. I suppose that the capacity can be increased to 8 MW by replacement of new hydro-machines but only 3.2 MW recovery is not attractive.

2) As Victoria Falls is one of the World's most significant natural monuments, the generating extension plan is not considered at this stage.

6. KAFUE GORGE POWER STATION

(1) **Date visited:** 9th June 1994, 10:00 - 12:00

(2) **Access:** No objections.

(3) **Dam and intake:** The Kafue Gorge dam comprised an earth-rockfill dam with a gated spillway. The outline of Dam was as follows:

1) Crest length: 375m
2) Crest width: 9m
3) Max. height: 50m

The reservoir capacity was 700 Mm^3. The intake was located on the right bank of the dam.

(4) **Headrace:** 10 km long headrace tunnel, surge gallery, penstock intakes and six vertical penstocks were installed.

(5) **Power station:** The machinery hall, transformer hall, control room and lift were located underground. The outline of hydro-machine was as follows:

1) Installed capacity: 150MW x 6 Units
2) Type: Vertical Francis
3) Gross head: 397m
4) Max. flow utilised: 252 m^3/s

No.5 and No.6 units stopped due to fire of 17.5kV cables between generators and step-up transformers inside cable shaft in 1989. After that, the restoration of these units was carried out.

(6) **Prospect for extension plan:** The feasibility study is proceeding by USA consultant to the Kafue Gorge lower plant (stage III) installed capacity 150MW x 3.

7. ITEZHI - TEZHI DAM

(1) **Date visited:** 13 July, 1994, 13:00 - 15:00

(2) Access: No objection

(3) **Dam:** The outline of the reservoir created by the Itezhi Tezhi dam was as follows:

1) Reservoir capacity: 5,000Mm^3
2) Max. height: 65m
3) Main dam was earth-rockfill structure
4) Two diversion tunnels, each of a cross-sectional area of 190m^2. One tunnel for the release of the regulated water, the other may serve as headrace for a future power plant.
5) Spill way was designed for a discharge of 4,200 m^3/s.
6) An emergency spillway was provided.
7) Completed year: 1976.

(4) **Prospect for extension plan:** According to FINNIDA power system master plan (1984-2004), an installation of 80MW had been proposed to utilize the head available at the dam. Because of the seasonal variations of the reservoir level, only 55 MW was considered as firm capacity. The progress of this plan is suspended due to financial matter.

8. MITA HILLS DAM AND LUNSEMFWA POWER STATION

(1) **Date visited:** 26th July 1994, 12:00 - 17:00

(2) **Access:** The access from Kabwe town to Mita Hill dam was earth road 92km and not so bad. The access from Mita Hill dam to diversion dam and storage tank was also earth road 42km and not so bad. The access from storage tank to power station along to penstocks (about 100m down) was used by a 4 ton trolley. Also, the steps existed along a trolley.

(3) **Mita Hills dam (Upstream dam):** This dam was located 30km upstream from Lunsemfwa power station and controlled river flow. The outline of this dam was as follows.

1) Type: Rockfill dam
2) Reservoir area: 45 km^2
3) Crest length: 500m
4) Crest height: 240 feet from dam bottom
5) High water level: 220 feet from dam bottom
6) Spill way: 2 radial gates (30' x 30', 44 ton/each) and emergency spill way.
7) Intake tower and gates: The gates were located in 100 feet from water level.
8) Construction period: 1955 - 1957

(4) **Diversion dam (Downstream dam):** This dam controlled the water flow to generation. The water intake for generation existed on the left bank of the dam.

(5) **Water conduction channel:** The type of water conduction channel was open trench. The length of water conduction channel between water intake to storage tank was 2km. The width was 8m. The water level inside water conduction channel was almost full. The maintenance condition was excellent.

(6) **Storage tank:** A storage tank and a spill way existed. The maintenance condition was excellent.

(7) **Penstocks:** Three penstocks existed. The length and diameter was 100m and 1m respectively. The maintenance condition was excellent.

(8) **Power station:** Three hydro-machines, 6MW each and Horizontal Francis type, were commissioned in 1945 existed in a building. The available capacity was 18MW. The power supply to the water pump and residences in Kabwe Mine only since Kabwe Mine was closed in June 1994. The design data was as follows.

- Discharge (m^3/s): 16
- Effective head (feet): 380

The maintenance condition was excellent.

(9) **Substation:** The generated voltage was stepped-up to 66kV. A 66 kV line was connected to Mulungushi power station.

(10) **Prospect for extension plan:**

1) The bulk electric energy is not required since Kabwe Mine (Broken Hill) was

closed in 1994. Consequently, the generating extension plan is not considered at this stage.

2) A sectional engineer told me as follows. ZCCM want to sell the surplus energy generated in the Lunsemfwa and Mulungushi Power Stations to ZESCO. On the other hand, ZCCM's Nampundwe Mine purchase the energy from ZESCO. Thus, ZCCM want to offset the energy charge each other.

9. MULUNGUSHI DAM AND POWER STATION

(1) **Date visited:** 27th July 1994, 9:00 - 11:00

(2) **Access:** The access from Kabwe town to Mulungushi dam was earth road 52km and not so bad. The access from dam to diversion dam and storage tank was earth road and not so bad. The access from storage tank to power station and substation along penstocks (about 300m fall) was used by a 4 ton trolley. The other access was not available.

(3) **Mulungushi dam (Upstream dam):** This dam was located 5km upstream from Mulungushi power station and controlled river flow. The outline of this dam was as follows.

1) Type: rockfill dam and concrete covered
2) Reservoir area:
3) Reservoir volume: 8,100 mil $feet^3$
4) Crest length: 50m
5) Crest height: 120 feet
6) Spill way: 40 gates, manual operated.
7) Intake: former intake was tower type, afterward it was constructed another place with 2 gates manual operated.
8) Completed year: 1923

(4) **Diversion dam:** This dam controlled the water flow to generation. The water intake existed on the left bank of the dam.

(5) **Water conduction channel:** The open type channel conducted the water to storage tank and it's length and width were 3km and 4m respectively. The water level in the channel was almost 70%.

(6) **Balance reservation and storage tank:** A balance reservoir and a storage tank with a spill way existed. Two manual operated gates existed.

(7) **Penstocks:** Three penstocks existed. One of them was abandoned. The diameter of two penstocks were 44" and 24" respectively.

(8) **Power station:** Four pelton hydro-machines existed in a building.

Unit No.	Capacity (MVA)	Comm. Year
1	2.5	1924
2	6.25	1927
3	6.25	1927
4	8	1947
Total	23	--

The installed capacity was 20MW. The available capacity was 16MW. The power supplies to the Kabwe Mine only same as Lunsemfwa power station. The design data was as follows:

- Discharge ($feet^3/s$): 300
- Effective head: 325m

The maintenance condition was excellent.

(9) **Substation:** The generated voltage was stepped-up to 66kV. Three 66kV lines existed, one of them was connected to Lunsemfwa power station and the rest were connected to Kabwe Mine (Broken Hill) via Kabwe substation of ZESCO.

(10) **Prospect for extension plan:** Same as Lunsemfwa power station

10. MWINILUNGA IN NORTH-WESTERN PROVINCE

Two hydropower potential sites located downstream and upstream of the Mwinilunga bridge were investigated. Also, the power demand of Mwinilunga township was discussed in the ZESCO Diesel Generating Powerstation.

(1) **Date visited:** 6th August 1994, 10:00 - 14:00

(2) **Access:**

1) Downstream site
The proposed dam is located at 7km downstream from the Mwinilunga bridge. The access road 4 km between main road (T5) and the Farmer Training Centre was easy by the car, and then the walking 2km to left bank of the dam site.

2) Upstream site
The proposed dam is located at 2 km upstream from the Mwinilunga bridge. The walking road existed both left and right bank of dam site.

(3) **Present situation of electric power supply in Mwinilunga township:**

The electric power supply for Mwinilunga township was established in 1970 and it's diesel power station was originally equipped with six diesel generators and total capacity was 725kW.

Since 1987, the original diesel generators were replaced to present diesel generators 3 x 250kW installed by the DANISH Government and the electricity have been supplied by the present diesel generators. The distribution network was still now operated at 11kV.

(4) **Demand forecast**

In 1981, the peak demand was 295kW. At the present, the peak demand is assumed 600kW. Annual average growth rate is 5.6 percent.

A constant increase of 5.6 percent per year during study period is assumed. In 2015, the probable peak demand will be reached to 1,880 kW.

Since the present capacity of diesel generators will be insufficient to meet the peak demand after 1998, the load shedding will be carried out. Fig 1 presents the peak demand and supply in Mwinilunga.

(5) **Potential of hydropower stations:**

The principal data of Downstream and Upstream hydropower stations are as follows.

Item	Downstream	Upstream
Gross head (m)	4 - 5	16 - 20
Min. discharge (m^3/s)	10	16
Mean discharge (m^3/s)	30	30
Firm capacity (kW)	320	2000
Installed capacity (kW)	1,200	4,600
Annual production energy (GWh/a)		
- Minimum	2.8	10.5
- Mean	7.0	26.0

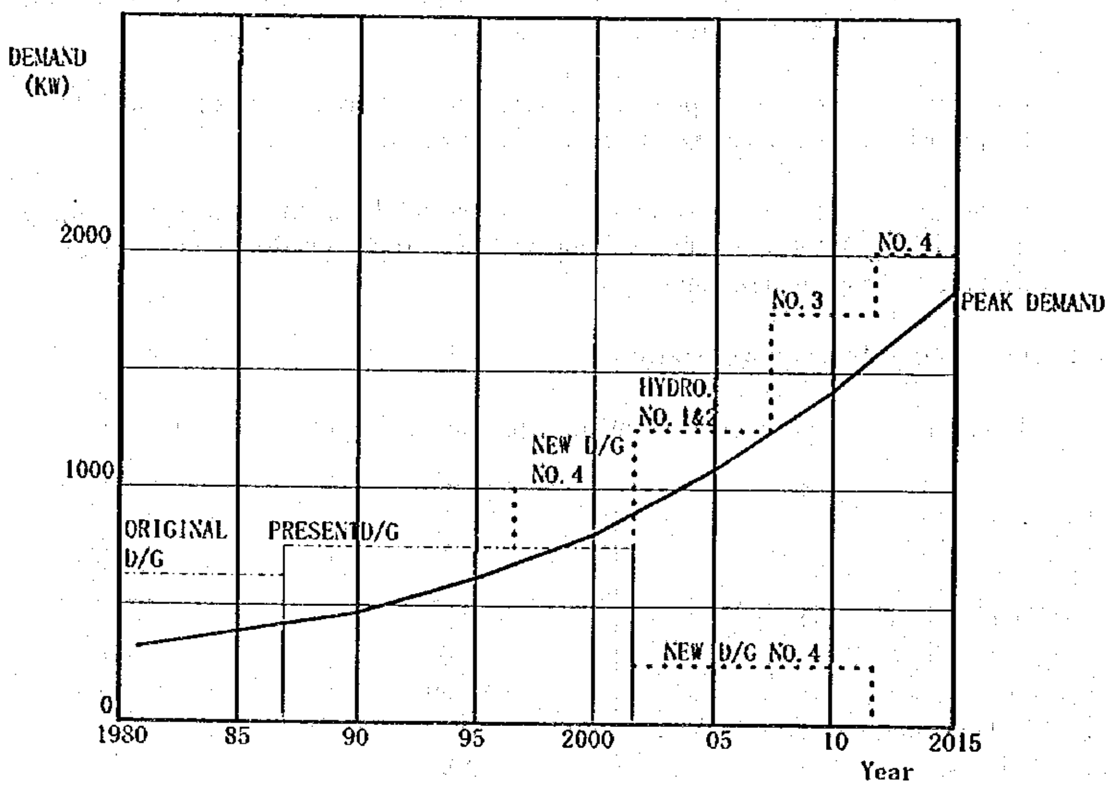
(Notes)
1) Gross head 5m of downstream dam is subjected to the level of Mwinilunga bridge.
2) Gross head 20m of upstream dam is subjected to the level of sewage petrol pumps.
3) Firm capacity (kW) is minimum generation capacity during dry season.

The hydropower station of downstream is insufficient to meet the demand in Mwinilunga township during the study period.

On the other hand, the hydropower station of upstream will be sufficient to meet the demand until 2015.

However, a new diesel generator (No. 4) is required by 1996 before completion of hydroelectric power station.

Figure-1 Supply and Demand



JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF ZAMBIA
MINISTRY OF ENERGY AND WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER RESOURCES MASTER PLAN

IN

THE REPUBLIC OF ZAMBIA

FINAL REPORT

SUPPORTING REPORT [L]

NAVIGATION

OCTOBER, 1995

YACHIYO ENGINEERING CO., LTD.
(YEC)

THE STUDY ON NATIONAL WATER RESOURCES MASTER PLAN IN THE REPUBLIC OF ZAMBIA

SUPPORTING REPORT (L)
NAVIGATION

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CHAPTER 1 GENERAL

Based on the report "The Development of Zambia's Inland Water Transportation System", published in April 1984, and discussions with the Ministry of Transport and Communications (MOTC), it is apparent that there is need to develop and expand the existing water transport system. The MOTC is in the process of establishing a Directorate of Shipping, Maritime Affairs and Inland Waterways (name not yet decided) to produce a government register of ports and shipping. It is hoped that this organisation will soon be fully operational and one of its functions will be to implement and monitor progress of the recommendations made in the report referenced above.

CHAPTER 2 POTENTIAL INLAND NAVIGATION AREAS

There is no nation-wide long-distance water borne transportation system in Zambia. Railway transportation and trucking provide the majority of the existing transportation network. This is due to difficulties in establishing and maintaining inland waterways because there are so many rapids and falls on the Zambian rivers, in addition to large seasonal fluctuation of river flows. On the other hand, there are some parts of rivers with gentle and stable flows as well as swamps, lakes and large scale reservoirs suitable for navigation. These areas are indicated in Figure 2-1 and are listed below.

1) Barotse Flood Plain, upstream of the Zambezi River
2) Kafue Flats, middle reaches of the Kafue River
3) Lake Mweru
4) Lake Tanganyika
5) Lake Bangweulu
6) Lake Mweru Wantipa
7) Lake Kariba
8) Lake Itezhi-Tezhi

The above-mentioned eight areas have possibilities for boat transportation. At present, boat transportation is only being operated in the four areas listed below.

- Barotse Flood Plain, upstream of the Zambezi River
- Lake Mweru
- Lake Tanganyika
- Lake Bangweulu

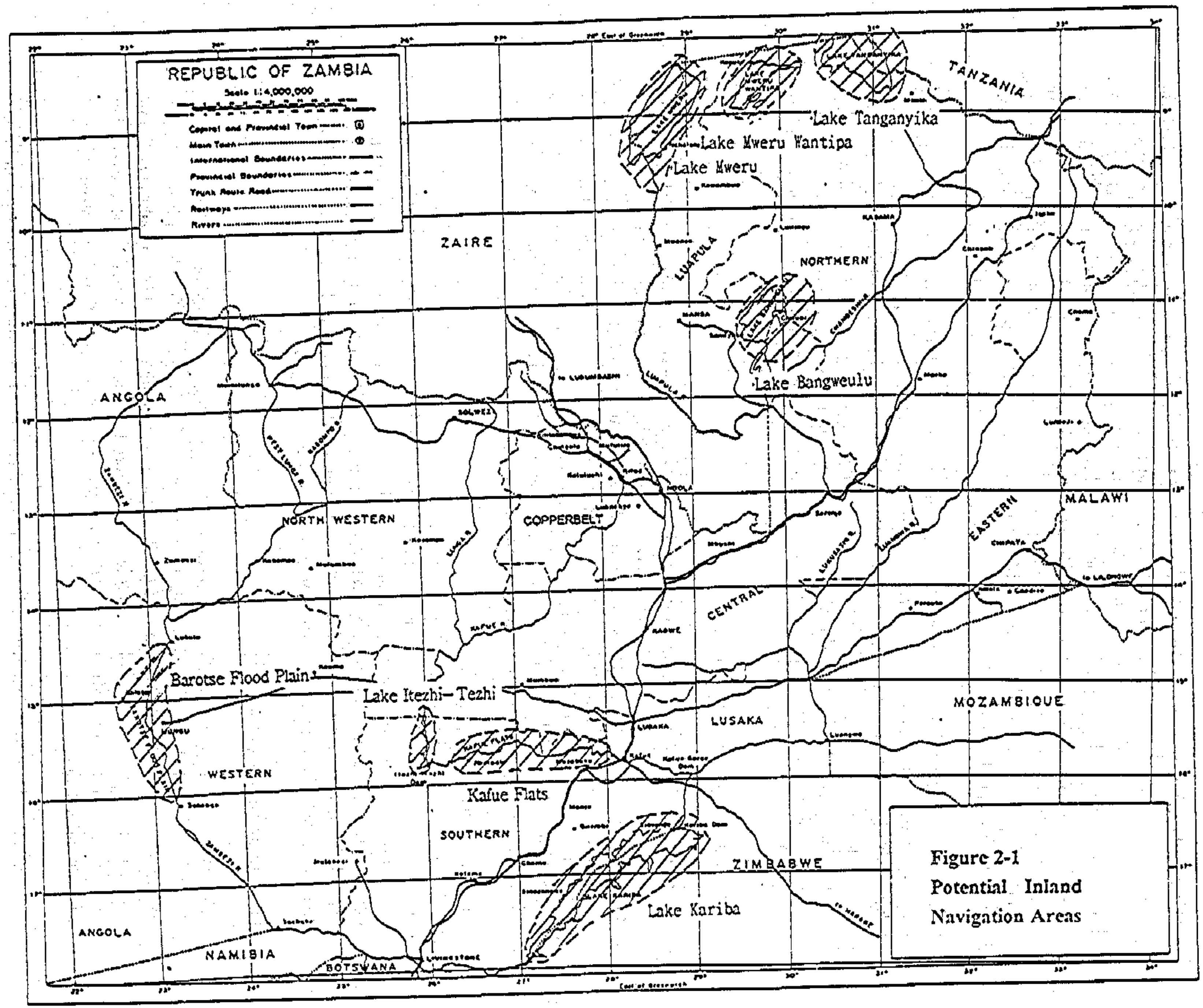

Figure 2-1
Potential Inland
Navigation Areas

CHAPTER 3 PRESENT SITUATION

(1) Upper Zambezi (Barotse Flood Plain)

Kalabo District, with a population of about 47,000, is the only area really dependent on water transport as no proper road links exist. All other districts on the Upper Zambezi are connected to the Zambian road network and are presently supplied satisfactorily by road vehicles, ferry and pontoon. The Mongu-Kalabo waterway, crossing the Zambezi main stream, is more important for water transport than the main Zambezi River. The only significant water transport carried out at present is between Mongu and Kalabo. However, during the dry season, there are problems of siltation leading to the river becoming too shallow for boat traffic.

At present, during the dry season, small dugout canoes can easily pass the canal, but long barges with a maximum carrying capacity of 2 to 3 tons can only do so with difficulty. Some dredging has been carried out but it is very expensive because of high fuel costs and the frequent need to repeat the operation. Alternative proposals have been tried including river training works such as the construction of groynes. There is a conflict of interests, however, in that tribes people need to cross the river with their cattle and so require shallow water.

(2) Lake Mweru/Luapula River

This pair of navigable waterways is shared by Zaire and Zambia. Marine activities on the waterways are similar to those on Lake Bangweulu. The area is surrounded by swamps and floating vegetation. The characteristics of the area varies with the wet and dry seasons, siltation is also a problem in the areas. The type of boats used is uneconomical because of their small size and high fuel consumption. However, about 10,000 people are dependent on water transport and the port of Nchelenge, the island of Kilwa and the river ports of Mwonso and Kashiba are due to be developed.

(3) Lake Tanganyika

As Zambia is a landlocked country, Lake Tanganyika provides the main international waterway in the South East Africa region. The lake has gained particular significance in the development of economic cooperation between the countries of the region, including Zaire, Uganda, Tanzania, Burundi, and Rwanda. In Zambia, Mpulungu has been defined as a very significant port for trade, and is to be upgraded accordingly.

(4) Lake Bangweulu

Lake Bangweulu is one of the waterways entirely within the borders of Zambia. Lake Bangweulu is a shallow lake with extensive swamps. There are three inhabited islands in the lake namely, Chisi, Mbabala, and Chilubi. There are approximately 50,000 inhabitants living in the area who are exclusively dependent on water transport. Previously, there existed a reliable water transport system, however, services have since deteriorated and often require government subsidies.

Some canals and waterways are no longer navigable due to swampy and soggy conditions prevailing in the area. Revival of the services that existed in the past will require the cleaning and dredging of the canals to maintain prolonged navigability. The ports of Samfya, Chilubi and Santa Maria are scheduled for improvement.

CHAPTER 4 IMPROVEMENT OF INLAND NAVIGATION

To improve inland navigation, a comprehensive navigation master plan should be established based on the national transportation policy and considering the following matters:

- Distribution of population and industries
- Number of passengers to be transported
- Feasibility of navigation compared to road and railway transportation
- Location of suitable waterways, ports, ferry and pontoons
- Type and amount of cargoes to be transported
- Type of carrier
- Maintenance of water ways and other facilities
- Management and organisation, etc.

The navigation master plan study should include all the items mentioned above and should therefore be carried out independently from this Study, which aims at the National Water Resources Master Plan.

Waterways require enough depth of water for navigation by boats, vessels, barges, etc. In some cases, a dam, built upstream of a waterway, discharges water or an adjacent river diverts its water to the waterway to keep enough water depth, especially in dry seasons. With the exception of these cases, navigation itself does not affect water resources. These methods could not be applied to upper Zambezi, Lake Mweru, and Lake Bangweulu because of enormous volumes of water needed. In short, navigation in Zambia does not affect water resources.

The main problem hindering navigation in Zambia is shallow water depth due to siltation or decrease of discharge. There are several methods to alleviate these problems, as outlined below.

a) Damming up water by a downstream dam or weir
b) Construction of deeper water river channel and/or canal
c) Concentration of low water flow in the steady river course by groynes and/or river channel improvement
d) Dredging of waterways with shallow water depth and narrow width

Method (a) could not be applied to any of the rivers in Zambia due to huge cost and low feasibility. However, if such structures are built for other purposes, such as hydroelectric power generation, water resources development, flood control, etc., the waterways will benefit from the increased water depth, as seen at present upstream of Kariba Dam and Itezhi-Tezhi Dam.

For Lake Mweru and Lake Bangweulu, methods (b) and (d) should be applied. Method (b) requires rather high costs but seems to be effective for the areas where waterways are blocked by siltation. However, continuous dredging work is also necessary for maintenance of the waterways.

For Upper Zambezi, especially from Mongu to Kalabo, methods (b), (c) and (d) are applicable. However, even if methods (b) and (c) are initially applied, structures such as river channels, canals and groynes, which require high construction cost, are quite difficult to maintain properly because they are located in the wide flood plain and are subject to large scale floods every year.

The problem is that large investment could not be input to this area from the viewpoint of the high cost and limited benefit. Therefore, the least cost method (d) should be applied for the time being. In conclusion, a feasibility study for navigation in this area, which includes comparisons with transportation by roads and bridges (or pontoons), is recommendable.

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF ZAMBIA
MINISTRY OF ENERGY AND WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER RESOURCES MASTER PLAN

IN

THE REPUBLIC OF ZAMBIA

FINAL REPORT

SUPPORTING REPORT [M]

FLOOD CONTROL

OCTOBER, 1995

YACHIYO ENGINEERING CO., LTD.
(YEC)

THE STUDY ON NATIONAL WATER RESOURCES MASTER PLAN IN THE REPUBLIC OF ZAMBIA

SUPPORTING REPORT (M)
FLOOD CONTROL

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CHAPTER 1 RIVER AND FLOOD CONDITIONS

1.1 Rivers in Zambia

The land of Zambia is divided into three main river basins; Zambezi River Basin, Zaire (Congo) River Basin and Lake Tanganyika Basin. Refer to Figure 1-1. Of the total land area of 751,852 km^2, an area of 569,588 km^2, corresponding to about 76 percent, is occupied by Zambezi River Basin, 21 percent by Zaire (Congo) River Basin and 2 percent by Tanganyika Lake Basin.

The Zambezi River is an international river having its basin in Angola, Namibia, Botswana, Zambia, Zimbabwe and Mozambique. Its water course measures 2,740 km, and river basin 1,330,000 km^2. In the African continent, it has the fourth biggest basin following Zaire (Congo) River (36,900,000 km^2), Nile River (30,100,000 km^2) and Niger River (20,920,000 km^2). Measuring 569,588 km^2, the Zambezi River basin in Zambia accounts for 43 percent of the total basin. The major rivers in the Zambezi River Basin in the country can be classified as Zambezi Main River, Kafue River and Luangwa River. The Chambeshi River Basin and Luapula River Basin form tributaries located at the uppermost reaches of the Zaire (Congo) River which is the biggest on the African continent. Table 1-1 shows the catchment area of each basin. Moreover, based on the names of those rivers carried on topographical maps on scales of one to 1,500,000 and one to 750,000, the list of rivers indicated in Table 1-2 ~ Table 1-6 was produced.

Table 1-1 Catchment Areas

Name of Basin	Catchment Area (km^2)	
	Total	In Zambia
Zambezi River	991,666	569,588
Main River	687,049	268,235
Kafue River	156,995	156,995
Luangwa River	147,622	144,358
Zaire (Congo) River	217,823	157,750
Chambeshi River	44,427	44,427
Luapula River	173,396	113,323
Lake Tanganyika	249,000	15,856
Total	-	751,852

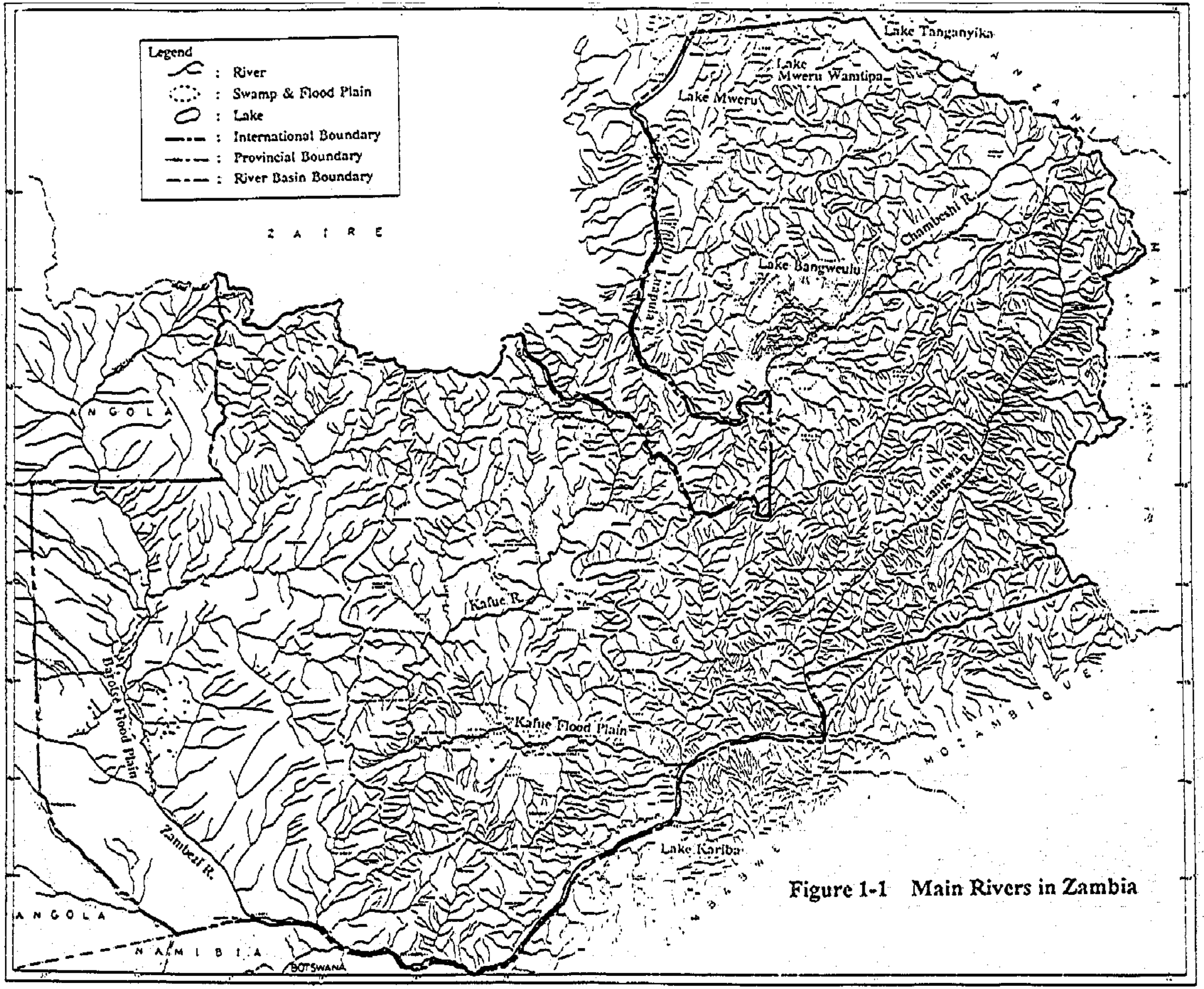


Figure 1-1 Main Rivers in Zambia

Table 1-2(1) Tributary System
(Zambezi River)

Stream Order			
1st	2nd	3rd	4th
Luangwa			
Mushika			
Chakwenga			
Mwambashi	Musangashi	Chisekwesa	
		Ikanda	
Musigiswa			
Chowe			
Chongwe	Kanyere		
	Chindulwe		
	Mitaba		
	Luimba		
	Kabutete		
	Chilimbana		
	Kapete		
	Kanakatapa		
Kafue			
Siakapu			
Lusitu			
Mbendele			
(SIAVONGA/ KARIBA DAM)			
Lufua	Nabuguyu		
Chibuwe			
Chezya			
Njongola			
Nangombe			
(SINAZONGWE)			
Sikalamba			
Zongwe	Muzuma		
	Kasinzi		
Zhimu	Kasyondola		
	Kabembe		
	Mafula		
	Matebele		
Mwenda			
(DEVIL'S GORGE)			
Mulola			
Maunga			
Mazanga			
Ngwemanzi	Lusowa		
Namaluba			
Kalomo	Namazuka		
	Rokumvura		
	Zimba	Matezi	
	Nkungwa		
	Nekoya		
	Mwemba		
	Sichikwenkwe	Nabuyani	
(BAKOTA GORGE)			
Sinde			
Bovu			
Luzila			
Ntengwe			
Ngwezi	Nambaza		
	Lunungu		
	Nanzeki	Kamacele	
	Nanyati		
	Mwemba		
Machili	Loazamba		
	Sichifulo	Sala	
		Choma	
	Nyitenda		
	Simatanga	Kanyane	
		Chilembe	
	Mulobezi	Mwezi	
		Kalobe	
	Luamulomba		
Loanja	Masese		
	Luamwila	Simakondo	

Table 1-2(2) Tributary System
(Zambezi River)

Stream Order			
1st	2nd	3rd	4th
(SESHEKE)			
Lusu			
Nioko	Lwampungu		
	Kwemba		
	Kamanga		
	Njoko		
Nangombe			
Lumbe	Luweumba		
	Kasinzi		
	Sonso	Kasibi	
		Kasansama	
	Mata		
	Sisapi	Suyi	
Luanso			
Kakenge			
Lui	Namukokoba		(Lake Makapaela)
	Mutondo	Namengo	
	Lukalanya		
	Siyowe	Nakayembe	
	Lwatembo		
	Mulwa	Lungamba	
Southern Lueti	Keyana		
	Lwao		
(SENANGA)			
BAROTSE FLOOD	L.Siwa		
PLAN	L.Njolo		
	L.Silita		
(MONGU)			
Ndoka	L.Chilele	L.Sihole	
	L.Lilambo	L.Liande	
	L.Siya	L.Tala	
Luanginga	Luambimba	Lwandilu	
		Omboya	
	Northern Lueti	Lwati	
		Nyengo Swamp	
		Utokota	
		Malando	
Luena	Ndanda		
	Likolomani		
	Luambuwa		
	Luampa	Mpande	
		Mulambwa	Ngenge
		Nyambe	
		Lemvu	
		Selonga	Makumba
		Mwangalesha	
	Nyango		
	Mukunkiki		
	Longe		
	Munkuye		
	Mandeu		
	(Lukulu)		
Lungwebungu	Kashiji	Chinonwe	
	Litapi		
	Lutembwe		
Kabompo	Lutali		
	Kawilo	Katuva	
		Mumbeji	Mufuli
	Dongwe	Chifuwe	
		Kanweji	
		Nkulashi	
		Lalafuta	Lunyachi
			Shiwishi
		Mufumbwe	
		Musondweji	Lower Musondweji
			-Kalombe(5th)
			-Kamukulwezi(5th)
			North Musondweji
			-Keyumbwe(5th)
			-Kashekete(5th)
		Lumba	

Table 1-2(3) Tributary System
(Zambezi River)

Stream Order			
1st	2nd	3rd	4th
		Loba	
		Chiwoko	
		Lwansununu	
		Kabanda	
		Manyinga	Lusongwa
	Makuwakwa		
	katendwa		
	Lavushi	Kamajiya	
	Mukundwiji		
	Chitampalova		
	Kamweji		
	West Lunga	Lufuko	
		Sambila	
		Lwamasongu	
		Mwanamitowa	
		Mwoji	
		Shilovu	
		Chilonga	
		Shilahu	
		Kasenga	
		Kamano	
		Nyangombi	
		Kamunji	
		Luakela	
		Mundwiji	
		Kapundu	
		Ingoma	
		Mujila	
	Chifuwe		
	Ngoza		
	Mwombezhi	Lwalaba	
		Mwafwe	Mushingashi
			Tunta
			Kamanu
			Mizenge
			Milunga
			Shikundwe
		Meheba	
		East Lumwana	Mulundwe
		Jiwundu	
	Wisaki		
	Nsangi		
	Lui		
	Kasanjiku	Luijishi	
		Nyavisonga	
	Mujimbeji		
	Musangezhi		
	Chisasa		
	Chisola		
	West Lumwana		
	Kalombe		
	Nyambwezu		
	Lumwana		
	Mufundu		
	Luamisamba		
Kaseki			
Makondu	Lunvuwe		
	Chito		
Lunyuwe			
Lukolwe			
(Lukaya)			
(Lushimba)	(Lwau)		
(Jimbe)			

Table 1-3(1) Tributary System
(Kafue River)

Stream Order			
1st	2nd	3rd	4th
Lesser Chongwe	Chisha		
Musaya			
Mukwisi			
Funswe			
Mungu			
Chilongolo			
Kaleya			
Mwembeshi	Kabile		
	Kembe	Myota	
	Chunga		
(KAFUE FLATS)			
Magoye	Muzuma		
	Ngwezi		
Chibenge			
Nangoma	Maruni		
Kasungula	Kasaka	Kaloba	
	Bwengwa	Mahumba	
		Chilala	
		Semalwa	
Silukuya	Munyeke	Ngongo	
		Semahwa	
Mpiuda	Chitongo		
Lutale	Chibila		
Nansenga	Namatonga		
	Nalusanga		
	Zara		
Lukomezi	Itapira		
Bauga			
Baunza			
Nanzhila	Sikaleta		
	Shapuya		
	Choma		
	Kasangva		
	Kasha		
	Winsiwinsi		
	Idiamala		
	Madiampaulwa		
	Siazingu		
	Kanyele		
Nkala	Lulonga		
(ITEZHI-TEZHI DAM)			
Musa	Kabulala		
	Lwangandu		
Mungasiya			
Lwamwanza			
Yongwe			
Nangamba	Luasanda		
Shishamba			
Nangoma	Bwela-Wa-Lesa		
	Lusangazi		
Lufupa	Ntemwa		
	Busanga Swamp		
	Ngubo		
	Ngoma		
	Lushimba		
	Mafumbwe		
	Mukunashi	Kalaba	
		Tete	
		Kakumbi	
	Shitema		
	Njenga		
	Nsuki		
	Shindamona		
	Dengwe		
Nyambala			
Mushingashi			
Lunga	Kaungashi	Nkono	
		Tzansa	
		Mafeta	
		Wisanga	

Table 1-3(2) Tributary System (Kafue River)

Stream Order			
1st	2nd	3rd	4th
	Mpungu		
	Mutanda		
	Makada		
	Mukeleshi	Kyunga	
	Mitumba	Lobela	
	Kisupa		
	Mushingashi	Muliashi	
		Chipapushi	
		Katombe	
	Mufwashi	Kolweji	
		Katondo	
	Musakazhi		
	Luma	Mushishima	
		Milunga	
		Mesha	
		Nyavilambi	
	Nykingwe		
	Mutanda	Shiwe	
		Kifubwa	
	Luanzhila	Mikilingi	
	Ngoywa		
Mutapanda			
Chipeta			
Lukanga	Mushingashi	Mambwe	
	Mundu		
	Mutandwe		
	Mufuwa	Kabanje	
	Lunjofwa		
Munwinu			
Luamala			
Mulalashi			
Luswishi	Mininga	Lwambowo	
		Mufunshi	Chamakolongo
	Funda		
	Lumwawa		
	Metendu Swamp		
Lufwanyama			
Lueia			
Chitoto			
Kafubu			
Kafulafuta	Ibenga		
Nkulumashiba			
Mitondo			
Kafubu			
Mafupa			
Mwambashi			
Mutandu			
Munyoshi	Mufukushi		
Muchindamu			

Table 1-4(1) Tributary System
(Luangwa River)

Stream Order			
1st	2nd	3rd	4th
Kakalo			
Rufunsa	Chamtondo		
Kaunga			
Ntantali			
Lunsemfwa	Milembo		
	Lukusashi	Fiperere	
		Ndauni	
		Kampoko	Tumbwe
			Nkumashi
		Mtoa	
		Mulembo	Kasunu
			Lelya
			Fikanda
		Manda	
		Mupetauke	
		Ntetezi	
		Lusiwasi	Kaombe
			Isamba
		Fukwe	
		Mweuse	
	Bandwe		
	Tutenge		
	Mushikashi		
	Mwapula	Paminembe	
	Mulungushi	Kayuni	
		Chile	
		Chikwata	
		Mwomboshi	Lombwa
		Chowa	Muswishi
		Mubofwe	Mondoka
		Ntasha	
		Kakalo	
		Chibwe	
		Mteteshi	Luashimba
			Lumbe
			Chifungo
	Lundashi		
	Mukango		
	Mulenge		
	Mkushi	Mupitapanshi	
		Kamimbya	
		Fikoko	
		Fyesha	
		Lupundu	
	Chisamba		
	Lunga	Chankalamu	
	Mukankamano		
	Katukutu		
	Lunchu	Yongwe	
	Miwanga		
	Katunga		
	Kakalakoshi	Tembwe	Munshiwemba
	Mubalashi	Lubwe	
		Kashitu	
	Muloba	Musofu	
	Mukango		
Mwateshi			
Nyimba			
Kasua			
Katondwe	Chisanga		
Mvuvye	Mtirizi	Mpundwe	
Miseme	Mtikila		
Kazikazi			
Msanzara	Singozi		
Mutinsase	Lusiwasi		
Kaseche			
Mpupushi			
Chimzinga			
Mwandangombe			
Mkusie	Fombwe		
Nkandwa			

Table 1-4(2) Tributary System
(Luangwa River)

Stream Order			
1st	2nd	3rd	4th
Ngala			
Wasa	Manda		
Mapandwe			
Kangwa			
Lusangozi			
Kapamba	Mwatezi		
	Mupamadzi	Lukula	
		Inambwa	
		Chintumukulu	
		(Mwatishi)	
Malauga			
Matizye			
Lupande	Lusandwa		
	Kasangazi		
	Nyamadzi		
	Milanzi		
	Mwangazi	Nkuku	
	Kasenengwa		
Mwatezi	Lutembwe	Chiwayu	
	Kamwanjiri		
	Msandile	Chilata	
	Pasora		
Mwangozi			
Lubi			
Mwamba			
Lukuzye	Chirume		
Mupamadzi	Mwatishi		
Katete			
Lukusuzi	Kakula		
	(Matisi)		
	(Kasangula)		
	(Msidza)		
	(Lusangashi)		
	(Lumimba)		
Munyamadzi	Mutinondo		
	Lucheche		
Lumimba			
Kapangala			
Mulandashi			
Lundazi	Lumezi		
Mwaleshi			
Zewe			
Luelo			
Lufila	Luswa		
Lundi			
Lunzi			
Lumezi			
Lupamadzi			
Bazima			
Musalango			
Manshya			
Kapemba			
Luwumbu	Bemba	Choma	
		Vumbo	
	Chire		
Matwashi			
Mwambwa			
Mushi			
Nkanka			
Kawumba			
Isalala			
Mulungwizi			

Table 1-5 Tributary System
(Chambeshi River)

Stream Order			
1st	2nd	3rd	4th
(Lulimala)			
LUAPULA			
Lumbatwa			
Kanchibya	Lwitikita		
Chibwa Swamp			
Munikashi			
Lulingila	Lubafeshi		
Lubanseshi	Munwa		
Mansha	Lukafashi		
Mununshi			
Lukulu	(Chishimba-		
	falls)	Kafubu	
		Luombe	
Lukashya			
Mapampa			
Lubu			
Kalungu	Nakonde		
	Chozi	Luchinde	Ngomba
		Luwala Swamp	
		Ntumba	
Losa	Lwanga		
Kabisya			
Chamtubu			

Table 1-6 Tributary System (Luapula River)

Stream Order			
1st	2nd	3rd	4th
(Lake Mweru)			
Luao			
Kalungwishi	Luntomfwe		
	Mwansamila		
	Mofwa		
	Itabu		
	Chisaka		
	Kapako		
	Luangwa	Lupansa	
Mwatishi			
Mbereshi			
Mununshi			
Luongo			
Luamfuwu			
Mansa	Lumanwa		
	Mubambi		
	Chibalashi		
Mufushi			
Mabila			
Manshinyini			
Lumbu			
Ngo			
Lwela	Chibishi		
	Mulungushi		(Lake Mweruwantipa)
	Lukulashi		
	Mwanbeshi		
	Mukonge		
	Mukubwe	Lupele	
Lusano			
Nkufi			
(Lake-Bangweulu)	(Katamwa-Channel)		
	(Lake-Kampolombo)	(Lake-Kangwena)	
	(Lake-Kasongole)		
	(Lake Kafumbo)		
	(Lake-Nsakalala)		
	Mwampanda		
	Lufubu		
	Luena		(Luena Estuary)
Luwombwa			
(Part in Zaire)	Mulembo	Kasanka	
		Kapabi Swamp	
	Lube		
	Munte		
	Musangashi		

Table 1-7 Tributary System
(Lake Tanganyika)

Stream Order			
1st	2nd	3rd	4th
Chisala Lunzua Lufubu			
	Chitete Mulunda Mukotwe Mukomanshi		
Lumzua Kalambo			

1.2 Topographic Features of Basins

(1) Zambezi Main River Basin

Zambezi Main River originates in the northernmost part of North Western Province, before flowing through part of Angola. After re-entering Zambia in the western part of North Western Province near to Zambezi Town, it flows past Lukulu, Mongu, Senanga and Sesheke in Western Province. Passing close to Livingstone, Siavonga and Chirundu in Southern Province, the Zambezi leaves Zambia at Luangwa in Lusaka Province to enter Mozambique.

The catchment area of Zambezi River (including Kafue River and Luangwa River) at the lowest reaches is 991,666 km^2. Of this area, the basin of Zambezi Main River within the country of Zambia accounts for 268,235 km^2, and the water course of the main river is 1,470 km long. The difference in elevation over this length is 729 m, with the average river bed slope amounting to $i = 1/2,040$. The Kafue River joins the flow 180 km upstream from the lowest point, and the Luangwa River at the lowest point. Another major tributary, Kabompo River, having its basin (72,751 km^2)in North Western Province on the upper reaches joins the flow at the left bank near to Lukulu Town.

As illustrated in Figure 1-2, the longitudinal section of the entire channel can be broadly classified into three major parts; a gradually sloping area in the upper reaches, a steep slope in the middle reaches and a gradually sloping area in the lower reaches.

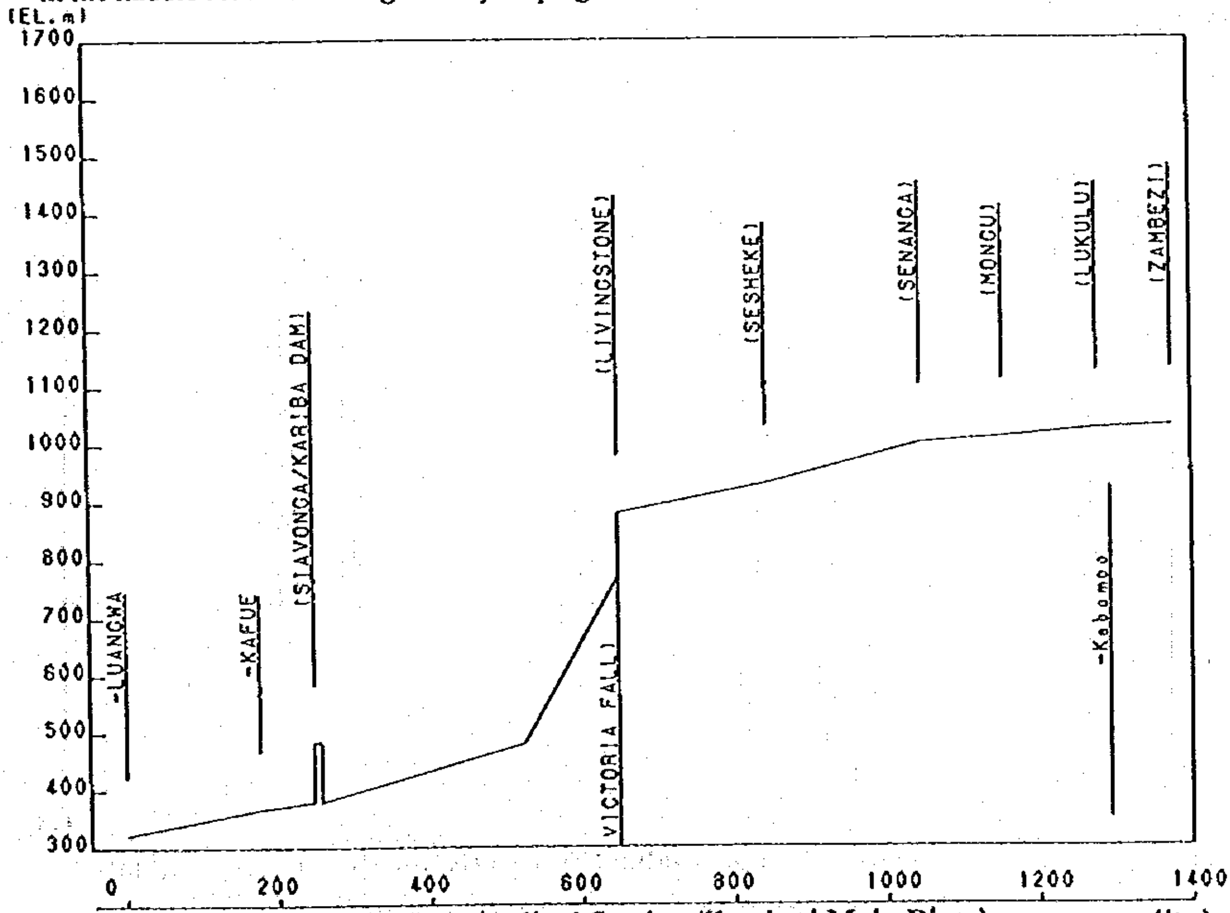


Figure 1-2 Longitudinal Section (Zambezi Main River)

An extensive floodplain called Barotse Flood Plain is formed in the area upstream of Senanga in the upper reaches, and the slope of the river bed presents a very gradual slope of i = 1/10,000. Several steep slopes are observed between Senanga and Livingstone on the lower reaches, but this area belongs to a gradually sloping area as represented by i ≐ 1/3,300. Between Victoria Falls at Livingstone and the upstream end of the Kariba Dam reservoir, the Zambezi flows through a series of steep gorges. The elevation is reduced by 380 m over a distance of about 120 km, giving an average river bed slope of i = 1/320. The lower reaches downstream of the Kariba dam again present a gentle slope, with the river bed slope of i = 1/4,300. Taking advantage of the steep slope, the 128-metre high Kariba Dam has created a reservoir extending for 5,180 km^2 of reservoir area with a water storage capacity of 160,368 million m^3 and a total extension of 280 km long.

(2) Kafue River Basin

The Kafue River is a major tributary accounting for 27 percent of the Zambezi River Basin. The Kafue River originates in Copperbelt Province flowing past Kitwe and through Central and Southern Provinces, passing Kafue town and bordering Lusaka Province, before joining the Zambezi Main river downstream of Chirundu. The point of confluence is located about 176 km up the river from the point where the Zambezi River flows into Mozambique. Refer to Figure 1-3.

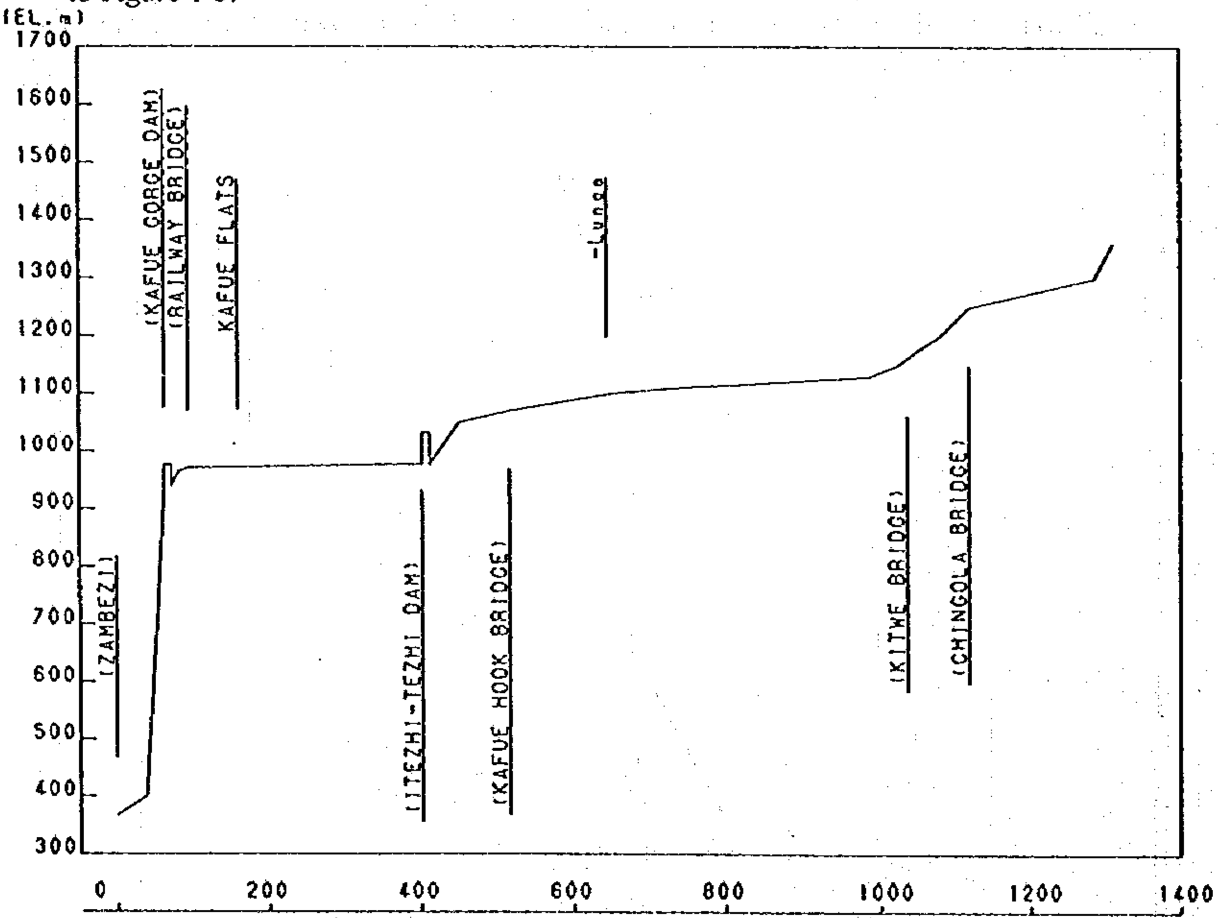


Figure 1-3 Longitudinal Section (Kafue River)

The catchment area amounts to 156,995 km^2, and the river is 1,310 km long. The difference in elevation measures 990 m, and the average river bed slope is i = 1/1,320. As a major tributary, the Lunga River having its basin (23,767 km^2) in North Western Province joins the flow at the right bank 130 km up the river from Kafue Hook Bridge. The Kafue River has an unusual configuration in longitudinal section. A conspicuous change in profile is marked by the Kafue Gorge Dam. The river has a general longitudinal section having a sharp slope in the mountain district of the uppermost reaches and a gentle slope in the downstream area. However, the gorge downstream of Kafue Gorge Dam has a drop in head of several hundred metres.

The Kafue River has flat swamps on the way from the uppermost reaches to Kitwe town, but the average river bed slope is as steep as i = 1/1,370. It presents a very sharp slope down the river from that position; then it takes on a gentle slope of i = 1/6,700 to the Itezhi-Tezhi Dam. The Itezhi-Tezhi Dam is located at the mouth of the valley, and the water goes down into the Kafue Flats.

The Kafue Flats is an almost completely flat area, extending over 320 km from the Itezhi-Tezhi Dam to the area near Kafue town. The Kafue River flows across the Flats, exhibiting repeated meandering. The difference in elevation of this area is only 10 to 15 m, and the average river bed slope is i = 1/20,000 to 30,000, representing an almost flat profile. The area between the Kafue Gorge Dam located about 20 km downstream from Kafue town to the Zambezi River is a series of gorges over the distance of 64 km, and the river drops through a height of 570 m at an average river bed slope of i = 1/110.

(3) Luangwa River Basin

The Luangwa River is the second biggest tributary of the Zambezi River Basin, accounting for 26 percent of the total basin of the Zambezi River. The major portion of the Luangwa River runs through the Eastern Province, except for part of the uppermost and lowest reaches. The origin of the river is located in the mountainous district of Northern Province close to the national boundary with Malawi, and the flow then enters the Eastern Province. In the middle reaches, the river forms the border with Northern Province and Central Province.

The lowest reaches form a boundary between Lusaka Province and Mozambique. The confluence between the Luangwa River and the Zambezi River forms the most downstream point of the Zambezi River in Zambia. In this region, there are no towns along the river.

The catchment area amounts to 147,622 km^2, and the water course extends for 850 km; the difference in elevation is 980 m with an average river bed slope of i = 1/870. As a major tributary, the Lunsemfwa River with catchment area (43,137 km^2) in Central Province and a part of Northern Province joins the river 90 km upstream from the point of confluence with the Zambezi River at the right bank.

Figure 1-4 shows the longitudinal section of the entire river channel; the river has steep slopes in upper reaches and gentle slopes in lower reaches, showing a typical longitudinal section. The upper reaches in the mountainous district of Northern Province have a steep slope with an average river bed slope of i = about 1/100. After the flow enters Eastern

(4) Chambeshi and Luapula River Basin

All rivers introduced above pertain to the Zambezi River Basin flowing to the eastern coast of the African continent. The Chambeshi River and the Luapula River are a tributaries of the Zaire (Congo) River flowing to the western coast. The uppermost reaches of the Chambeshi River originate in the mountainous district of Northern Province bordering on Tanzania. Running down the Northern Province, the Chambeshi River becomes the Luapula River at the middle reaches. Turning northwards and bordering on Zaire, the river flows into Lake Mweru.

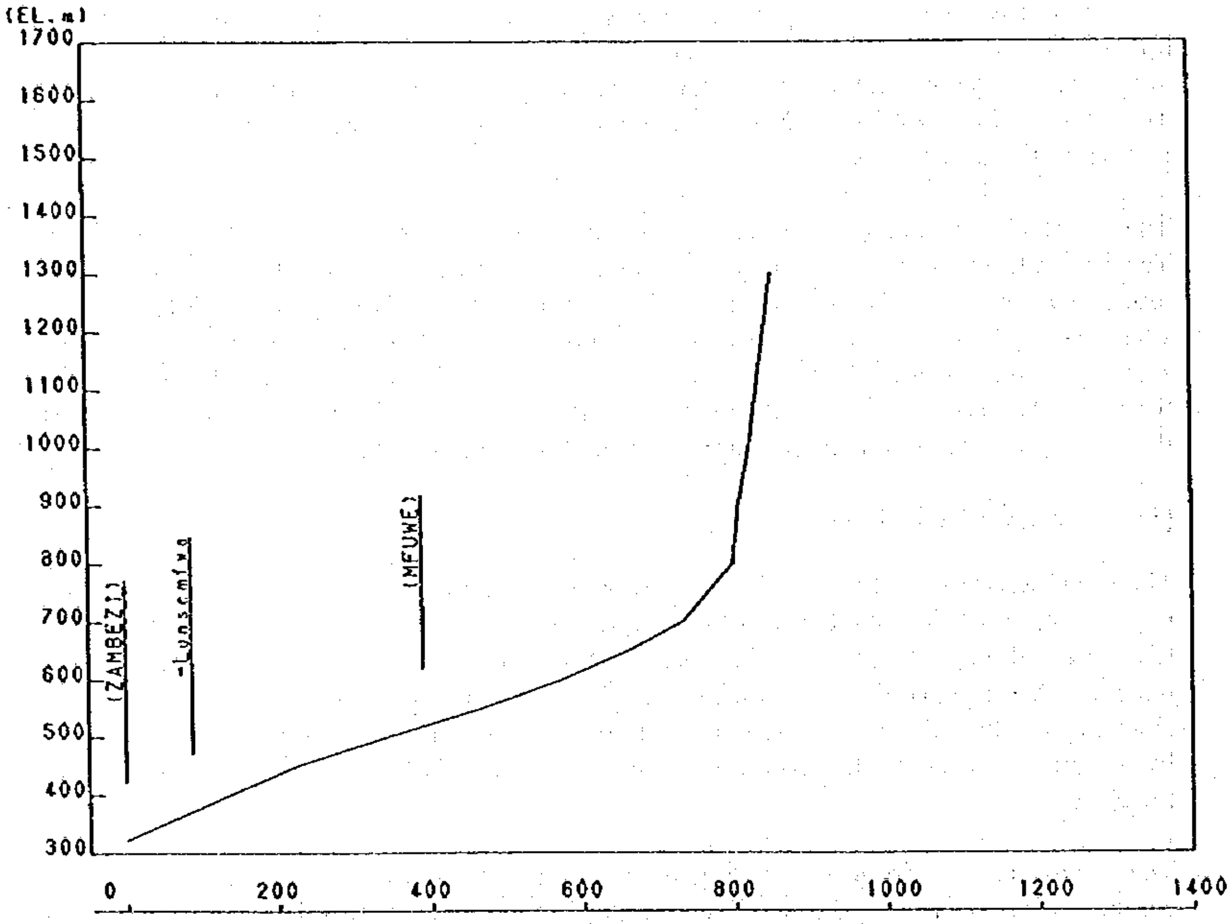


Figure 1-4 Longitudinal Section (Luangwa River) (km)

The catchment area at the lowest reaches measures 217,823 km^2, of which 157,750 km^2 lies within the national territory of Zambia. The total length of the main river course before it enters Lake Mweru is 1,120 km, and the difference in elevation is 689 metres, giving an average river bed slope of i = 1/1,650.

The upper reaches are called Chambeshi River. Assuming for the sake of convenience, that the border is placed at the Mbati of hydrometric water level observation station located near the Isangano National Park, the length of Chambeshi River is 410 km with a catchment area amounting to 44,427 km^2.

Figure 1-5 illustrates the longitudinal section of the entire river channel. The mountainous district of the upper reaches forms a steep slope with an average river bed slope of i = 1/240. Coming out of the mountainous district, the river exhibits a more gradual slope of i = 1/6,000. After the Chambeshi River Changes its name to the Luapula River, the river runs through swamps and a network of channels linked to Lake Bangweulu. The flow again increases its slope after it has entered the area bordering Zaire, and the average river bed slope up to Lake Mweru is i = 1/2,000.

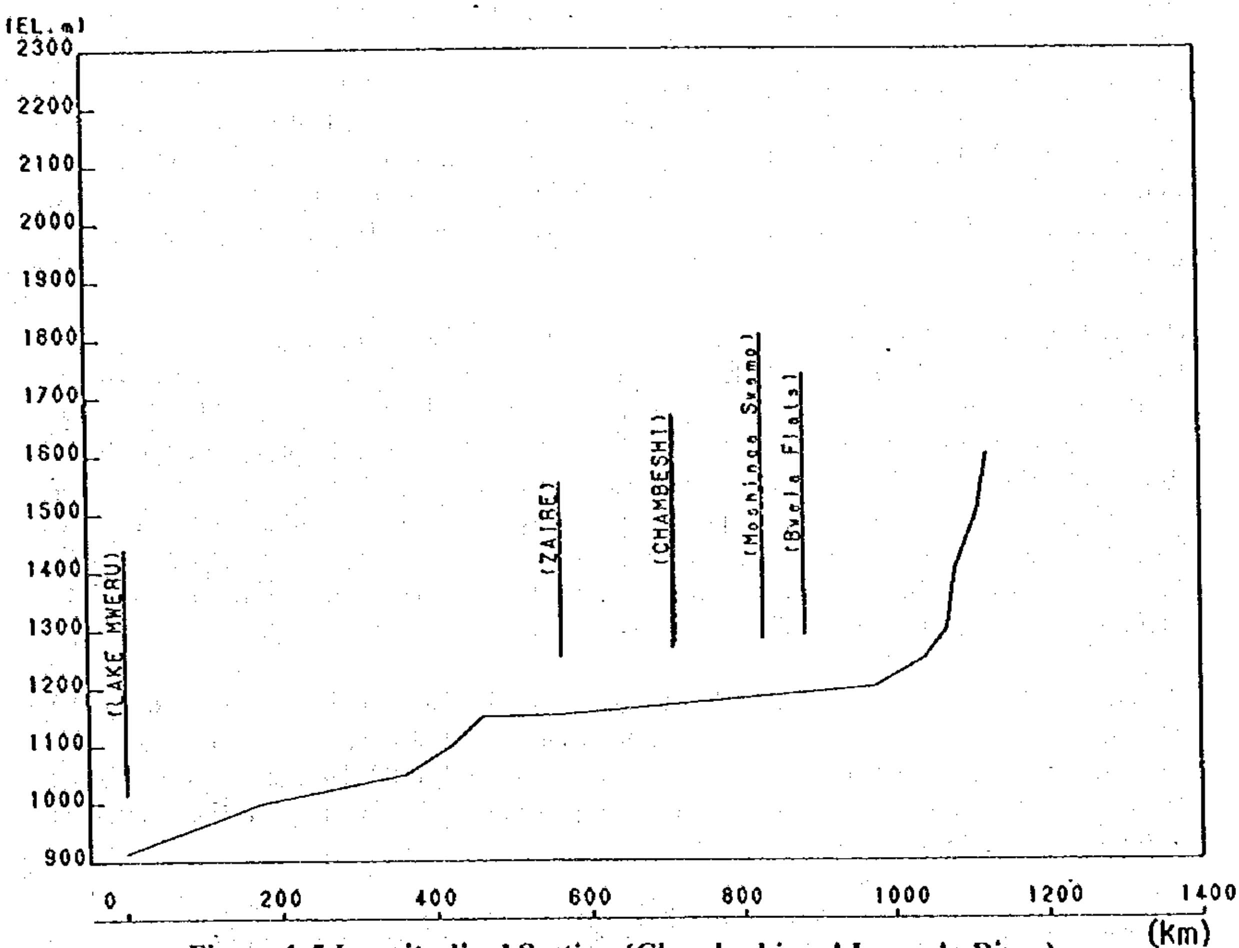


Figure 1-5 Longitudinal Section (Chambeshi and Luapula River)

(5) Lake Tanganyika Basin

Of the Lake Tanganyika basin, an area of 15,856 km^2 belongs to Zambia, and contains several small rivers, the largest of which is Lufubu River having a catchment area of 9,027 km^2.

1.3 Flood Runoff Characteristics

For annual rainfall distribution, the year in Zambia can be clearly divided into two seasons; the rainy season from November to April and the dry season from May to October. Flood is restricted to the rainy season. The annual rainfall varies from 700 to 1400 mm, and does not usually occur as short-term, concentrated rainfall. Because of the large scale of the basins, a series of big flood runoffs will extend over a long period of time, without causing a concentrated runoff. Thus, serious floods do not occur over the entire river.

To explain the runoff characteristics of the rivers in Zambia, Table 1-8 and Figure 1-6 introduce the monthly discharge, based on the discharge data of the hydrometric stations at Mwambashi (827 km^2), Smith's Bridge (8,914 km^2) and Kafue Hook Bridge (96,239 km^2) on the Kafue River. The average discharge is high during the period from December to July, with a maximum in March. However, variations throughout the year occur gradually, with no obvious peaks.

The discharge is 91 m^3/s for Mwambashi catchment area of 827 km^2, resulting in a specific discharge of 0.11 $m^3/s/km^2$. Similarly, the specific discharge is 0.06 and 0.03 $m^3/s/km^2$ at Smith's Bridge and Kafue Hook Bridge, respectively. Thus, flood specific discharge normally tends to decrease with the increase in the catchment area. Based on the discharge observed by the nation-wide hydrometric stations shown in Table 1-9, the specific discharge of floods in Zambian rivers falls within the range from 0.02 to 0.4 $m^3/s/km^2$. Figure 1-7 illustrates the range of specific discharge for world rivers. The specific discharge of the Zambian rivers described here agree with the figures for the rivers on the flat lands of the world, suggesting that the flood discharge is small.

Annual runoffs at Mwambashi, Smith's Bridge and Kafue Hook Bridge are 309 mm, 282 mm and 122 mm, respectively. Since the annual rainfall in the upstream basin ranges from 1,180 to 1,250 m, the coefficients of runoff at Mwambashi, Smith's Bridge and Kafue Hook Bridge are 0.25, 0.23 and 0.09. Since evapotranspiration has a great impact, the coefficient of runoff is generally small.

Table 1-8 Monthly Discharge

Month	Mwambashi				Smith's Bridge				Kafue Hook Bridge			
	Max. Dis. (m^3/s)	Min. Dis. (m^3/s)	Mean Dis. (m^3/s)	Rainfall (mm)	Max. Dis. (m^3/s)	Min. Dis. (m^3/s)	Mean Dis. (m^3/s)	Rainfall (mm)	Max. Dis. (m^3/s)	Min. Dis. (m^3/s)	Mean Dis. (m^3/s)	Rainfall (mm)
Oct.	7	1	2	33	48	4	12	33	121	23	66	54
Nov.	16	1	2	124	69	3	16	124	248	23	70	163
Dec.	42	2	6	300	260	8	46	300	556	37	142	264
Jan.	47	3	12	288	277	17	100	288	1,165	106	338	271
Feb.	44	6	18	244	293	53	157	244	2,574	143	619	236
Mar.	91	6	19	164	541	68	186	164	2,446	114	774	237
Apr.	65	6	13	44	472	57	156	44	2,889	153	709	77
May.	27	2	6	4	232	29	89	4	2,078	94	428	5
Jun.	13	2	4	1	155	15	50	1	1,141	61	229	0
Jul.	9	2	3	0	107	11	33	0	629	48	147	0
Aug.	7	1	3	0	63	8	24	0	360	41	113	1
Sep.	5	1	2	3	50	5	17	3	255	32	89	4

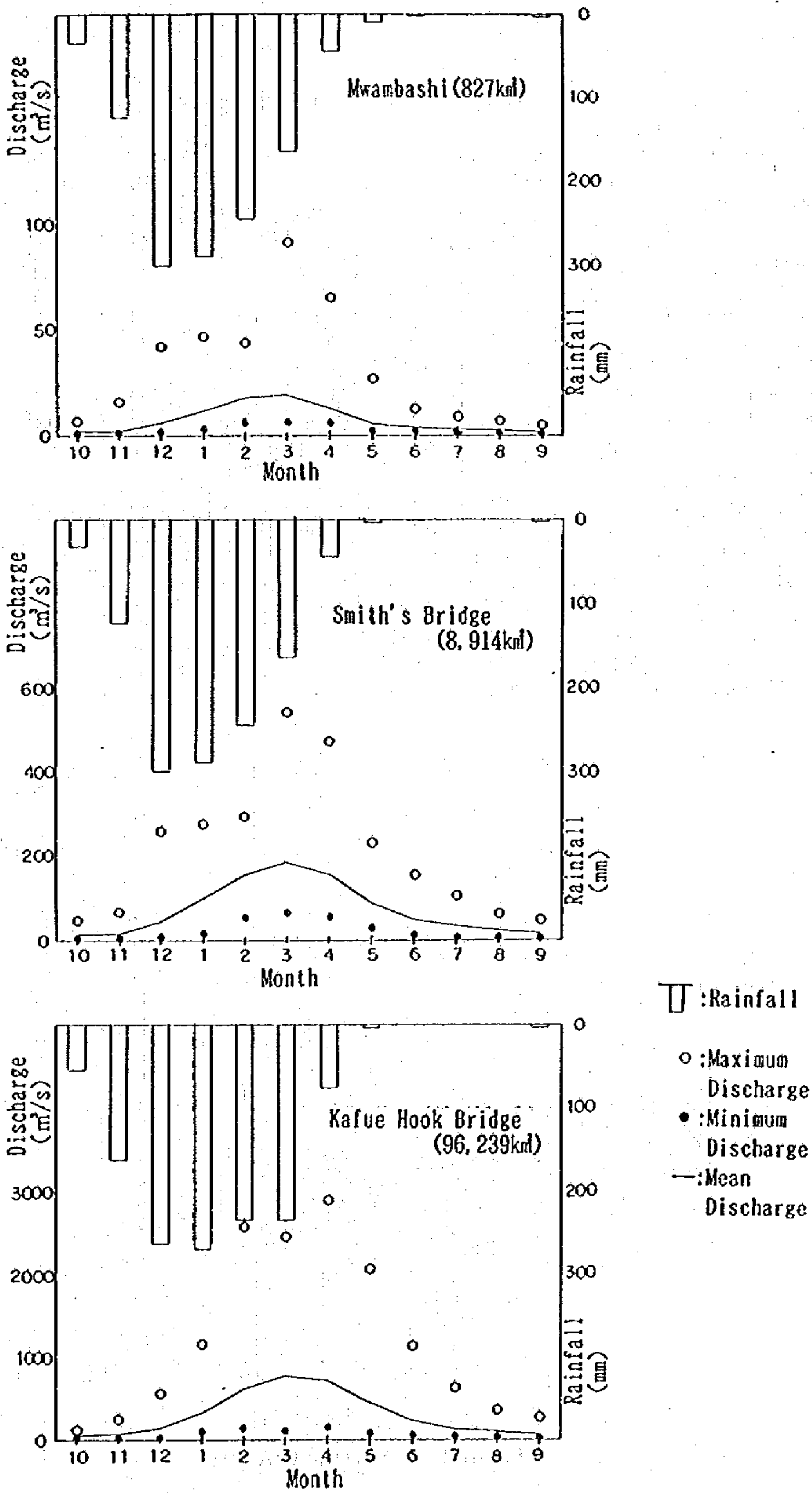


Figure 1-6 Monthly Discharge

Table 1-9 Maximum Discharge

Station	Catchment Area (km^2)	Maximum Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)	Station	Catchment Area (km^2)	Maximum Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
Zambezi River				Luangwa River			
Mwinilunga	4,538	805	0.18	Mkushi Boma	181	29	0.16
Kalabo	34,621	973	0.028	Madizomoyo Q.	319	120	0.38
Kabompo Boma	42,740	1,371	0.032	Lusiwasi	995	86	0.086
Watopa Pontoon	67,261	1,822	0.027	Ndevu Camp	91,861	6,466	0.070
Zambezi P.H	87,275	5,360	0.061	Luangwa Bridge	140,922	10,213	0.072
Lukulu	206,531	5,667	0.027	Luapula River			
Kalomo Dam	2,190	503	0.23	Chipili	1,220	175	0.14
Romor Farm	118	20	0.17	Chishimba Falls	2,580	157	0.061
Chongwe	1,922	192	0.10	Mw/-Ka R.B.	4,170	140	0.034
Kafue River				Kundabwika F.	12,396	538	0.043
Mwambashi	827	91	0.11	Chambeshi O.P.	34,745	1,446	0.042
Kasempa P.H.	1,062	150	0.14	Chembe Ferry	123,072	4,227	0.034
Masaiti Bridge	1,375	69	0.050	Kashiba	161,275	4,821	0.030
Raglan Farm	5,775	267	0.046	Tanganyika L.			
Chifumpa Pont.	20,999	1,743	0.083	Keso Falls	9,027	725	0.080
Chilenga	34,451	1,118	0.032				
Kafue Hook Br.	96,239	2,889	0.030				
Itezhi-Tezhi	107,191	4,072	0.038				

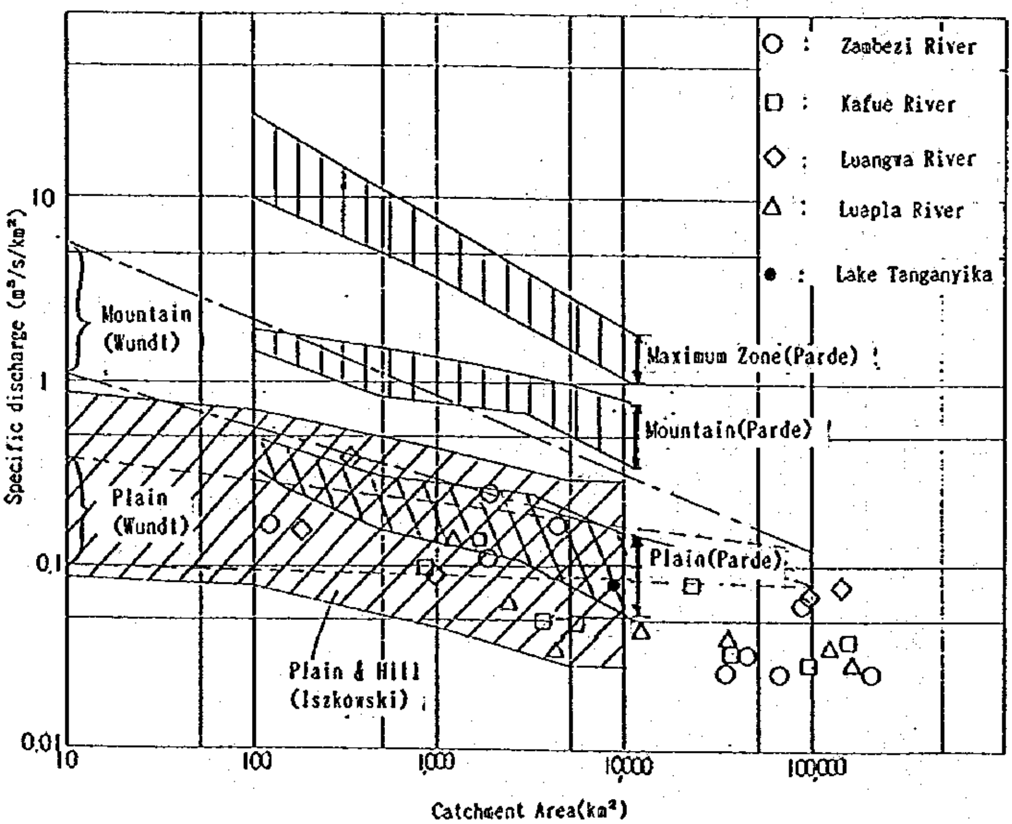


Figure 1-7 Specific Discharge

1.4 Social Characteristics

The following Table 1-10 summarises the Zambian land use and floodplain areas arranged for each river according to the results of the Landsat satellite imagery analysis carried out in this Study :

Table 1-10 Land Use and Floodplain Area

(unit: km²)

Classification	Nationwide	Zambezi	Kafue	Luangwa	Luapula	Tanganyika
Urban	1,065 0.14%	228 0.08%	508 0.32%	109 0.08%	206 0.13%	18 0.11%
Agriculture	11,506 1.5%	1,503 0.6%	3,379 2.2%	5,221 3.6%	1,040 0.7%	82 0.5%
Floodplain	49,599 6.6%	18,672 7.0%	10,788 6.9%	2,739 1.9%	17,401 11.0%	806 5.1%
Swamp	16,861 2.2%	476 0.2%	6,262 4.0%	80 0.1%	9,721 6.2%	322 2.0%
Lake	11,644 1.5%	2,158 0.8%	573 0.4%	82 0.1%	6,858 4.3%	1,973 12.4%
Total Area	751,851 100.0%	268,234 100.0%	156,998 100.0%	144,857 100.0%	157,748 100.0%	15,856 100.0%

With the urban area and agricultural area put together, the land used in Zambia accounts for less than 2 percent of the total national land; this is a very small percentage. For the urban area, 48 percent of the total national land is concentrated in Lusaka, the capital of the country, and the Kafue River Basin including Copperbelt, one of the centres of the industrial activities. This figure exhibits the highest concentration rate in the country, but corresponds to only 0.32 percent of the basin area.

The agricultural area is concentrated around the major roads such as T1, T2, T3 and M9, centring on Lusaka and Copperbelt. Furthermore, extensive agricultural land is found in the area of national boundary of Malawi in the upper reaches of the Luangwa River. Thus, the Kafue River Basin and the Luangwa River Basin account for 75 percent of the total agricultural area of the country.

The floodplain area occupies 6.6 percent of the national land. When swamps and lakes are added, an area of about ten percent pertains to the plain land. The floodplain featuring a high value in land use is concentrated around the upper Zambezi River to the west of Zambia, Lukanga Swamp in the centre of the Kafue River Basin, the Kafue Flats, the Chambeshi River in the north and Lake Bangweulu. The Zambezi River Basin and Kafue River Basin account for seven percent of the total catchment area, while the Luapula River Basin occupies 11 percent.

The above describes the outline of land use in the entire basin area and floodplains. The following describes the land use in the floodplain accompanied by flood control issues. In Zambia, land use is largely restricted to comparatively higher land, and almost no lower lands are used. It can be said at least that there is no city or township located within the floodplains in Zambia. Agriculture is also scarce within the floodplains. According to the current situation in the use of land in Zambia, security against floods can be considered to be sufficiently high.

1.5 Flood Damage

The present situations of flood are summarised as follows:

1) As the cities and townships are situated in the highlands, it is reported that large scale flood damage to citizens, property, and agricultural lands has not occurred.
2) In cites and townships, however, it is reported that flood damages due to small rivers' inundation and inadequate drainage systems occur during the rainy season.
3) In the following flood plains or swamps, the situations are different between the rainy and dry seasons due to river inundation. These areas have significant potential for agricultural development because water can be easily obtained and is readily available.
   - Barotse Flood Plain
   - Lukanga Swamp
   - Kafue Flats
   - Bangweulu Swamps
   - Mweru Wantipa Swamps
   - Lake Mweru-Luapula Swamp

Flooding and inundation of small rivers and drainage channels in city areas appear due to inadequate drainage systems. Therefore, this will be investigated separately from this Study. More serious cases of flooding are investigated by a study from available records.

The situations of flood damages for the following two townships were investigated by field survey and interview. The situations of both townships are similar. The houses are located near the river bank, river improvement has not been carried out, discharge capacity is not adequate and short term inundation has occurred. Flood control by small-dam or river improvement (e.g. excavation of river bed) will be effective to mitigate flood damage. Due to the fact that the flow is not so high, the peak time of flood is short and these areas are not swamp, the flood water does not spread over the land.

(1) Maamba (Southern Province)

In 1989, heavy rainfall caused sheet flow from the escarpment to be funnelled into Maamba township damaging the medical clinic.

- Rainfall

Feb. 10, 1989	06:30-08:00	:	70.3mm
Feb. 11, 1989	08:00-11:00	:	64.0mm
Monthly total		:	665.0mm

- Exceptional heavy rainfall and flood

(2) Kitwe (Copperbelt Province)

Flooding occurs along the Kafue river and streams that run through the city and join the Kafue river. Notable streams are Kwacha stream which starts from Kwacha and runs through Ipusukilo compound bordering with Kwacha East, and Riverside stream between Ipusukilo stage 1 and stage 2.

Areas affected with seasonal flooding of the Kafue river and the streams are Kabolanda compound, Ipusukilo compound and Chipata compound. It can be noted that these areas are high density settlements which are unplanned and have grown over the years. They are illegal settlements with little or no council services. The council however still has to take care of the people in these areas when floods occur as they are residents of the city.

Although the flooding occurs every year with flood damage to houses, a more serious disaster occurred during the rainy season of 1979-1980. Kitwe City Council reported twenty one collapsed houses in Kabulonda compound. To protect the families against the floods in future, six families were resettled in the same township and fifteen moved to another township.

Ipusukilo compound is affected by the flooding of riverside stream. This township is being upgraded and roads and drainage have been improved under a PUSH programme of 'food for work' involving the local community.

There are no flood protection works along the Kafue river. As township in the flood prone area like Ipusukilo are being upgraded, there is need for such works to prevent loss of life and property in the event of a flood.

CHAPTER 2 EXISTING FLOOD CONTROL FACILITIES

There are no purpose built flood control facilities in Zambia. However, dams such as Itezhi-Tezhi Dam have large storage volume so that the flood discharge can be decreased. Therefore, the inundated area of Kafue Flats downstream, is decreased. Also, it will be considered that the each flood plain will have the same function to the areas downstream. The following Table 2-1 shows the major particulars of the main Zambia dams for reference, although flood control is not an objective for these projects.

The following shows an overview of the total finance cost for Kabwe Surface Water Supply Project Dam:

1) Total Finance Cost .... 33,973,000 ECU (41,000,000 US$)

- Detailed site investigations : 1.87%
- Final design : 2.10%
- Preliminary and general : 13.95%
- Gravity Dam (Height=16m, Concrete volume=25,000 m^3) : 23.48%
- Treatment plant (37,500 m^3/day) : 9.94%
- Pumping stations (0.45 m^3/s x 150kw; 0.43m^3/s x 1,100kW) : 3.30%
- Site substation : 1.79%
- Office and staff housing : 0.60%
- Pipeline (750mm x 7.5km, 850mm x 7.0km, 950mm x 7.0km) : 36.48%
- Complementary works : 3.12%
- Construction design and supervision : 3.64%

2) Project Duration (From August 1987 to July 1990) .... : 36 months

Table 2-1 List of Existing Large Dams in Zambia

Items	Mulungushi Dam	Mita Hill Dam	Kariba Dam	Kafue Gorge Dam	Itezhi-Tezhi Dam	Kabwe Surface Water Supply Project Dam
(1) Location						
- River	Mulungushi	Lunsemfwa	Zambezi	Kafue	Kafue	Mulungushi
- Nearest City	Kabwe (S.E. 50 km)	Kabwe (ENE. 74 km)	Lusaka (SES 135km)	Lusaka (S. 45 km)	Lusaka (W. 250 km)	Kabwe (N.E. 22 km)
- Province	Central	Central	Southern	Southern & Lusaka	Southern	Central
(2) Completion Year	1924	1959	1959	1971	1978	1990
(3) Purpose	Hydropower	Hydropower	Hydropower	Hydropower	Hydropower	Water Supply 37,500 m^3/d
(4) Reservoir						
- Catchment Area(km^2)	4,490	4,270	663,880	152.810	105,620	2,450
- Gross Capacity(Mm^3)	255.0	680.0	185,000.0	840.0	5,700.0	9.5
- Live Capacity (Mm^3)			69,000.0	700.0	5,000.0	8.6
- Max. W/L (EL.m)	1,069.3		489.2		1,033.0	1,108.95
- Storage W/L (EL.m)	1,068.6		484.6	976.6	1,029.5	1,107.80
- Surface Area (km^2)	31	65	5,180	800	370	3.2
- Length (km)			280			
(5) Dam						
- Type	Rockfill	Rockfill	Arch	Rockfill	Rockfill	G/Concrete
- Max. Height (m)	47	49	128	53	70	16.0
- Crest Altitude (EL.m)	1,070		489.5	981.5	1,035.5	1,110.0
- Length of Crest (m)	46	73	579	375	1,800	420
- Volume (m^3)	214,000		1,320,000	1,200,000	8,500,000	25,000
(6) Spillway						
- Max. Discharge(m^3/s)	400 (approx.)	450 (approx.)	9,500	4,250	4,200	1,000 Design/F:375

CHAPTER 3 FLOOD CONTROL PLAN

3.1 General Approach

Flood accident derives from the imbalance existing between the flood as natural phenomenon and social request for ensuring safety. When the social request is greater than the required investment, flood control will be planned and various flood prevention plans will be implemented. If floodplain has a great deal of accumulated capital, much investment must be made to prevent flood damage from occurring due to inundation.

Flood control methods can be broadly classified into two types: one is to reduce the volume of runoff, the other is to expand the discharge capacity of the river. The major methods of reducing the volume of runoff include flood control by dams or retarding basin, open-levee, cut-off and diversion channels. All of these methods reduce the flood flow to a level less than the discharge capacity of the river by decreasing the overall amount of flood on the upper reaches.

Methods of expanding the discharge capacity of the river are called river improvement. This aims to expand the river channel section as a whole by a combination of such measures as expansion of river channel width, dredging of the river bed, construction of levees and modification of the flood plain profile, thereby ensuring that the discharge capacity of the river is greater than the volume of flood runoff. With these measures, various combinations are studied in relation to the particular requirements of the site, and the optimum method is selected. In this case, the basis for the study is the design flood discharge.

The design flood discharge is required in order to formulate a flood control master plan. Design for the cross section of river channels to be improved, the cross section of flood spillways for river works such as flood control dams, intake weirs, and the substructure of bridges across rivers, should be carefully done after examining the design flood discharge. The design flood discharge may be determined by considering the maximum discharge in the past, but the standard procedure is to use the probable discharge. There are two methods to determine the probable discharge: one is probability analysis of the observed discharge, the other is runoff calculations using with the probable rainfall. The method to be employed should be chosen considering the situation of the existing observed data.

3.2 Probable Rainfall and Discharge

3.2.1 Probable Rainfall

Analysis has been made to determine the design storm rainfall depth required for estimating the design flood (e.g. of spillways). Inadequate spillway capacity of dams may be responsible for causing dam disasters during abnormal floods. It is therefore essential that the spillway capacity of dams to be constructed should be carefully estimated on the basis of analysis of past records in that region.

(1) Collection of maximum records of daily rainfall in each year

There are 22 reporting meteorological stations whose daily rainfall data are available over 30 years. Table 3-1 shows the observation stations. Moreover, Table 3-2 and Table 3-3 indicate the annual maximum daily and 2-day rainfalls at each station.

Table 3-1 Rainfall Observation Stations and Observation Periods (Daily Rainfall)

Province	Station	Observation Period	Province	Station	Observation Period
Lusaka	Lusaka	1950/01-1993/10	Western	Mongu	1935/02-1993/09
Central	Kabwe	1950/01-1993/09		Kaoma	1961/01-1993/09
Northern	Kasama	1933/05-1993/08		Sesheke	1950/01-1993/07
	Mbala	1961/01-1993/09	Copperbelt	Ndola	1940/01-1993/07
	Mpika	1932/04-1993/08	Northwestern	Solwezi	1961/01-1993/09
Eastern	Chipata	1945/11-1993/09		Mwinilunga	1932/04-1993/08
	Lundazi	1956/01-1993/09		Zambezi	1953/11-1993/09
	Petauke	1950/01-1993/10		Kabompo	1961/01-1993/07
Southern	Livingstone	1932/04-1993/09		Kasempa	1938/01-1993/07
	Choma	1950/01-1993/09	Luapula	Mansa	1960/01-1993/08
	Kafue Polder	1957/06-1993/08		Kawambwa	1956/08-1993/08

Table 3-2 (1) Annual Maximum Daily Rainfall

Lusaka

Date of occurrence	daily rainfall
1950 1 24	49.0
1951 2 26	51.0
1952 1 24	65.0
1952 12 30	75.0
1954 1 20	42.0
1954 12 27	57.0
1956 3 22	45.0
1957 2 21	44.0
1958 2 21	50.0
1958 12 12	53.0
1959 12 29	53.0
1960 11 25	45.0
1962 3 18	69.0
1962 12 22	63.0
1963 12 30	38.0
1965 1 3	82.0
1966 2 3	57.0
1968 12 17	39.0
1974 3 20	190.0
1975 1 27	101.0
1976 3 14	45.0
1977 2 15	51.0
1977 12 15	119.0
1978 12 14	86.0
1980 3 21	58.0
1981 3 3	88.0
1982 2 8	69.0
1983 1 21	71.0
1984 1 31	44.0
1984 11 4	58.0
1985 12 25	60.0
1986 12 8	65.0
1988 3 18	114.0
1989 2 3	104.0
1990 2 5	57.0
1991 4 7	133.0
1992 11 13	68.0
1993 1 5	55.0

Kabwe

Date of occurrence	daily rainfall
1950 1 13	38.0
1951 1 30	54.0
1952 2 7	58.0
1953 3 19	84.0
1953 12 15	91.0
1955 2 25	65.0
1956 4 20	61.0
1957 4 7	43.0
1957 12 25	33.0
1958 12 13	51.0
1960 1 24	65.0
1961 1 24	68.0
1962 3 18	80.0
1962 12 25	85.0
1964 2 5	38.0
1965 1 28	76.0
1966 1 31	41.0
1966 12 17	55.0
1967 12 3	122.0
1968 12 31	86.0
1969 12 25	75.0
1971 2 16	56.0
1971 12 23	55.0
1973 2 11	90.0
1974 1 31	83.0
1974 11 19	73.0
1975 12 19	69.0
1976 12 25	52.0
1978 2 12	74.0
1978 12 24	82.0
1979 11 21	49.0
1981 2 13	73.0
1982 2 18	47.0
1983 2 7	67.0
1983 12 7	86.0
1984 12 16	51.0
1985 12 26	58.0
1987 1 23	49.0
1987 12 1	48.0
1989 2 11	56.0
1990 1 2	56.0
1991 1 21	87.0
1992 3 23	58.0
1992 12 22	56.0

Kasama

Date of occurrence	daily rainfall
1933 12 28	67.0
1934 12 9	62.0
1935 12 25	94.0
1937 2 10	60.0
1938 2 10	60.0
1939 2 2	55.0
1940 1 25	47.0
1941 3 26	93.0
1946 1 15	47.0
1946 12 22	88.0
1948 3 14	86.0
1949 3 3	41.0
1950 3 20	65.0
1951 3 16	63.0
1952 3 27	65.0
1953 1 30	65.0
1953 12 30	65.0
1955 1 15	82.0
1956 2 23	52.0
1957 4 19	77.0
1958 2 12	60.0
1958 12 12	37.0
1960 3 12	69.0
1961 2 24	88.0
1961 12 8	31.0
1963 1 15	76.0
1963 12 23	69.0
1964 12 24	70.0
1965 12 28	64.0
1967 2 21	47.0
1968 1 12	66.0
1969 3 13	53.0
1970 2 17	44.0
1970 12 15	47.0
1972 2 11	61.0
1973 1 6	61.0
1973 12 6	78.0
1975 3 19	55.0
1976 2 2	68.0
1977 3 30	76.0
1978 3 14	78.0
1979 2 1	69.0
1980 4 12	77.0
1980 12 4	79.0
1982 4 25	73.0
1983 1 14	78.0
1984 2 27	71.0
1984 11 12	70.0
1985 2 15	52.0
1986 12 20	51.0
1988 2 5	70.0
1989 3 21	53.0
1989 11 12	73.0
1991 1 8	53.0
1992 2 4	77.0
1992 12 20	72.0

Mbala

Date of occurrence	daily rainfall
1961 3 19	31.0
1961 12 12	74.0
1962 12 25	83.0
1963 12 16	55.0
1964 12 31	77.0
1966 3 18	69.0
1967 4 21	64.0
1967 11 24	49.0
1969 4 9	48.0
1970 2 19	59.0
1971 3 12	79.0
1971 12 23	51.0
1973 1 20	73.0
1974 4 2	58.0
1975 1 3	76.0
1976 2 23	64.0
1977 4 3	52.0
1978 4 26	57.0
1979 2 23	59.0
1980 4 10	53.0
1981 1 29	90.0
1982 2 20	76.0
1982 12 26	70.0
1984 1 6	58.0
1984 12 6	58.0
1986 2 16	97.0
1986 12 17	77.0
1988 3 19	64.0
1989 4 1	115.0
1990 4 9	72.0
1991 3 10	78.0
1992 2 21	68.0
1992 12 28	83.0

Mpika

Date of occurrence	daily rainfall
1933 1 27	61.0
1934 2 24	93.0
1935 1 15	56.0
1936 3 6	69.0
1937 1 3	43.0
1938 1 31	41.0
1944 3 11	43.0
1945 1 14	78.0
1947 2 22	39.0
1947 11 25	84.0
1949 11 27	43.0
1950 1 27	119.0
1951 1 4	59.0
1952 1 18	58.0
1953 3 24	50.0
1954 2 24	62.0
1955 3 3	76.0
1956 4 3	69.0
1956 11 30	62.0
1958 2 13	57.0
1959 3 11	52.0
1960 1 6	50.0
1961 1 24	41.0
1962 1 18	59.0
1962 11 7	47.0
1963 11 15	38.0
1965 3 8	69.0
1965 12 7	116.0
1966 12 16	52.0
1967 12 14	61.0
1969 2 5	45.0
1970 4 19	58.0
1970 12 21	70.0
1972 2 27	53.0
1973 2 27	62.0
1974 4 1	180.0
1974 12 19	73.0
1975 12 7	40.0
1976 11 14	67.0
1978 3 16	58.0
1979 4 15	69.0
1979 11 23	52.0
1981 2 13	70.0
1981 11 28	64.0
1983 2 14	60.0
1984 2 28	52.0
1984 12 19	38.0
1985 12 2	32.0
1986 12 17	53.0
1987 12 18	73.0
1989 3 31	112.0
1990 2 24	103.0
1991 1 5	88.0
1991 12 21	93.0
1993 1 23	55.0

Chipata

Date of occurrence	daily rainfall
1946 3 21	60.0
1947 3 1	81.0
1948 3 29	70.0
1948 11 30	82.0
1950 2 17	91.0
1950 11 18	49.0
1951 11 21	60.0
1953 1 5	69.0
1954 1 18	54.0
1955 1 12	133.0
1956 2 2	78.0
1956 12 5	62.0
1958 1 21	59.0
1959 2 21	97.0
1959 12 14	81.0
1961 2 18	79.0
1962 1 30	71.0
1963 1 2	65.0
1964 2 20	83.0
1965 1 3	54.0
1966 2 28	42.0
1967 1 21	87.0
1967 12 23	47.0
1969 1 26	82.0
1970 2 28	82.0
1971 2 18	66.0
1971 12 27	58.0
1973 2 18	55.0
1974 2 15	82.0
1974 12 25	48.0
1976 3 7	45.0
1977 2 26	69.0
1978 1 22	93.0
1978 12 13	87.4
1980 1 27	43.0
1981 2 20	84.0
1982 2 6	55.0
1982 12 12	72.0
1984 3 6	55.0
1984 12 18	65.0
1985 12 11	58.0
1986 12 10	67.0
1988 3 6	78.0
1989 1 22	68.0
1990 1 1	76.0
1991 1 27	42.0
1992 1 5	58.0
1992 12 14	50.0

Lundazi

Date of occurrence	daily rainfall
1956 3 29	47.0
1957 2 20	74.0
1957 12 18	31.0
1958 12 24	55.0
1960 3 3	90.0
1961 1 6	84.0
1962 1 5	46.0
1963 2 15	112.0
1964 2 22	80.0
1965 2 11	76.0
1966 3 8	76.0
1967 1 21	73.0
1968 2 4	71.0
1969 1 5	65.0
1970 3 3	40.0
1972 1 25	42.0
1973 3 9	127.0
1974 3 11	52.0
1975 3 11	64.0
1976 3 19	54.0
1977 1 17	51.0
1977 12 23	66.0
1979 2 20	84.0
1980 1 11	76.0
1980 12 23	66.0
1982 4 20	55.0
1983 4 4	57.0
1984 2 24	46.0
1984 12 19	57.0
1985 12 2	76.0
1987 3 9	77.0
1988 3 14	78.0
1989 1 17	76.0
1990 1 2	54.0
1991 2 17	42.0
1992 3 28	86.0
1993 1 31	55.0

Petauke

Date of occurrence	daily rainfall
1950 1 24	118.0
1951 2 10	95.0
1952 1 25	64.0
1953 3 3	59.0
1954 2 12	53.0
1955 1 11	61.0
1955 11 28	61.0
1957 3 10	56.0
1958 2 17	67.0
1958 12 8	77.0
1959 12 13	105.0
1961 2 15	83.0
1961 12 16	58.0
1963 2 25	60.0
1964 2 6	81.0
1965 1 18	57.0
1966 3 1	47.0
1967 2 20	67.0
1968 4 15	42.0
1969 2 9	48.0
1970 2 2	56.0
1970 12 2	81.0
1972 2 21	86.0
1972 11 7	58.0
1974 2 26	60.0
1974 12 27	47.0
1976 2 21	59.0
1976 12 20	73.0
1977 11 12	79.0
1978 12 16	53.0
1980 2 26	64.0
1981 2 6	55.0
1982 2 8	83.0
1983 1 20	88.0
1984 1 20	61.0
1985 1 10	60.0
1986 1 1	72.0
1987 1 17	40.0
1988 3 4	78.0
1988 2 8	89.0
1989 12 1	103.0
1991 1 2	55.0
1992 1 22	35.0
1993 1 23	82.0
1993 10 28	4.0

Livingstone

Date of occurrence	daily rainfall
1933 1 18	72.0
1934 1 17	144.0
1934 12 31	53.0
1936 2 16	49.0
1936 12 13	64.0
1947 7 1	91.0
1947 12 28	100.0
1949 1 20	51.0
1950 2 28	46.0
1951 1 21	51.0
1952 1 7	118.0
1952 11 5	52.0
1954 2 11	53.0
1955 1 6	81.0
1956 3 26	60.0
1956 12 1	37.0
1957 12 9	65.0
1959 1 7	99.0
1960 3 24	32.0
1961 2 5	69.0
1961 12 2	53.0
1962 12 20	35.0
1964 1 8	93.0
1964 12 6	74.0
1966 1 18	42.0
1967 2 13	72.0
1968 1 24	33.0
1969 3 14	91.0
1970 1 17	47.0
1971 1 19	62.0
1972 1 18	56.0
1973 1 5	67.0
1973 11 24	53.0
1974 12 19	42.0
1976 3 19	53.0
1977 2 7	55.0
1978 3 8	85.0
1978 12 15	74.0
1979 12 28	35.0
1981 2 27	88.0
1982 5 7	37.0
1983 4 6	83.0
1983 12 24	66.0
1985 1 25	49.0
1985 12 26	63.0
1987 1 28	76.0
1987 12 6	71.0
1989 2 26	42.0
1990 1 16	64.0
1990 1 4	55.0
1991 12 21	88.0
1993 1 1	117.0

Choma

Date of occurrence	daily rainfall
1950 2 15	72.0
1951 3 20	79.0
1952 2 25	53.0
1953 3 20	69.0
1954 2 6	73.0
1954 12 6	73.0
1956 2 5	88.0
1957 2 15	116.0
1957 12 25	59.0
1958 12 13	83.0
1959 12 21	61.0
1960 12 21	47.0
1962 1 18	37.0
1962 12 15	50.0
1964 1 3	46.0
1965 1 21	79.0
1967 3 20	53.0
1968 1 20	61.0
1969 2 18	90.0
1969 12 26	55.0
1971 1 21	63.0
1972 1 31	70.0
1973 1 5	43.0
1974 1 9	68.0
1974 12 28	67.0
1976 3 25	66.0
1977 1 29	35.0
1977 12 17	81.0
1978 12 25	51.0
1979 11 25	88.0
1980 11 15	65.0
1982 2 19	68.0
1983 1 24	88.0
1983 12 4	83.0
1984 11 19	68.0
1986 1 11	84.0
1986 11 9	73.0
1988 2 13	46.0
1989 1 14	53.0
1990 2 7	53.0
1990 12 15	66.0
1992 1 22	37.0
1992 12 12	63.0

Kafue Polder

Date of occurrence	daily rainfall
1950 1 24	87.0
1950 12 8	59.0
1959 12 15	64.0
1961 1 20	107.0
1962 4 12	77.0
1962 12 17	64.0
1964 1 6	48.0
1964 12 27	82.0
1966 1 31	51.0
1966 12 19	32.0
1967 12 2	56.0
1969 3 21	60.0
1969 12 7	63.0
1970 11 24	110.0
1971 12 31	147.0
1973 2 25	102.0
1973 12 26	59.0
1974 11 21	107.0
1976 4 7	67.0
1977 1 15	44.0
1977 11 30	78.0
1978 12 15	70.0
1980 1 24	57.0
1981 2 23	54.0
1981 12 25	82.0
1983 1 22	57.0
1984 2 9	44.0
1985 1 18	48.0
1986 4 17	56.0
1986 10 16	93.0
1988 1 7	44.0
1989 2 8	100.0
1990 1 26	60.0
1990 12 26	83.0
1992 1 11	75.0
1992 12 15	43.0

Mongu

Date of occurrence	daily rainfall
1935 3 30	42.0
1935 12 21	77.0
1937 2 16	83.0
1937 12 20	98.0
1945 3 10	52.0
1945 12 21	68.0
1947 2 26	48.0
1948 2 5	63.0
1951 1 21	51.0
1952 1 7	148.0
1952 11 5	52.0
1955 1 28	61.0
1956 4 20	51.0
1957 2 23	108.0
1958 1 24	85.0
1958 11 30	71.0
1959 12 23	49.0
1961 1 13	52.0
1962 1 13	82.0
1962 12 30	83.0
1963 12 6	60.0
1965 4 1	44.0
1966 1 11	66.0
1967 1 22	38.0
1968 4 16	104.0
1969 2 13	237.0
1969 10 18	53.0
1971 1 22	82.0
1972 1 6	74.0
1973 2 13	65.0
1974 2 17	104.0
1974 12 28	50.0
1976 3 22	67.0
1977 3 5	60.0
1977 12 20	88.0
1979 1 28	46.0
1980 2 19	48.0
1981 2 21	91.0
1982 2 27	57.0
1982 11 17	48.0
1984 1 12	36.0
1984 12 13	36.0
1985 12 2	66.0
1986 12 8	40.0
1988 1 5	67.0
1989 2 21	82.0
1990 1 12	65.0
1991 2 9	19.0
1992 1 22	68.0
1993 4 12	106.0

Table 3-2(2) Annual Maximum Daily Rainfall

Kaoma

Date of occurrence	daily rainfall
1951 2 16	57.9
1951 12 22	51.0
1952 12 11	35.0
1954 1 9	37.0
1955 1 2	67.0
1956 2 13	43.9
1957 1 21	63.0
1958 1 10	55.0
1959 11 18	145.0
1970 1 20	66.0
1971 1 7	59.0
1971 12 31	42.9
1972 12 18	31.0
1974 2 17	87.0
1974 12 18	87.0
1975 1 21	55.0
1977 2 27	71.0
1978 2 2	57.9
1978 12 5	83.0
1979 12 2	59.0
1981 1 9	63.0
1981 12 29	41.0
1982 10 13	51.0
1984 1 12	75.0
1985 1 13	47.0
1986 4 17	78.0
1987 1 18	50.0
1988 2 18	79.0
1989 1 14	65.0
1990 4 4	67.0
1990 12 26	34.0
1992 1 30	51.0
1993 3 4	62.0

Sesheke

Date of occurrence	daily rainfall
1950 1 11	73.0
1951 3 20	111.0
1952 2 2	47.0
1953 1 2	51.0
1953 12 19	74.0
1954 12 20	88.0
1955 12 31	45.0
1957 2 5	55.0
1959 2 22	101.0
1958 12 12	85.0
1960 2 13	82.0
1961 3 14	54.0
1962 1 27	40.0
1962 12 12	43.0
1963 12 4	65.0
1964 12 11	38.0
1966 3 3	53.0
1967 1 23	36.0
1967 10 30	166.0
1969 3 14	60.0
1969 11 27	39.0
1971 1 22	43.0
1972 4 2	65.0
1973 2 16	31.0
1974 2 24	45.0
1975 3 19	61.0
1976 3 20	41.0
1977 2 7	92.0
1977 12 27	91.0
1982 10 17	36.0
1983 12 27	41.0
1985 1 23	32.0
1986 1 2	58.0
1986 11 30	32.0
1988 2 13	71.0
1989 1 25	59.0
1990 4 3	56.0
1991 2 10	41.0
1991 12 22	69.0
1993 1 31	49.0

Ndola

Date of occurrence	daily rainfall
1942 11 6	41.0
1945 3 1	135.0
1946 2 17	54.0
1948 1 11	93.0
1949 12 5	33.4
1950 1 26	85.0
1950 12 23	67.0
1952 3 4	71.0
1952 12 11	43.0
1953 12 8	106.0
1955 2 22	79.0
1956 2 8	85.0
1956 12 13	39.0
1958 3 12	77.0
1958 11 8	33.0
1960 2 22	63.0
1961 2 11	84.0
1961 12 15	36.
1962 12 15	45.0
1963 12 4	48.0
1965 1 25	65.0
1966 2 6	82.0
1967 1 3	76.0
1967 11 1	55.0
1969 1 24	110.0
1970 3 8	67.0
1970 12 18	55.0
1972 2 26	165.0
1972 12 9	39.0
1974 1 9	91.0
1975 2 9	47.0
1975 12 28	48.0
1977 3 14	62.4
1977 12 18	65.0
1979 3 28	84.9
1979 12 10	62.0
1981 2 12	60.4
1982 1 6	59.0
1982 12 18	81.0
1983 12 29	81.0
1984 12 6	53.0
1985 11 10	56.0
1987 3 13	57.0
1987 12 3	54.0
1989 2 11	43.0
1990 2 13	50.0
1991 1 18	78.0
1991 11 13	38.0
1993 1 31	119.0

Solwezi

Date of occurrence	daily rainfall
1951 3 19	69.0
1952 1 29	50.0
1952 12 2	58.0
1953 12 4	69.0
1955 1 29	66.0
1965 3 1	51.0
1967 2 4	78.0
1968 2 7	77.9
1969 1 4	90.0
1969 12 16	53.0
1970 11 11	58.0
1972 1 27	102.0
1973 3 5	72.0
1974 1 30	35.0
1974 11 26	58.0
1976 2 24	77.0
1977 1 14	73.0
1978 3 14	65.0
1978 12 3	58.0
1979 12 22	65.0
1981 2 16	81.0
1982 2 12	69.0
1983 4 6	71.0
1983 12 19	70.0
1985 5 13	59.0
1985 12 14	59.0
1987 2 10	69.0
1987 12 30	81.0
1989 3 23	51.0
1989 3 25	127.0
1991 1 25	130.0
1992 2 14	92.0
1993 1 5	84.0

Mwinilunga

Date of occurrence	daily rainfall
1950 1 11	31.0
1955 10 22	72.9
1952 3 14	66.4
1953 2 24	59.4
1954 3 17	61.0
1954 12 6	37.0
1955 11 23	82.0
1957 3 29	55.0
1957 10 3	56.0
1958 12 24	93.0
1959 12 11	59.0
1961 3 13	49.0
1962 2 11	35.0
1962 12 3	92.0
1963 11 7	54.0
1964 12 25	67.0
1965 3 1	95.0
1967 3 19	50.0
1969 3 14	76.0
1969 3 18	76.0
1970 3 12	61.0
1970 12 19	80.0
1971 12 18	73.0
1973 2 21	123.0
1973 11 3	60.0
1975 1 18	71.0
1976 2 28	81.0
1976 12 17	63.0
1977 11 20	53.0
1979 3 9	73.0
1980 4 11	83.0
1989 10 23	71.0
1981 11 27	82.0
1983 1 20	63.0
1984 2 1	62.0
1985 3 25	67.0
1986 3 21	93.0
1988 11 12	85.0
1989 1 9	74.0
1989 2 14	73.0
1992 1 21	48.0
1992 2 28	81.0
1991 12 7	116.0
1993 2 6	73.0

Zambezi

Date of occurrence	daily rainfall
1933 12 9	53.9
1934 12 15	135.9
1935 1 4	57.9
1937 1 19	65.9
1937 12 31	34.9
1939 2 1	76.9
1939 1 22	55.9
1939 12 21	51.9
1942 2 14	54.0
1942 12 11	63.9
1944 3 13	110.9
1945 2 15	59.9
1955 12 3	91.9
1957 1 11	43.0
1957 12 23	61.0
1959 11 12	43.0
1953 10 13	45.0
1970 11 28	47.0
1972 1 2	75.0
1971 2 21	39.0
1974 3 1	93.0
1975 2 23	51.0
1975 1 27	33.0
1975 12 18	35.0
1977 12 2	70.9
1979 2 13	59.9
1980 3 2	63.9
1981 2 15	55.9
1982 1 21	47.9
1982 12 9	47.0
1984 3 17	55.0
1985 2 2	41.9
1985 3 15	45.0
1985 12 8	65.0
1987 12 14	73.0
1988 1 1	67.0
1988 12 23	52.9
1990 12 27	56.9
1991 12 20	97.9
1992 11 25	53.9

Kabompo

Date of occurrence	daily rainfall
1951 1 6	34.0
1961 11 13	77.0
1952 11 30	78.0
1963 11 19	49.0
1964 12 21	52.0
1966 3 1	91.0
1967 3 3	96.0
1968 2 7	77.0
1968 11 25	53.0
1969 12 2	53.0
1970 11 27	74.0
1971 11 29	62.0
1973 2 8	40.0
1973 11 13	57.0
1975 2 9	53.0
1976 3 15	46.0
1977 2 25	64.0
1978 3 25	33.0
1979 1 27	71.0
1979 12 15	66.0
1981 3 4	80.0
1982 1 26	71.0
1982 12 9	53.0
1984 1 31	69.0
1985 3 16	91.0
1986 3 1	59.0
1986 12 6	55.0
1988 2 29	64.0
1988 11 9	78.0
1990 1 8	53.0
1990 12 20	87.0
1991 12 20	82.0
1993 1 26	78.0

Kasempa

Date of occurrence	daily rainfall
1938 1 14	57.0
1938 11 13	41.0
1939 12 23	80.9
1941 2 7	113.0
1942 1 15	121.0
1942 12 7	49.0
1944 1 12	42.0
1946 3 4	182.0
1947 1 9	30.0
1949 3 3	38.0
1949 12 29	233.0
1950 12 10	65.0
1952 2 12	64.0
1952 11 12	54.0
1954 1 20	46.0
1955 2 7	59.0
1955 3 9	181.0
1956 11 4	63.0
1957 11 30	51.0
1958 12 11	63.0
1960 1 6	76.0
1960 12 31	73.0
1962 2 2	48.0
1962 12 3	67.0
1964 1 13	41.0
1965 1 5	53.0
1966 3 4	55.0
1967 1 4	46.0
1968 3 10	67.0
1968 12 3	117.0
1969 11 12	55.0
1970 11 10	72.0
1971 12 2	150.0
1972 11 25	46.0
1973 12 12	50.0
1975 2 3	74.0
1976 1 27	50.0
1977 1 12	83.0
1978 4 15	59.0
1979 1 23	94.0
1980 3 4	99.0
1981 1 8	119.0
1982 2 22	91.0
1982 10 18	45.0
1984 1 13	51.0
1984 11 11	59.0
1986 1 26	76.0
1987 2 24	41.0
1987 11 29	33.0
1989 1 28	41.0
1990 1 4	74.0
1991 3 16	54.0
1992 3 22	74.0
1992 12 9	78.0

Mansa

Date of occurrence	daily rainfall
1950 1 5	61.0
1960 12 25	61.0
1962 4 9	66.0
1963 1 19	55.0
1963 12 6	57.0
1965 2 1	84.0
1966 2 3	61.0
1967 3 21	66.0
1968 1 20	50.0
1969 2 15	38.0
1969 10 16	56.0
1970 11 21	57.0
1972 11 23	45.0
1973 3 20	69.0
1974 1 3	63.0
1975 3 10	95.0
1976 3 17	54.0
1976 12 4	55.0
1978 4 23	42.0
1979 3 20	57.0
1980 3 6	84.0
1981 1 21	75.0
1982 2 6	52.0
1982 10 28	60.0
1984 1 31	54.0
1985 2 24	77.0
1985 12 8	59.0
1987 2 10	55.0
1988 1 24	46.0
1988 12 15	48.0
1989 12 16	60.0
1990 12 11	60.0
1992 2 8	65.0
1992 12 22	72.0

Kawambwa

Date of occurrence	daily rainfall
1951 1 8	42.0
1951 10 25	80.0
1959 3 7	40.0
1949 3 24	35.0
1951 1 11	72.0
1951 12 10	80.0
1952 11 8	69.0
1953 10 25	68.0
1955 3 1	61.0
1955 3 14	62.0
1957 3 24	53.0
1957 11 28	63.0
1969 11 27	65.0
1959 11 9	56.0
1971 1 6	66.0
1972 3 16	79.0
1973 3 12	77.0
1974 5 18	65.0
1974 10 16	69.0
1975 2 16	59.0
1977 3 30	56.0
1977 10 23	61.0
1978 12 19	81.0
1980 1 3	66.0
1980 11 14	71.0
1982 1 30	72.0
1982 12 20	48.0
1984 1 5	40.0
1985 1 15	61.0
1985 12 3	74.0
1987 3 31	81.0
1988 2 13	70.0
1989 2 16	65.0
1990 2 13	40.0
1991 3 23	77.0
1992 3 22	42.0
1992 11 21	61.0

Table 3-3 (1) Annual Maximum 2-day Rainfall

Lusaka

Date of occurrence	2-days rainfall
1950 1 14	118.0
1951 2 27	51.0
1952 1 24	85.0
1952 12 30	75.0
1954 1 20	79.0
1954 12 28	61.0
1956 2 5	65.0
1957 2 24	62.0
1958 1 25	69.0
1958 12 13	66.0
1959 12 29	96.0
1961 1 17	61.0
1962 3 10	111.0
1962 12 23	81.0
1964 1 5	52.0
1965 1 3	85.0
1966 2 4	62.0
1966 12 18	67.0
1974 3 28	198.0
1975 1 27	107.0
1976 3 14	52.0
1977 2 16	61.0
1977 12 15	119.0
1978 12 15	115.4
1980 3 27	59.0
1981 3 4	72.4
1982 1 22	95.0
1983 1 22	83.0
1984 2 1	53.0
1985 1 23	56.0
1986 4 17	94.0
1986 12 8	55.0
1988 3 11	115.0
1989 2 4	103.0
1990 4 29	68.0
1991 4 2	136.0
1991 11 14	64.0
1993 1 10	69.0

Kabwe

Date of occurrence	2-days rainfall
1950 2 18	57.0
1951 1 30	87.0
1952 1 28	73.0
1953 3 20	105.0
1953 12 18	93.0
1955 2 25	104.0
1956 4 21	65.0
1957 1 8	46.0
1957 12 14	95.0
1959 2 10	93.0
1959 12 28	149.0
1961 1 13	90.0
1962 3 18	130.0
1963 1 2	104.0
1964 2 6	130.0
1965 1 20	127.0
1966 1 31	81.0
1967 1 3	74.0
1967 12 4	123.0
1968 12 31	111.0
1969 12 28	95.0
1971 2 15	75.0
1972 1 3	76.0
1973 2 14	113.0
1973 11 28	67.0
1974 11 19	83.0
1976 3 24	105.0
1977 3 1	80.0
1978 2 13	143.0
1978 12 25	98.0
1979 11 21	66.0
1980 12 16	78.0
1982 2 18	63.0
1983 1 24	95.0
1983 12 3	98.0
1984 12 16	97.0
1986 1 12	81.0
1987 1 23	66.0
1987 12 7	68.0
1989 1 31	69.0
1989 12 31	71.0
1991 1 21	93.0
1991 12 27	66.6
1992 12 18	69.0

Kasama

Date of occurrence	2-days rainfall
1933 12 28	132.0
1935 1 18	73.0
1935 12 28	100.0
1937 1 4	92.0
1938 2 11	97.0
1939 1 19	86.0
1940 3 23	48.0
1941 3 27	140.0
1946 1 15	77.0
1946 12 18	81.0
1947 12 26	75.0
1949 1 8	56.0
1950 1 25	71.0
1951 3 17	79.0
1952 3 27	86.0
1953 1 30	71.0
1953 12 30	88.0
1955 1 16	84.0
1956 1 30	82.0
1957 4 20	105.0
1958 2 13	84.0
1959 4 3	60.0
1960 3 13	76.0
1961 1 24	94.0
1961 12 7	94.0
1963 1 18	81.0
1963 12 25	84.0
1965 2 11	88.0
1965 12 21	81.0
1966 11 13	58.0
1968 4 22	70.0
1969 1 20	56.0
1970 3 15	101.0
1971 3 5	71.0
1971 11 11	87.0
1973 4 12	89.0
1973 12 5	70.4
1975 4 4	93.0
1976 1 17	107.0
1977 3 31	92.0
1978 3 15	86.0
1979 2 1	86.0
1979 12 29	180.0
1980 12 4	151.0
1982 4 15	86.0
1983 1 14	114.0
1984 3 21	100.0
1984 11 12	121.0
1986 1 23	88.0
1986 12 20	85.0
1988 2 5	98.0
1988 11 18	78.0
1989 11 13	128.0
1991 1 12	101.0
1992 2 5	87.0
1992 12 20	73.0

Mbala

Date of occurrence	2-days rainfall
1961 3 13	68.0
1961 12 13	98.0
1963 2 8	111.0
1963 11 27	62.0
1965 1 1	107.0
1966 3 17	85.0
1967 4 21	72.0
1967 11 24	69.0
1969 2 8	41.0
1970 2 19	80.0
1971 1 26	82.0
1971 12 24	83.0
1973 1 21	82.0
1974 1 5	78.0
1975 1 2	102.0
1975 12 12	75.0
1977 1 31	58.0
1977 12 26	63.0
1979 3 31	72.0
1979 12 3	64.0
1981 1 30	92.0
1982 3 4	103.0
1982 12 26	79.0
1984 1 14	66.0
1985 2 8	68.0
1986 2 17	99.0
1986 12 17	95.0
1988 3 20	75.0
1989 4 2	110.0
1990 4 9	89.0
1991 3 20	116.0
1992 1 3	79.0
1992 12 28	95.0

Mpika

Date of occurrence	2-days rainfall
1933 1 28	71.4
1934 2 25	88.4
1935 1 6	72.4
1936 2 16	84.4
1937 1 3	93.0
1937 12 25	71.0
1944 3 21	88.0
1945 1 14	103.0
1947 2 23	59.0
1947 11 30	90.0
1949 1 7	54.0
1950 1 28	137.0
1951 1 5	102.0
1952 1 11	98.0
1953 3 12	74.0
1954 1 9	74.0
1955 3 4	83.0
1956 3 19	76.0
1957 2 18	78.0
1958 2 13	134.0
1959 3 12	70.0
1959 12 25	32.0
1960 12 14	58.0
1962 1 3	108.0
1963 3 17	51.0
1963 11 15	103.0
1965 1 2	66.0
1965 12 8	120.0
1966 12 12	82.0
1967 12 7	89.0
1969 2 6	70.0
1970 2 3	61.0
1970 12 21	76.0
1972 2 28	73.0
1973 2 17	88.0
1974 4 2	232.0
1974 12 28	78.0
1975 12 22	62.0
1977 2 26	87.0
1978 3 16	80.0
1979 2 2	87.0
1980 2 25	90.0
1981 2 17	85.0
1981 11 29	77.0
1983 2 15	46.0
1984 2 20	75.0
1984 12 28	102.9
1986 1 28	87.0
1986 12 18	73.0
1988 3 15	96.0
1989 4 1	155.0
1990 2 25	124.0
1991 1 6	98.0
1991 12 21	125.0
1993 1 23	73.0

Chipata

Date of occurrence	2-days rainfall
1946 3 16	61.0
1947 3 2	73.0
1948 3 25	70.0
1948 12 1	61.0
1950 2 17	138.0
1951 2 11	67.0
1951 12 15	84.0
1953 1 8	79.0
1954 2 18	58.0
1955 1 13	152.0
1956 2 2	87.0
1956 12 18	84.0
1958 1 25	88.0
1959 1 13	124.0
1959 12 14	113.0
1961 2 18	97.0
1962 1 30	84.0
1963 1 2	74.0
1964 1 11	91.0
1965 1 4	67.0
1966 1 3	56.0
1967 1 22	89.0
1968 3 5	70.0
1969 1 26	121.0
1970 3 3	83.0
1971 2 18	100.0
1972 2 22	75.0
1973 2 18	92.0
1974 2 16	69.0
1975 3 3	69.0
1976 2 13	79.0
1977 2 26	166.0
1978 1 21	149.0
1978 12 19	168.0
1980 3 8	54.0
1981 2 21	140.0
1982 2 6	85.0
1982 12 12	102.0
1984 3 7	83.0
1984 12 17	92.0
1985 12 11	72.0
1986 12 18	59.0
1988 3 15	59.0
1989 1 22	109.0
1989 11 16	87.0
1991 2 28	51.0
1992 1 6	68.0
1992 12 15	94.0

Lundazi

Date of occurrence	2-days rainfall
1956 3 30	75.0
1957 2 28	50.0
1957 12 19	35.0
1959 1 15	85.0
1959 12 12	90.0
1961 1 1	72.0
1961 12 27	68.0
1963 2 18	126.0
1964 2 22	86.0
1965 2 12	77.0
1966 3 8	80.0
1967 4 14	81.0
1968 2 4	71.0
1968 12 15	70.0
1970 1 4	52.0
1972 3 25	42.0
1973 3 18	123.0
1974 3 12	53.0
1975 3 11	68.0
1976 1 18	67.0
1976 12 11	59.0
1978 3 15	83.0
1979 2 21	85.0
1980 1 12	120.0
1980 12 24	90.0
1981 12 26	72.0
1983 2 13	57.0
1984 2 14	52.6
1984 12 20	76.0
1985 12 3	55.0
1987 3 18	81.0
1988 3 15	103.0
1989 1 13	124.0
1990 1 2	73.0
1991 2 17	64.0
1992 3 29	90.0
1993 1 16	78.0

Petauke

Date of occurrence	2-days rainfall
1950 1 24	148.0
1951 2 11	103.0
1952 1 25	67.0
1953 3 3	143.0
1954 2 13	75.0
1955 1 12	31.0
1956 2 27	84.0
1957 1 22	72.0
1957 12 11	113.0
1959 1 13	107.0
1959 12 14	175.0
1961 2 16	127.0
1961 12 17	94.0
1963 2 25	83.0
1964 2 8	107.0
1965 1 1	79.0
1966 3 1	65.0
1967 2 28	125.0
1968 2 28	71.0
1969 2 9	49.0
1970 2 2	76.0
1970 12 3	90.0
1972 2 22	89.0
1972 11 8	96.0
1974 1 3	71.0
1975 2 28	69.0
1976 2 21	15.0
1976 12 21	95.0
1978 2 2	83.0
1978 12 16	78.0
1980 3 4	90.0
1981 2 6	74.0
1982 2 7	118.0
1983 1 20	78.0
1984 1 20	78.0
1985 3 19	104.0
1986 1 2	76.0
1986 12 10	51.0
1988 3 5	88.0
1989 1 8	96.4
1989 12 1	103.4
1991 1 28	79.4
1992 1 23	37.4
1993 1 24	83.4
1993 10 28	4.4

Livingstone

Date of occurrence	2-days rainfall
1932 12 28	39.0
1934 1 17	159.0
1934 12 13	79.0
1936 2 13	72.0
1936 12 13	97.0
1947 2 1	98.0
1947 12 20	103.0
1949 3 23	63.0
1950 2 18	73.0
1951 1 22	89.0
1952 1 4	213.0
1952 11 6	62.0
1954 2 11	55.0
1955 1 6	83.0
1956 3 26	90.0
1957 1 11	56.0
1958 1 18	101.0
1959 1 8	123.0
1959 12 27	45.0
1961 2 8	103.0
1961 12 2	55.0
1962 12 29	162.0
1964 3 9	105.0
1964 12 6	101.0
1966 1 29	71.0
1967 2 13	72.0
1968 1 25	55.0
1969 3 14	98.0
1969 12 23	56.0
1970 12 22	89.0
1972 4 3	65.0
1973 1 9	73.0
1973 12 23	72.0
1974 12 13	101.0
1976 3 20	88.0
1977 2 8	71.0
1978 3 9	117.0
1978 12 15	104.0
1979 12 7	39.0
1981 2 28	65.0
1981 11 28	47.0
1983 1 24	78.0
1983 12 25	68.0
1985 1 28	51.0
1985 12 25	64.0
1987 1 15	99.0
1987 12 6	100.0
1989 2 26	140.0
1990 1 3	88.0
1991 1 3	83.0
1991 12 23	130.0
1993 1 1	152.0

Choma

Date of occurrence	2-days rainfall
1950 2 15	80.0
1951 3 21	53.0
1952 2 25	74.0
1953 3 21	87.0
1954 2 7	80.0
1954 12 7	186.0
1956 2 5	88.0
1957 1 18	124.0
1957 12 28	92.0
1958 12 13	145.0
1960 2 10	87.0
1960 12 30	57.0
1962 1 11	61.0
1962 12 25	78.0
1963 12 3	64.0
1965 1 23	188.0
1966 2 21	40.0
1967 1 22	58.0
1968 1 21	119.0
1969 2 18	98.0
1969 12 18	85.0
1971 1 13	73.0
1972 2 1	81.0
1973 2 24	55.0
1974 2 13	117.0
1974 12 20	98.0
1975 12 26	96.0
1977 1 29	40.0
1977 12 18	139.0
1978 12 13	64.0
1979 11 26	95.0
1980 11 28	76.0
1981 11 27	75.0
1983 1 24	124.0
1983 12 5	96.0
1985 2 3	75.0
1986 2 26	108.0
1986 11 9	73.0
1988 2 24	48.0
1989 1 27	96.0
1990 2 2	82.0
1990 12 15	66.0
1991 12 23	56.0
1993 2 25	70.0

Kafue Polder

Date of occurrence	2-days rainfall
1957 12 26	110.0
1958 12 9	73.0
1959 12 16	82.0
1961 1 21	110.0
1962 4 13	83.0
1962 12 1	67.0
1964 1 7	78.0
1964 12 18	114.0
1966 1 18	68.0
1966 12 20	165.0
1967 12 3	66.0
1968 12 8	51.0
1969 12 5	75.0
1970 11 25	115.0
1972 1 1	148.0
1973 2 25	118.0
1974 2 12	75.0
1974 11 24	118.0
1976 4 4	74.0
1976 12 10	45.0
1977 12 1	40.0
1978 12 15	138.0
1979 12 10	85.0
1981 1 12	85.0
1981 12 29	88.0
1982 11 23	79.0
1984 2 10	53.0
1985 2 6	57.0
1986 4 17	85.0
1986 10 17	100.0
1988 1 8	98.0
1989 2 6	113.0
1990 1 29	155.0
1991 2 14	89.0
1992 1 15	15.0
1992 12 15	76.0

Mongu

Date of occurrence	2-days rainfall
1935 3 30	41.0
1935 12 22	54.0
1937 2 18	101.0
1937 12 21	119.0
1945 3 11	88.0
1945 12 31	88.0
1947 2 28	82.0
1948 2 5	35.0
1948 12 27	28.0
1951 1 22	88.0
1952 1 8	213.0
1952 11 6	62.0
1955 1 24	63.0
1955 12 21	66.0
1957 2 24	177.0
1958 2 3	125.0
1958 12 1	139.0
1959 12 24	75.0
1961 1 8	81.0
1962 1 14	122.0
1962 12 30	104.0
1963 12 6	97.0
1965 2 25	58.0
1965 11 16	58.0
1967 1 31	46.0
1968 4 17	165.0
1969 2 17	251.0
1969 10 19	54.0
1971 1 23	69.0
1972 1 5	87.0
1973 2 24	69.0
1974 2 18	115.0
1974 12 14	88.0
1975 12 24	83.0
1977 3 5	94.0
1977 12 21	94.0
1978 12 12	66.0
1979 12 6	58.0
1981 2 21	108.0
1982 2 27	53.0
1982 11 27	73.0
1984 3 13	53.0
1985 2 8	58.0
1985 12 2	68.0
1986 12 9	87.0
1987 12 3	76.0
1989 2 21	116.0
1990 1 12	65.0
1991 2 18	116.0
1992 1 22	71.0
1993 4 12	166.0

Table 3-3(2) Annual Maximum 2-day Rainfall

Kaoma

Date of occurrence	2-day rainfall
1961 2 17	81.0
1962 12 22	77.0
1963 3 2	71.0
1964 2 16	57.0
1965 1 2	102.0
1966 2 15	70.0
1967 1 22	81.0
1968 1 11	50.0
1968 12 18	145.0
1970 1 21	72.0
1971 1 7	75.0
1971 12 31	52.0
1972 12 10	54.0
1974 2 17	82.0
1974 12 18	87.0
1976 3 15	75.0
1977 2 20	81.0
1978 1 31	81.0
1978 12 12	99.0
1979 12 3	63.0
1981 1 9	67.0
1982 1 4	33.0
1983 1 13	52.0
1984 1 12	69.0
1985 1 13	58.0
1986 1 16	103.0
1987 1 19	98.0
1988 2 10	79.0
1989 1 15	54.0
1990 1 1	87.0
1991 1 23	44.0
1992 3 10	62.0
1993 3 4	78.0

Sesheke

Date of occurrence	2-day rainfall
1950 1 18	87.0
1951 1 20	151.0
1952 2 2	83.0
1953 3 1	78.0
1953 12 28	110.0
1954 12 28	188.0
1956 1 3	38.0
1956 11 6	50.0
1958 2 23	152.0
1959 1 7	91.0
1960 2 13	86.0
1961 3 7	61.0
1962 1 23	42.0
1963 2 25	62.0
1963 12 4	70.0
1965 2 26	55.0
1966 3 4	82.0
1967 1 24	66.0
1967 10 30	109.0
1969 3 15	75.0
1970 1 2	35.0
1970 12 23	71.0
1972 1 23	101.0
1973 2 19	64.0
1974 2 24	81.0
1975 3 19	41.0
1976 3 20	81.0
1977 2 7	171.0
1977 12 27	189.0
1982 2 19	35.0
1983 1 23	53.0
1983 12 27	63.0
1985 2 8	75.0
1985 12 20	75.0
1987 2 7	88.0
1988 2 15	48.0
1989 1 28	86.0
1990 2 8	88.0
1991 2 11	67.0
1991 12 23	129.0
1993 2 1	51.0

Ndola

Date of occurrence	2-day rainfall
1942 11 5	49.0
1945 5 11	115.0
1945 12 11	56.0
1948 1 12	86.0
1948 12 1	31.0
1950 1 28	59.0
1950 12 23	78.0
1951 12 17	103.0
1952 11 11	68.0
1953 12 1	113.0
1955 1 28	85.0
1956 2 9	100.0
1956 12 14	103.0
1958 3 12	72.0
1959 2 11	66.0
1960 2 15	68.0
1961 2 19	90.0
1961 12 18	119.0
1963 1 4	69.0
1964 1 5	109.0
1965 1 27	70.0
1965 12 10	82.0
1967 1 25	59.0
1967 11 1	55.0
1969 1 25	143.0
1970 1 20	84.0
1970 11 18	65.0
1972 2 22	141.0
1972 12 7	82.0
1974 2 21	119.0
1974 12 29	148.0
1975 12 28	110.0
1977 1 22	73.0
1977 12 11	132.0
1979 3 21	85.0
1979 12 11	72.0
1981 2 13	95.0
1982 1 8	81.0
1983 1 25	120.0
1983 12 30	95.0
1984 12 7	118.0
1985 11 11	78.0
1987 2 24	76.0
1987 12 3	60.0
1989 2 11	120.0
1990 3 25	114.0
1991 1 18	151.0
1991 12 18	52.0
1993 2 1	123.0

Solwezi

Date of occurrence	2-day rainfall
1961 3 20	97.0
1962 4 9	59.0
1963 1 15	68.0
1963 12 5	83.0
1964 11 21	83.0
1966 2 27	86.0
1967 3 4	87.0
1968 2 7	78.0
1969 1 5	139.0
1969 12 4	78.0
1970 11 11	84.0
1972 2 28	118.0
1973 3 6	76.0
1974 1 31	84.0
1975 3 16	60.0
1976 2 24	104.0
1977 3 14	76.0
1978 3 15	117.0
1978 12 2	116.0
1979 12 21	76.0
1981 2 17	84.0
1982 2 13	71.0
1983 4 6	100.0
1984 2 10	114.0
1985 1 27	55.0
1985 12 14	78.0
1987 2 10	116.0
1987 12 31	90.0
1989 3 23	93.0
1990 3 26	133.0
1991 1 26	166.0
1991 10 28	107.0
1993 1 5	103.0

Mwinilunga

Date of occurrence	2-day rainfall
1950 3 12	72.0
1950 10 23	79.0
1952 3 15	72.0
1953 2 26	73.0
1954 3 10	79.0
1954 12 9	55.0
1955 11 25	73.0
1957 2 25	75.0
1957 10 4	55.0
1958 12 21	100.0
1960 3 1	79.0
1961 1 31	91.0
1962 2 12	85.0
1962 12 3	110.0
1963 11 8	73.0
1964 12 25	107.0
1966 3 16	138.0
1967 3 20	60.0
1968 3 15	105.0
1969 1 22	97.0
1970 3 12	80.0
1971 2 4	92.0
1971 12 16	76.0
1973 2 21	124.0
1974 4 5	70.0
1975 1 19	81.0
1976 2 28	89.0
1976 12 17	70.0
1978 3 22	57.0
1978 12 26	76.0
1980 4 11	83.0
1980 10 23	71.0
1981 11 20	94.0
1983 1 21	88.0
1983 11 22	74.0
1985 3 26	79.0
1986 3 22	117.0
1986 11 13	87.0
1988 1 9	81.0
1989 2 14	75.0
1990 1 22	66.0
1991 2 20	59.0
1991 12 8	116.0
1992 12 16	104.0

Zambezi

Date of occurrence	2-day rainfall
1953 12 9	63.0
1954 12 16	113.0
1956 1 30	74.0
1957 2 20	94.0
1957 12 16	98.0
1959 2 10	110.0
1960 1 1	181.0
1961 3 7	64.0
1962 2 27	80.0
1962 11 21	69.0
1964 3 14	118.0
1965 2 18	78.0
1965 12 4	116.0
1967 1 12	53.0
1967 12 3	74.0
1969 1 4	71.0
1969 10 28	74.0
1970 11 27	55.0
1972 1 3	78.0
1973 2 22	76.0
1974 3 2	110.0
1975 3 5	71.0
1976 1 15	69.0
1976 12 24	42.0
1977 12 2	104.0
1978 11 3	67.0
1980 3 5	87.0
1981 2 18	109.0
1982 2 22	64.0
1983 2 8	55.0
1984 1 4	68.0
1985 1 12	44.0
1986 3 17	59.0
1987 2 6	75.0
1987 12 15	88.0
1989 1 9	108.0
1990 2 2	68.0
1991 1 20	100.0
1991 12 28	146.0
1992 11 26	101.0

Kabompo

Date of occurrence	2-day rainfall
1960 3 6	57.0
1961 11 11	79.0
1962 11 30	91.0
1963 11 22	54.0
1965 1 15	56.0
1966 3 1	123.0
1967 3 4	97.0
1968 2 7	78.0
1969 2 23	66.0
1969 12 17	78.0
1970 11 27	83.0
1971 11 19	63.0
1973 2 10	55.0
1974 2 10	63.0
1975 2 10	88.0
1976 4 7	82.0
1976 12 9	86.0
1978 3 31	98.0
1979 1 27	71.0
1979 12 15	81.0
1981 3 4	89.0
1982 1 26	92.0
1982 12 10	61.0
1984 2 1	73.0
1985 3 26	103.0
1986 2 7	92.0
1986 11 8	65.0
1988 3 8	111.0
1989 3 16	104.0
1990 1 9	71.0
1990 12 29	103.0
1991 12 20	102.0
1993 1 20	87.0

Kasempa

Date of occurrence	2-day rainfall
1938 2 24	84.0
1938 12 2	52.0
1939 12 23	68.0
1941 2 8	135.0
1942 8 15	113.0
1942 12 11	54.0
1944 3 22	75.0
1946 3 5	133.0
1947 3 16	82.0
1948 12 25	68.0
1949 12 30	170.0
1950 12 19	46.0
1952 1 29	86.0
1952 11 1	63.0
1954 1 21	68.0
1955 2 8	100.0
1956 3 10	111.0
1956 11 5	91.0
1958 2 21	67.0
1958 12 31	64.0
1960 3 21	40.0
1961 1 26	122.0
1962 2 21	78.0
1962 12 3	105.0
1964 1 23	86.0
1965 1 5	78.0
1966 1 8	67.0
1967 1 9	66.0
1968 3 11	68.0
1968 12 6	142.0
1969 12 10	71.0
1970 12 20	84.0
1971 12 2	160.0
1972 11 25	48.0
1974 1 10	68.0
1975 1 4	63.0
1976 1 27	61.0
1977 1 12	95.0
1977 12 13	77.0
1979 1 24	120.0
1980 3 5	114.0
1981 1 9	116.0
1982 2 23	103.0
1983 1 7	49.0
1984 1 14	57.0
1985 1 27	78.0
1986 1 26	88.0
1986 10 31	66.0
1988 3 17	145.0
1989 3 20	97.0
1989 12 31	73.0
1991 1 13	75.0
1992 3 21	86.0
1992 12 10	83.0

Mansa

Date of occurrence	2-day rainfall
1960 3 10	68.0
1961 1 11	74.0
1962 4 10	101.0
1963 1 15	66.0
1963 12 24	45.0
1965 2 1	84.0
1966 2 16	76.0
1967 1 22	82.0
1967 12 4	78.0
1969 2 9	48.0
1970 1 28	65.0
1971 2 3	95.0
1971 12 23	77.0
1973 3 21	72.0
1974 1 4	80.0
1975 3 11	103.0
1975 12 8	83.0
1976 12 5	58.0
1978 3 13	57.0
1979 1 24	79.0
1980 1 8	103.0
1981 1 22	85.0
1982 3 8	72.0
1983 2 10	88.0
1984 1 15	87.0
1985 3 1	81.0
1986 1 31	86.0
1987 2 11	82.0
1988 3 16	63.0
1989 3 2	68.0
1989 12 17	112.0
1990 12 11	87.0
1992 1 12	60.0
1992 12 23	80.0

Kawambwa

Date of occurrence	2-day rainfall
1957 3 13	84.0
1958 3 19	111.0
1959 3 7	65.0
1960 3 24	77.0
1961 1 11	77.0
1961 12 10	93.0
1962 11 8	89.0
1963 10 25	80.0
1965 3 1	91.0
1966 3 14	65.0
1966 12 4	64.0
1967 12 14	90.0
1968 12 16	70.0
1970 2 13	83.0
1970 12 17	75.0
1972 4 15	96.0
1972 12 13	88.0
1974 5 11	115.0
1974 10 19	73.0
1976 2 16	74.0
1977 3 30	65.0
1977 10 24	88.0
1978 12 20	103.0
1980 4 4	83.0
1980 11 14	75.0
1982 1 30	116.0
1982 12 17	57.0
1984 1 10	51.0
1985 2 26	77.0
1985 12 3	88.0
1987 3 31	92.0
1988 2 13	65.0
1989 2 17	76.0
1990 1 19	65.0
1991 3 29	121.0
1992 3 22	53.0
1992 11 21	68.0

(2) Collection of maximum records of hourly rainfall in each year

The following eight meteorological stations (Table 3-4) which are located in the each province were elected from the above 22 stations. Table 3-5 indicates annual maximum rainfall for various durations: 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, 24 hours and 48 hours.

Table 3-4 Rainfall Observation Stations and Observation Periods (Hourly Rainfall)

Province	Station	Observation Period
Lusaka	Lusaka	1971-1992 (11 years)
Northern	Kasama	1971-1994 (24 years)
Eastern	Chipata	1971-1988 (18 years)
Southern	Livingstone	1971-1992 (21 years)
Western	Mongu	1971-1994 (24 years)
Copperbelt	Ndola	1971-1994 (23 years)
Northwestern	Kasempa	1971-1993 (14 years)
Northern	Mansa	1974-1992 (19 years)

(3) Probable rainfall

Concerning daily rainfall, the probable rainfall for each stations was analysed. Figure 3-1 and Table 3-6 show the probable rainfall for each meteorological station in Zambia. Refer to Figure 3-2.

Table 3-6 Probable Rainfall

No.	Province	Station	One day Rainfall		Two days Rainfall	
			①Rmax (mm)	②R^{100} (mm)	③Rmax (mm)	④R^{100} (mm)
1	Lusaka	Lusaka	190.0	196.3	190.0	229.5
2	Central	Kabwe	122.0	117.9	143.0	151.7
3	Northern	Kasama	95.0	96.1	151.0	144.5
4		Mbala	115.0	114.1	118.0	127.0
5		Mpika	180.0	145.2	232.0	168.6
6	Eastern	Chipata	139.0	113.3	151.0	162.7
7		Lundazi	122.0	119.4	128.0	138.4
8		Petauke	118.0	195.2	180.0	173.5
9	Southern	Livingstone	148.0	157.3	213.0	234.8
10		Choma	116.0	106.2	145.0	152.8
11		Kafue Polder	147.0	145.9	155.0	164.3
12	Western	Mongu	237.0	157.3	251.0	207.2
13		Kaoma	167.0	106.3	169.0	128.2
14		Sesheke	308.0	163.0	351.0	212.5
15	Copperbelt	Ndola	119.0	133.6	151.0	191.9
16	North-western	Solwezi	130.0	134.5	167.0	162.4
17		Mwinilunga	123.0	123.6	136.0	138.5
18		Zambezi	110.0	129.7	147.0	143.2
19		Kabompo	99.0	110.1	122.0	123.8
20		Kasempa	253.0	209.0	270.0	208.4
21	Luapula	Mansa	95.0	101.1	113.0	115.8
22		Kawambwa	81.0	99.5	121.0	130.8

*①, ③Maximum Rainfall ②, ④ Probable Rainfall (1 in 100)

Table 3-5 (1) Annual Maximum Hourly Rainfall

Lusaka							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1971 11 24	31.0	1971 11 24	43.7	1971 11 24	43.9	1971 11 24	43.9
1972 12 16	26.4	1972 12 16	29.2	1972 1 29	35.3	1972 1 29	40.1
1973 1 7	40.1	1973 1 7	45.9	1973 1 7	52.5	1973 1 7	54.5
1974 1 2	30.2	1974 1 2	37.8	1974 1 2	42.4	1974 1 2	48.0
1975 11 19	24.7	1975 11 19	45.3	1975 11 19	61.0	1975 11 19	72.7
1976 3 25	30.1	1976 12 28	38.7	1976 12 28	41.5	1976 3 25	46.7
1977 3 18	27.1	1977 3 18	36.7	1977 3 18	43.8	1977 3 18	47.3
1978 12 16	36.5	1978 12 16	56.0	1978 12 16	65.2	1978 12 16	79.1
1990 2 22	32.8	1990 4 29	36.7	1990 4 29	38.8	1990 4 29	40.4
1991 10 21	31.3	1991 10 21	38.2	1991 10 21	39.8	1991 10 21	43.5
1992 12 18	8.8	1992 12 18	17.3	1992 12 18	17.3	1992 12 18	17.3

Lusaka					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1971 11 24	43.9	1971 11 24	43.9	1971 11 24	71.1
1972 1 29	45.0	1972 1 29	45.2	1972 1 29	59.9
1973 1 7	54.8	1973 1 7	57.3	1973 2 17	73.2
1974 1 2	48.3	1974 1 2	49.6	1974 1 2	59.6
1975 11 19	72.7	1975 11 19	72.7	1975 11 19	86.1
1976 3 25	74.3	1976 3 25	75.6	1976 3 25	75.9
1977 3 18	48.6	1977 3 18	53.6	1977 3 18	68.0
1978 12 16	79.1	1978 12 16	79.1	1978 12 16	79.1
1990 4 29	40.4	1990 4 29	48.6	1990 4 29	49.2
1991 10 21	43.5	1991 10 21	43.5	1991 10 21	44.5
1992 12 18	17.3	1992 12 18	17.5	1992 12 18	17.5

Table 3-5 (2) Annual Maximum Hourly Rainfall

Kasama							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1971 3 4	35.1	1971 3 4	37.8	1971 3 4	41.2	1971 3 4	45.5
1972 2 11	40.1	1972 11 11	40.6	1972 11 11	47.5	1972 2 11	52.6
1973 4 11	43.7	1973 4 11	63.0	1973 2 22	91.0	1973 2 23	160.9
1974 1 29	49.1	1974 12 7	52.4	1974 12 7	58.0	1974 12 7	63.5
1975 11 21	71.3	1975 11 21	133.0	1975 11 21	152.3	1975 11 21	186.1
1976 4 3	42.0	1976 2 1	61.6	1976 2 1	65.0	1976 2 1	69.0
1977 12 24	26.0	1977 12 20	29.7	1977 12 20	31.4	1977 3 30	57.2
1978 3 14	63.9	1978 3 14	64.0	1978 3 14	70.1	1978 3 14	70.1
1979 2 1	54.1	1979 2 1	68.3	1979 2 1	68.3	1979 2 1	68.3
1980 12 29	39.9	1980 12 29	48.6	1980 4 12	52.4	1980 4 12	71.4
1981 11 4	39.1	1981 11 4	74.3	1981 11 4	74.3	1981 11 4	74.3
1982 3 14	36.6	1982 2 18	53.4	1982 2 18	53.4	1982 4 19	58.8
1983 3 4	38.0	1983 1 14	51.8	1983 1 14	55.2	1983 1 14	67.5
1984 12 13	25.5	1984 12 20	40.0	1984 12 20	60.0	1984 2 27	69.9
1985 3 18	26.2	1985 3 18	52.0	1985 3 18	56.0	1985 3 18	64.3
1986 1 23	23.3	1986 1 23	32.5	1986 1 23	38.5	1986 1 23	45.1
1987 2 16	46.4	1987 2 16	47.4	1987 2 16	48.3	1987 2 16	50.4
1988 2 4	40.5	1988 2 4	50.0	1988 2 4	50.0	1988 2 4	50.0
1989 3 5	19.6	1989 1 1	23.6	1989 1 1	25.6	1989 1 5	34.9
1990 12 23	51.0	1990 12 23	67.3	1990 12 23	67.3	1990 12 23	68.5
1991 1 12	40.0	1991 1 11	45.3	1991 1 11	48.3	1991 1 12	49.6
1992 2 29	25.0	1992 2 29	46.8	1992 2 29	49.8	1992 2 29	49.8
1993 3 31	33.1	1993 3 31	38.0	1993 3 31	38.2	1993 2 10	39.7
1994 3 30	59.0	1994 3 30	65.6	1994 3 30	69.7	1994 3 30	80.4

Kasama					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1971 3 4	45.5	1971 3 4	70.1	1971 3 4	71.6
1972 2 11	59.4	1972 2 11	61.5	1972 11 9	91.2
1973 2 23	178.9	1973 2 23	178.9	1973 2 23	185.1
1974 12 6	63.5	1974 12 6	77.2	1974 12 6	77.4
1975 11 21	205.9	1975 11 21	205.9	1975 11 21	215.6
1976 2 1	69.3	1976 2 1	72.5	1976 1 16	110.4
1977 3 30	57.2	1977 3 30	76.0	1977 3 30	92.0
1978 3 14	70.1	1978 3 14	70.1	1978 3 14	85.6
1979 2 1	69.3	1979 2 1	71.3	1979 1 31	87.7
1980 4 12	71.5	1980 12 29	99.8	1980 12 29	100.2
1981 11 4	74.3	1981 11 4	79.0	1981 12 3	140.8
1982 4 19	58.8	1982 4 19	79.0	1982 4 18	86.0
1983 1 14	69.0	1983 1 2	83.8	1983 1 14	119.8
1984 2 27	71.0	1984 2 27	78.0	1984 3 28	100.4
1985 3 18	65.0	1985 11 12	70.0	1985 11 11	121.0
1986 1 23	51.1	1986 2 5	52.0	1986 1 22	74.1
1987 2 16	51.4	1987 12 20	61.7	1987 12 19	85.9
1988 2 4	50.0	1988 2 4	70.0	1988 2 5	90.0
1989 1 1	37.7	1989 3 23	56.9	1989 11 9	77.7
1990 11 12	73.4	1990 11 12	122.9	1990 11 21	128.3
1991 1 12	51.7	1991 1 11	98.0	1991 1 11	112.0
1992 2 29	49.8	1992 2 4	77.0	1992 2 4	87.0
1993 2 10	40.2	1993 12 20	72.0	1993 2 19	73.0
1994 3 30	81.0	1994 3 30	81.0	1994 3 30	81.7

Table 3-5 (3) Annual Maximum Hourly Rainfall

Chipata							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1971 4 11	37.1	1971 4 11	43.9	1971 4 11	43.9	1971 4 11	49.8
1972 2 28	33.8	1972 2 28	65.3	1972 2 28	93.2	1972 2 28	116.3
1973 2 18	38.6	1973 2 18	62.5	1973 2 18	64.0	1973 2 18	64.0
1974 11 24	32.8	1974 2 15	55.6	1974 2 15	73.1	1974 2 15	78.3
1975 3 2	44.8	1975 3 2	46.9	1975 3 2	47.1	1975 3 2	47.5
1976 2 25	29.5	1976 2 15	34.5	1976 2 15	35.3	1976 3 7	43.2
1977 11 9	35.1	1977 2 9	60.4	1977 2 9	61.6	1977 2 9	61.6
1978 1 21	51.0	1978 1 21	64.3	1978 1 21	76.0	1978 1 21	80.4
1979 3 30	24.8	1979 2 24	48.0	1979 2 24	49.0	1979 2 24	72.4
1980 3 27	25.0	1980 11 17	36.1	1980 11 7	41.8	1980 11 7	42.0
1981 2 20	38.4	1981 2 20	66.5	1981 2 20	70.8	1981 2 20	81.5
1982 12 8	33.4	1982 12 8	35.1	1982 12 8	35.9	1982 1 19	41.9
1983 12 12	41.5	1983 12 12	44.0	1983 12 12	44.8	1983 4 5	45.7
1984 1 1	22.0	1984 1 1	23.2	1984 1 1	23.2	1984 1 2	29.4
1985 1 25	52.7	1985 12 10	76.0	1985 12 10	81.5	1985 12 10	85.0
1986 3 1	25.0	1986 3 1	27.5	1986 12 12	33.3	1986 12 12	41.8
1987 12 8	40.8	1987 12 8	43.5	1987 12 8	47.5	1987 12 13	53.8
1988 3 7	47.0	1988 3 7	61.5	1988 3 7	69.7	1988 3 7	77.7

Chipata					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1971 2 17	72.1	1971 2 17	93.2	1971 101.3	101.3
1972 2 28	116.3	1972 2 28	157.2	1972 174.2	174.2
1973 2 18	64.7	1973 2 18	64.8	1973 100.5	100.5
1974 2 15	81.6	1974 2 15	81.6	1974 88.7	88.7
1975 3 2	47.5	1975 3 2	50.6	1975 68.1	68.1
1976 3 7	44.5	1976 2 12	76.9	1976 101.2	101.2
1977 2 9	63.6	1977 2 26	79.4	1977 114.3	114.3
1978 1 21	95.0	1978 1 21	137.4	1978 184.9	184.9
1979 2 24	72.4	1979 12 19	87.0	1979 106.0	106.0
1980 11 7	43.0	1980 1 27	43.0	1980 54.0	54.0
1981 2 20	82.5	1981 2 20	93.6	1981 140.0	140.0
1982 1 19	41.9	1982 2 6	53.8	1982 83.4	83.4
1983 4 5	45.7	1983 12 12	72.0	1983 101.7	101.7
1984 3 6	55.0	1984 3 6	55.0	1984 89.0	89.0
1985 12 10	85.0	1985 12 16	85.0	1985 92.4	92.4
1986 12 11	58.3	1986 2 11	61.0	1986 75.0	75.0
1987 12 10	66.7	1987 12 16	72.9	1987 115.6	115.6
1988 3 6	78.0	1988 3 6	78.0	1988 89.3	89.3

Table 3-5 (4) Annual Maximum Hourly Rainfall

Livingstone							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1971 11 24	31.2	1971 11 24	43.9	1971 11 13	47.2	1971 11 13	54.9
1972 12 15	22.4	1972 12 15	33.0	1972 12 15	33.5	1972 12 15	34.0
1974 1 12	25.1	1974 1 12	44.2	1974 1 12	44.2	1974 1 12	44.2
1975 12 17	44.9	1975 12 17	58.4	1975 12 17	70.9	1975 12 17	93.6
1976 1 11	31.0	1976 1 11	32.4	1976 3 15	34.4	1976 3 19	49.7
1977 2 17	31.7	1977 2 7	38.0	1977 2 7	42.1	1977 2 7	45.7
1978 3 9	54.5	1978 2 2	66.0	1978 2 2	66.0	1978 2 2	66.0
1979 1 20	32.0	1979 1 20	37.8	1979 1 20	41.6	1979 1 20	44.5
1980 12 26	25.2	1980 4 7	33.0	1980 4 7	33.0	1980 4 7	33.0
1981 1 28	28.7	1981 1 28	33.7	1981 11 9	37.0	1981 1 28	51.5
1982 11 26	24.7	1982 5 7	36.7	1982 5 7	37.0	1982 5 7	37.0
1983 2 10	33.2	1983 2 10	41.4	1983 12 9	45.8	1983 10 18	59.3
1984 12 25	53.5	1984 12 25	58.5	1984 12 25	59.5	1984 12 25	60.9
1985 1 25	39.9	1985 1 25	39.9	1985 1 25	39.9	1985 1 25	39.9
1986 4 24	32.8	1986 3 20	39.9	1986 3 20	41.3	1986 12 24	62.9
1987 1 20	76.1	1987 1 20	76.2	1987 1 20	76.5	1987 1 20	76.5
1988 12 6	57.1	1988 12 6	69.1	1988 12 6	70.0	1988 12 6	71.0
1989 11 8	41.3	1989 11 8	42.2	1989 11 8	42.5	1989 11 8	42.5
1990 4 6	43.5	1990 1 14	57.3	1990 1 14	60.3	1990 1 14	61.5
1991 1 8	27.7	1991 1 8	34.6	1991 1 8	35.6	1991 1 8	37.6
1992 12 19	44.2	1992 12 19	46.9	1992 12 25	51.2	1992 12 25	94.7

Livingstone					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1971 12 23	54.9	1971 12 23	66.3	1971 12 23	78.0
1972 12 15	34.5	1972 1 18	55.9	1972 3 31	83.1
1974 1 12	44.2	1974 11 24	53.0	1974 12 22	72.0
1975 12 17	100.7	1975 12 12	102.9	1975 12 12	110.1
1976 3 19	51.7	1976 1 10	62.7	1976 3 18	91.3
1977 2 7	48.7	1977 2 7	65.4	1977 2 7	70.9
1978 2 2	66.0	1978 3 9	85.0	1978 3 8	117.0
1979 1 20	47.5	1979 12 15	74.0	1979 12 14	104.0
1980 12 28	34.3	1980 12 27	35.5	1980 12 5	53.8
1981 1 28	52.6	1981 2 7	80.3	1981 2 27	85.0
1982 5 7	37.0	1982 5 7	42.4	1982 5 7	47.1
1983 10 17	70.8	1983 10 17	73.8	1983 10 17	88.3
1984 12 25	62.4	1984 12 24	66.9	1984 12 24	84.3
1985 1 25	39.9	1985 1 25	39.9	1985 1 25	67.1
1986 12 4	62.9	1986 12 24	63.3	1986 12 24	63.5
1987 1 20	76.5	1987 1 15	99.0	1987 1 15	113.0
1988 12 6	71.0	1988 12 5	106.5	1988 12 5	107.5
1989 2 25	52.2	1989 2 20	85.8	1989 2 20	140.3
1990 1 14	62.4	1990 2 8	87.5	1990 2 8	88.0
1991 1 8	49.5	1991 1 8	85.8	1991 1 8	95.4
1992 12 23	96.6	1992 12 23	119.7	1992 12 23	152.5
		1993 1 1	117.0	1993 12 31	152.0

Table 3-5 (5) Annual Maximum Hourly Rainfall

Mongu							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1971 1 29	38.4	1971 1 29	38.4	1971 1 29	38.9	1971 1 29	38.9
1972 12 20	19.6	1972 1 4	21.6	1972 3 27	28.4	1972 3 27	46.2
1973 12 8	17.8	1973 12 8	19.8	1973 12 8	20.1	1973 12 8	26.4
1974 1 4	30.2	1974 5 9	37.8	1974 5 9	37.8	1974 1 1	49.3
1975 2 24	44.7	1975 2 14	46.6	1975 2 14	46.8	1975 12 28	48.5
1976 12 25	27.4	1976 12 25	38.3	1976 12 25	54.1	1976 12 25	59.4
1977 3 2	29.4	1977 12 7	39.8	1977 12 7	42.8	1977 12 7	44.8
1978 12 21	66.1	1978 12 20	77.5	1978 12 20	79.7	1978 12 20	85.5
1979 1 28	41.9	1979 1 28	43.8	1979 1 28	43.8	1979 1 28	43.8
1980 12 6	99.0	1980 12 6	102.0	1980 12 6	112.2	1980 12 6	125.7
1981 2 18	48.0	1981 2 18	72.3	1981 12 28	80.7	1981 2 18	87.0
1982 1 23	39.3	1982 1 23	49.3	1982 1 23	53.2	1982 1 23	55.0
1983 3 10	35.7	1983 3 10	37.7	1983 3 10	38.7	1983 11 28	39.9
1984 1 13	35.3	1984 1 13	70.5	1984 1 13	105.6	1984 1 12	178.5
1985 12 20	22.5	1985 12 20	25.8	1985 12 20	27.0	1985 2 14	31.0
1986 12 2	30.8	1986 12 2	38.8	1986 12 2	49.4	1986 12 2	57.4
1987 1 19	28.0	1987 1 19	33.2	1987 1 19	35.7	1987 1 16	48.0
1988 3 5	65.3	1988 3 5	127.1	1988 3 5	178.7	1988 3 5	243.7
1989 2 22	28.8	1989 2 22	46.9	1989 2 22	51.2	1989 2 22	78.4
1990 12 11	16.0	1990 12 11	24.4	1990 12 11	25.8	1990 12 11	26.4
1991 2 10	39.0	1991 2 10	64.0	1991 2 10	83.0	1991 2 10	83.2
1992 11 15	11.6	1992 11 15	13.6	1992 11 15	14.1	1993 12 20	39.0
1993 12 7	28.0	1993 12 20	36.8	1993 12 20	38.8	1994 1 21	75.5
1994 1 21	59.2	1994 1 21	62.1	1994 1 21	63.3		

Mongu					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1971 1 29	43.7	1971 2 22	62.0	1971 2 22	69.0
1972 3 27	56.1	1972 1 6	74.9	1972 1 5	87.0
1973 12 8	38.4	1973 2 13	65.0	1973 2 13	69.0
1974 1 1	60.7	1974 2 17	104.0	1974 2 17	119.0
1975 12 28	49.9	1975 12 28	49.9	1975 12 13	68.0
1976 12 25	60.9	1976 12 25	81.7	1976 12 25	98.5
1977 12 7	44.9	1977 3 5	60.0	1977 3 4	94.0
1978 12 20	85.5	1978 12 20	93.0	1978 3 9	122.5
1979 1 28	47.1	1979 2 28	49.2	1979 12 11	76.1
1980 12 6	136.2	1980 12 6	144.0	1980 12 6	147.5
1981 2 18	87.3	1981 2 21	97.7	1981 2 20	107.5
1982 1 23	56.6	1982 2 27	57.0	1982 2 26	58.0
1983 11 27	47.4	1983 11 27	58.2	1983 11 26	78.0
1984 1 12	284.1	1984 1 12	284.1	1984 1 12	305.9
1985 2 14	36.8	1985 12 13	38.0	1985 2 6	58.6
1986 12 2	66.0	1986 12 2	66.0	1986 12 1	68.0
1987 1 16	48.7	1987 1 16	48.7	1987 12 8	87.0
1988 3 5	251.4	1988 3 5	252.3	1988 3 5	256.5
1989 2 21	79.5	1989 2 21	87.6	1989 2 20	115.7
1990 12 11	26.4	1990 12 12	65.0	1990 12 12	65.0
1991 2 9	88.5	1991 2 9	88.5	1991 2 9	116.6
1992 11 15	14.1	1992 1 22	69.0	1992 1 21	71.0
1993 12 20	58.5	1993 4 12	106.0	1993 4 12	106.0
1994 1 21	81.8	1994 1 21	92.3	1994 1 21	99.6

Table 3-5 (6) Annual Maximum Hourly Rainfall

Ndola							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1971 11 19	36.1	1971 2 27	39.4	1971 2 27	45.7	1971 2 27	47.5
1972 2 26	50.8	1972 2 26	104.1	1972 2 26	104.1	1972 2 26	105.4
1973 12 31	33.5	1973 12 31	34.0	1973 12 31	34.0	1973 12 6	36.3
1974 1 9	59.0	1974 1 9	66.0	1974 1 9	71.0	1974 1 9	84.4
1975 1 31	46.0	1975 12 28	58.0	1975 2 9	62.5	1975 2 9	66.5
1976 12 27	62.9	1976 12 27	75.9	1976 12 27	78.0	1976 12 27	80.0
1977 4 3	44.8	1977 4 3	47.6	1977 4 3	49.9	1977 3 14	59.2
1978 12 10	62.6	1978 12 10	79.7	1978 12 10	88.1	1978 12 10	88.1
1979 2 22	32.2	1979 3 28	54.6	1979 3 28	67.2	1979 3 28	78.4
1980 2 21	60.5	1980 2 21	60.5	1980 2 21	60.5	1980 2 21	60.5
1981 2 13	37.4	1981 2 13	51.8	1981 2 13	56.3	1981 2 13	79.5
1982 12 29	25.6	1982 2 14	36.8	1982 2 14	43.7	1982 12 5	47.1
1983 12 19	37.5	1983 12 19	54.5	1983 12 19	69.1	1983 12 19	80.9
1984 10 21	46.0	1984 10 21	55.2	1984 12 29	71.0	1984 12 29	80.0
1985 2 20	39.2	1985 12 6	46.0	1985 12 6	54.1	1985 12 6	57.1
1986 3 19	25.0	1986 3 19	36.0	1986 3 19	36.0	1986 11 10	52.5
1987 3 13	43.2	1987 3 13	46.5	1987 3 13	49.0	1987 3 13	52.1
1988 2 8	23.7	1988 2 8	35.9	1988 2 8	39.4	1988 2 8	41.1
1989 1 27	32.0	1989 1 27	54.2	1989 1 27	61.0	1989 1 27	62.3
1990 2 13	48.3	1990 3 26	72.2	1990 3 26	72.3	1990 2 13	89.3
1991 12 8	26.6	1991 12 8	40.1	1991 12 19	42.8	1991 12 19	51.7
1992 12 13	34.4	1992 12 13	37.4	1992 12 13	42.9	1992 12 13	49.9
1994 12 31	40.3	1994 12 31	44.9	1994 12 31	44.9	1994 12 31	44.9

Ndola					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1971 2 27	56.9	1971 12 18	59.2	1971 1 29	68.6
1972 2 26	105.4	1972 2 26	115.6	1972 2 26	151.6
1973 12 6	38.9	1973 12 6	57.9	1973 12 6	58.7
1974 1 9	90.4	1974 1 9	101.3	1974 2 20	119.6
1975 2 9	66.5	1975 2 9	66.5	1975 12 28	107.9
1976 12 27	80.0	1976 12 26	99.1	1976 12 26	113.0
1977 3 14	59.7	1977 3 14	68.2	1977 1 21	74.9
1978 12 10	88.1	1978 12 10	88.1	1978 12 10	132.2
1979 3 28	84.4	1979 3 28	84.6	1979 2 21	87.7
1980 2 21	60.5	1980 12 10	72.4	1980 12 10	72.4
1981 2 12	92.5	1981 2 12	94.4	1981 2 11	94.5
1982 12 5	54.9	1982 1 6	58.0	1982 1 5	61.0
1983 12 19	82.4	1983 1 24	91.1	1983 1 24	134.3
1984 12 29	93.1	1984 12 28	94.3	1984 12 19	105.0
1985 12 5	59.1	1985 12 6	66.9	1985 12 5	116.0
1986 11 10	56.0	1986 3 19	60.0	1986 11 10	69.6
1987 3 13	52.1	1987 3 13	58.5	1987 2 13	76.1
1988 2 8	41.4	1988 12 3	54.0	1988 12 2	68.0
1989 12 7	67.4	1989 2 11	88.0	1989 2 10	120.0
1990 2 13	90.3	1990 3 25	103.7	1990 3 25	113.8
1991 12 19	53.2	1991 1 18	78.0	1991 1 18	151.0
1992 12 13	50.1	1992 12 13	50.1	1992 1 24	52.0
1994 12 31	59.7	1994 12 30	119.0	1994 12 30	122.0

Table 3-5 (7) Annual Maximum Hourly Rainfall

Kaseapa							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1971 11 10	45.7	1971 11 10	56.1	1971 11 10	58.4	1971 11 10	63.5
1972 12 2	41.1	1972 12 2	68.3	1972 12 2	73.7	1972 12 2	110.5
1973 11 25	26.2	1973 11 25	42.7	1973 11 25	45.2	1973 11 25	46.5
1974 12 12	49.8	1974 12 12	49.8	1974 12 12	49.8	1974 1 1	50.4
1975 12 2	50.3	1975 1 27	52.0	1975 2 3	55.5	1975 2 3	72.6
1976 1 27	49.2	1976 1 27	57.8	1976 1 27	57.8	1976 1 27	57.8
1977 1 12	60.4	1977 1 12	60.6	1977 12 23	61.5	1977 1 12	72.2
1978 3 6	31.7	1978 4 15	47.2	1978 4 15	53.3	1978 4 15	58.3
1979 1 23	71.7	1979 1 23	82.3	1979 1 23	83.3	1979 1 23	85.8
1980 11 30	56.0	1980 2 4	61.0	1980 3 5	64.4	1980 3 5	91.4
1984 1 22	18.3	1984 1 22	22.0	1984 1 22	22.0	1984 1 13	28.2
1991 12 8	30.2	1991 12 8	36.1	1991 2 14	37.6	1991 2 14	43.0
1992 3 23	55.2	1992 3 23	68.5	1992 3 23	73.3	1992 3 23	84.3
1993 11 1	39.9	1993 11 1	52.6	1993 11 1	57.6	1993 11 1	60.0

Kaseapa					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1971 2 11	69.6	1971 2 11	73.7	1971 12 19	94.7
1972 12 2	145.0	1972 12 2	145.0	1972 12 2	154.7
1973 11 25	46.5	1973 11 25	46.5	1973 11 25	46.5
1974 11 1	53.0	1974 11 1	53.0	1974 1 7	66.0
1975 2 4	74.8	1975 2 4	77.1	1975 1 3	83.0
1976 1 27	58.7	1976 1 26	66.4	1976 1 26	67.7
1977 1 12	83.4	1977 1 12	93.9	1977 1 11	102.8
1978 12 4	59.5	1978 12 4	59.5	1978 12 4	86.8
1979 1 23	88.8	1979 1 23	104.3	1979 1 23	136.6
1980 3 4	107.4	1980 3 4	133.7	1980 3 4	164.4
1984 1 13	44.5	1984 1 13	53.7	1984 1 13	56.5
1991 2 14	48.6	1991 3 10	54.0	1991 1 12	75.0
1992 3 23	84.3	1992 3 23	85.3	1992 3 21	105.6
1993 11 1	60.0	1993 11 1	60.0	1993 3 8	63.2

Table 3-5 (8) Annual Maximum Hourly Rainfall

Mansa							
Date of occurrence	one-hour rainfall	Date of occurrence	two-hour rainfall	Date of occurrence	three-hour rainfall	Date of occurrence	six-hour rainfall
1974 3 29	30.6	1974 2 22	46.1	1974 2 22	47.6	1974 2 22	48.3
1975 3 11	45.5	1975 3 11	83.6	1975 3 11	90.0	1975 3 11	100.1
1976 1 30	29.2	1976 1 30	41.8	1976 1 30	48.5	1976 1 30	48.3
1977 12 5	45.9	1977 12 5	47.7	1977 12 5	48.0	1977 12 5	48.0
1978 12 8	32.3	1978 3 12	34.9	1978 3 12	39.2	1978 3 12	40.0
1979 2 28	43.1	1979 2 28	43.1	1979 1 24	46.7	1979 1 24	70.8
1980 2 19	47.9	1980 3 7	50.5	1980 3 7	53.2	1980 3 7	76.2
1981 1 21	40.5	1981 1 1	53.0	1981 1 1	56.9	1981 1 1	59.9
1982 2 6	32.4	1982 1 9	45.8	1982 2 6	48.5	1982 2 6	52.1
1983 12 24	41.0	1983 12 24	47.3	1983 12 24	47.5	1983 11 10	48.5
1984 1 25	42.5	1984 11 25	51.1	1984 1 18	52.9	1984 1 18	55.2
1985 1 9	25.5	1985 1 9	35.5	1985 2 28	36.8	1985 1 9	42.7
1986 12 28	38.7	1986 12 28	49.0	1986 12 8	51.9	1986 12 28	61.6
1987 4 1	49.0	1987 4 1	49.0	1987 3 31	51.3	1987 3 31	51.8
1988 11 8	36.0	1988 11 8	36.0	1988 1 25	43.1	1988 1 25	46.6
1989 11 6	24.3	1989 11 6	26.3	1989 11 6	28.5	1989 1 2	38.1
1990 2 11	44.9	1990 2 14	48.7	1990 2 14	50.8	1990 2 14	51.2
1991 2 28	58.5	1991 2 28	59.5	1991 2 28	59.7	1991 2 28	59.9
1992 2 8	36.6	1992 2 8	42.6	1992 2 8	44.9	1992 2 8	45.4
		1993 11 21	24.9	1993 11 21	27.0	1993 11 21	28.0

Mansa					
Date of occurrence	twelve-hour rainfall	Date of occurrence	twenty-four-hour rainfall	Date of occurrence	fourty-eight-hour rainfall
1974 2 22	48.3	1974 1 3	63.0	1974 1 3	80.0
1975 3 11	102.7	1975 3 11	102.7	1975 3 11	118.0
1976 2 7	58.2	1976 2 7	58.2	1976 12 5	63.3
1977 12 5	49.8	1977 12 4	55.1	1977 12 4	57.9
1978 3 12	40.0	1978 12 8	54.0	1978 3 10	63.6
1979 1 23	76.5	1979 1 23	77.1	1979 1 23	79.8
1980 3 6	82.0	1980 3 6	95.0	1980 3 6	103.7
1981 5 22	74.5	1981 1 21	74.5	1981 1 21	84.5
1982 3 7	60.6	1982 3 7	68.6	1982 3 7	82.8
1983 1 20	60.0	1983 10 20	60.1	1983 2 8	86.0
1984 1 18	55.2	1984 1 18	55.3	1984 1 24	67.2
1985 1 9	47.4	1985 2 28	77.0	1985 2 18	81.0
1986 12 28	63.6	1986 12 28	64.1	1986 1 31	86.0
1987 3 31	51.8	1987 2 10	59.0	1987 2 10	82.0
1988 1 25	46.6	1988 3 15	58.9	1988 3 15	63.0
1989 1 1	44.4	1989 1 1	52.0	1989 1 1	84.4
1990 2 14	51.2	1990 12 16	80.0	1990 12 10	112.0
1991 2 28	59.9	1991 12 10	80.0	1991 12 10	87.0
1992 1 12	57.2	1992 1 12	57.2	1992 1 12	63.7
1993 11 21	28.0	1993 12 27	72.0	1993 12 27	80.0

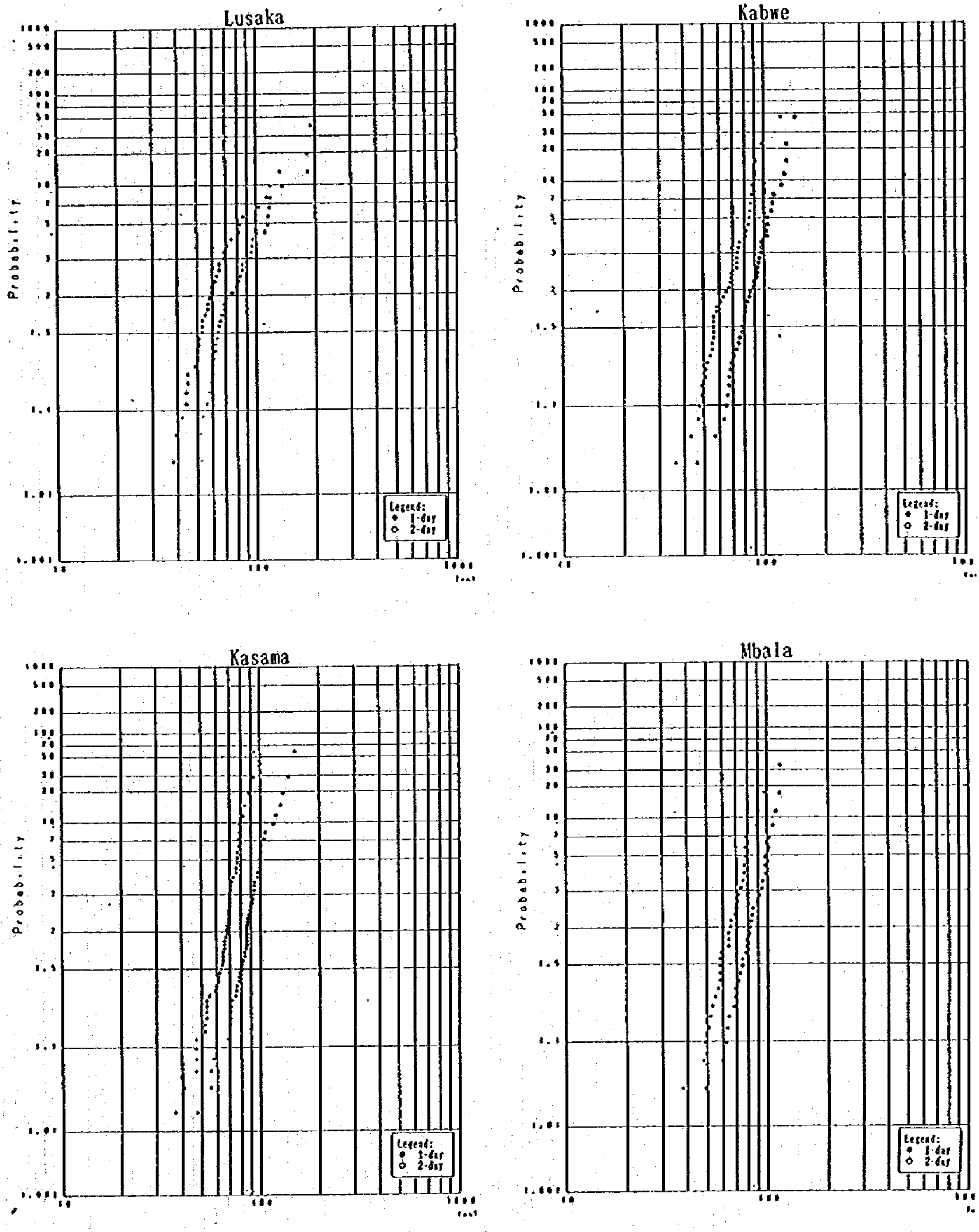


Figure 3-1 (1) Plotting Position of Probable Rainfall (1-day and 2-day)

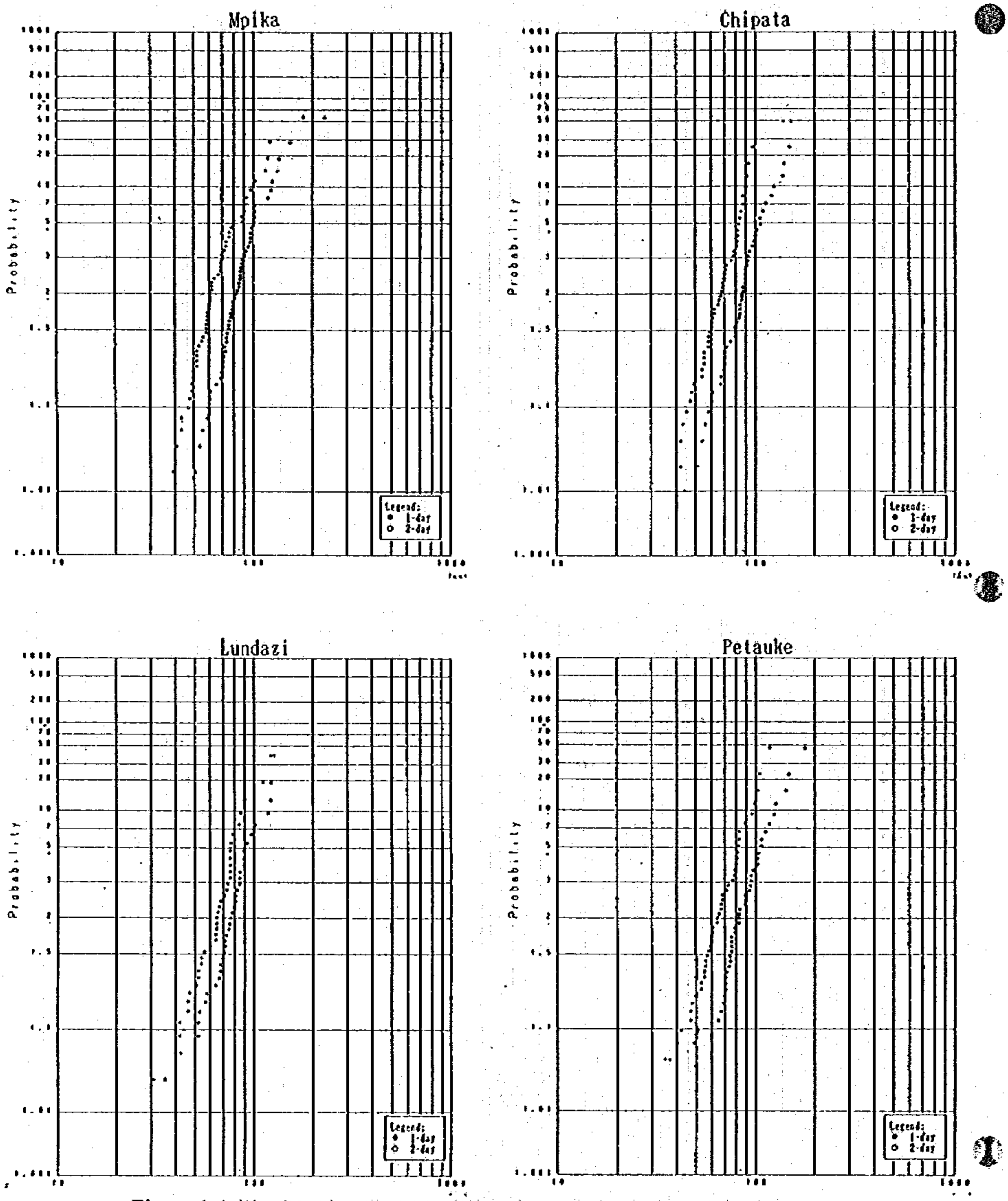


Figure 3-1 (2) Plotting Position of Probable Rainfall (1-day and 2-day)

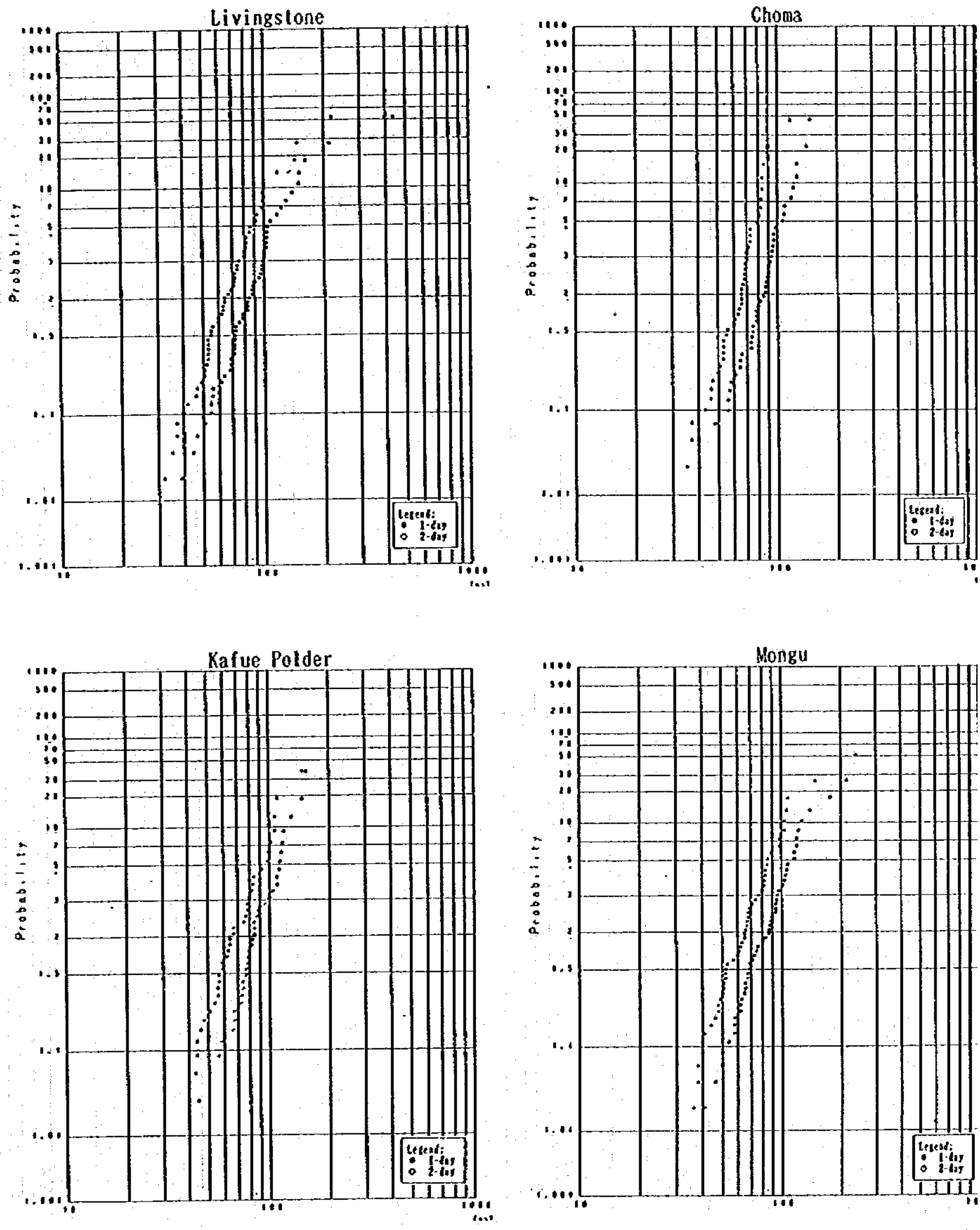


Figure 3-1 (3) Plotting Position of Probable Rainfall (1-day and 2-day)

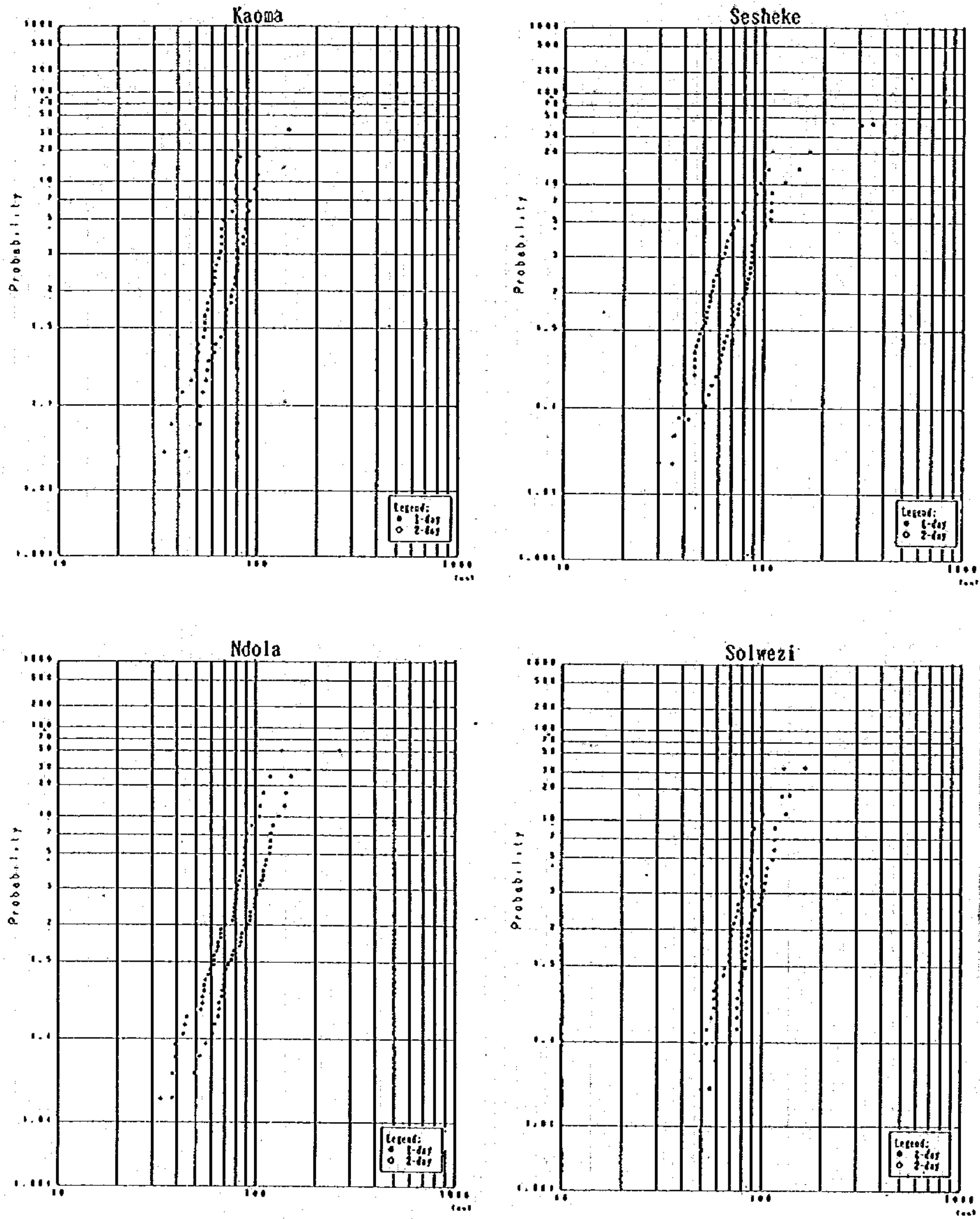


Figure 3-1 (4) Plotting Position of Probable Rainfall (1-day and 2-day)

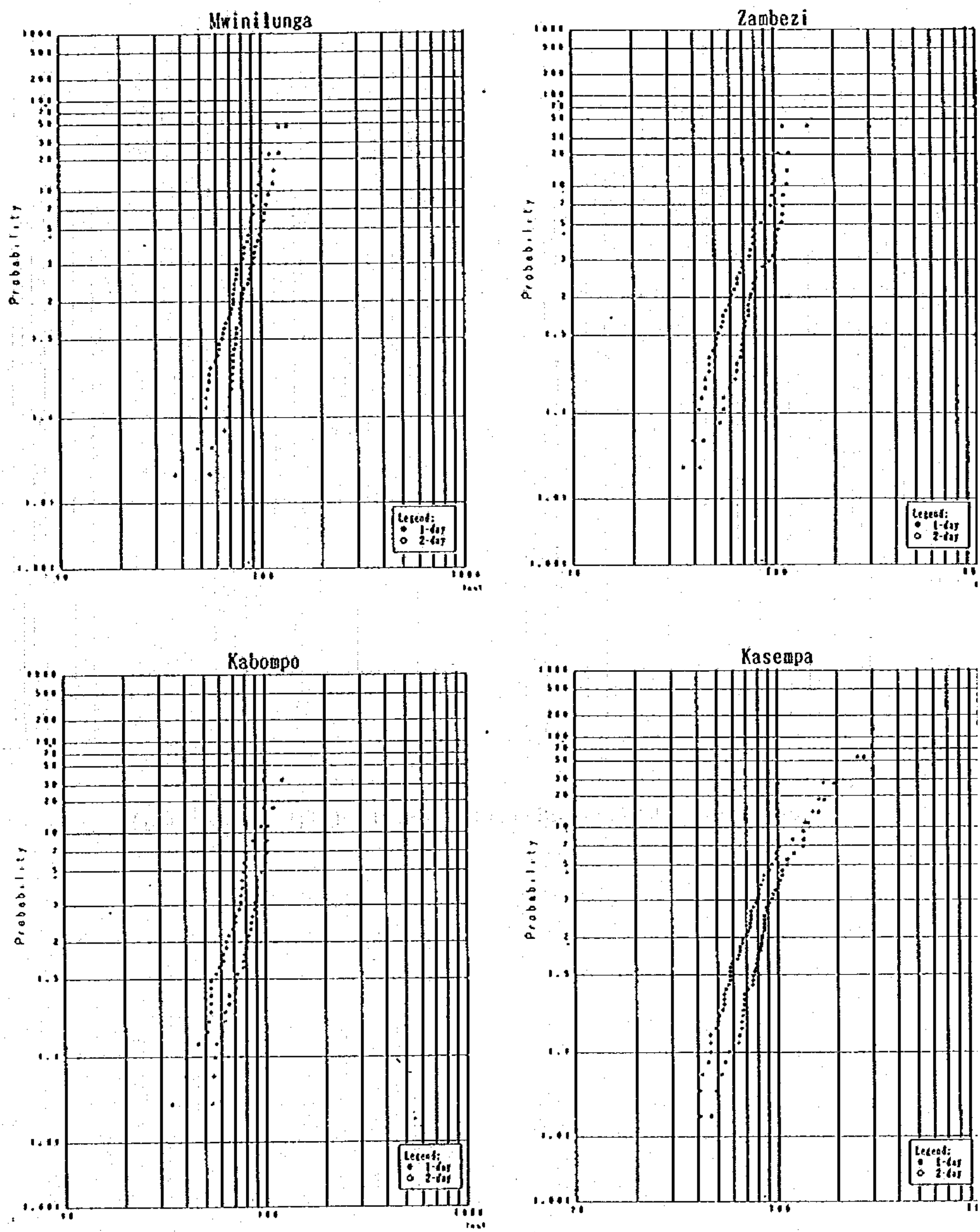


Figure 3-1 (5) Plotting Position of Probable Rainfall (1-day and 2-day)

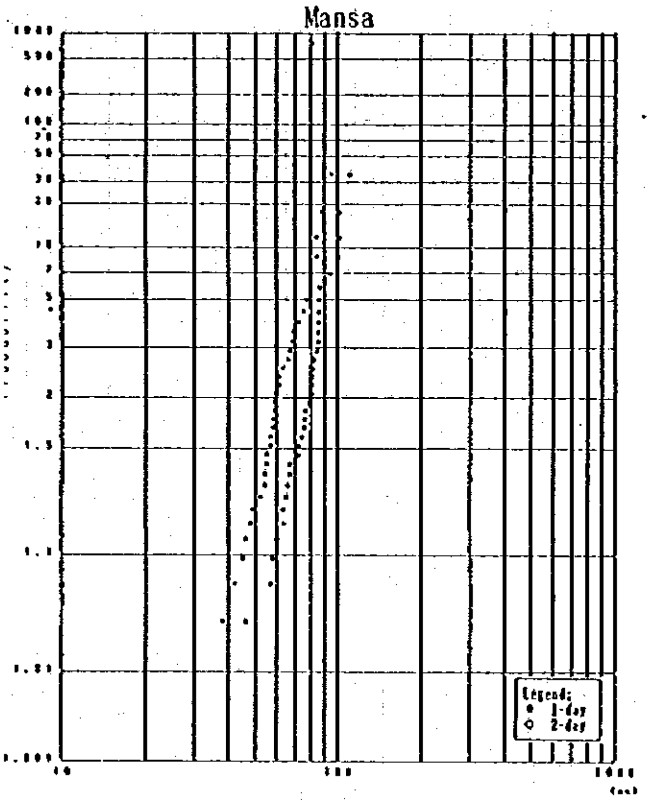


Figure 3-1 (6) Plotting Position of Probable Rainfall (1-day and 2-day)

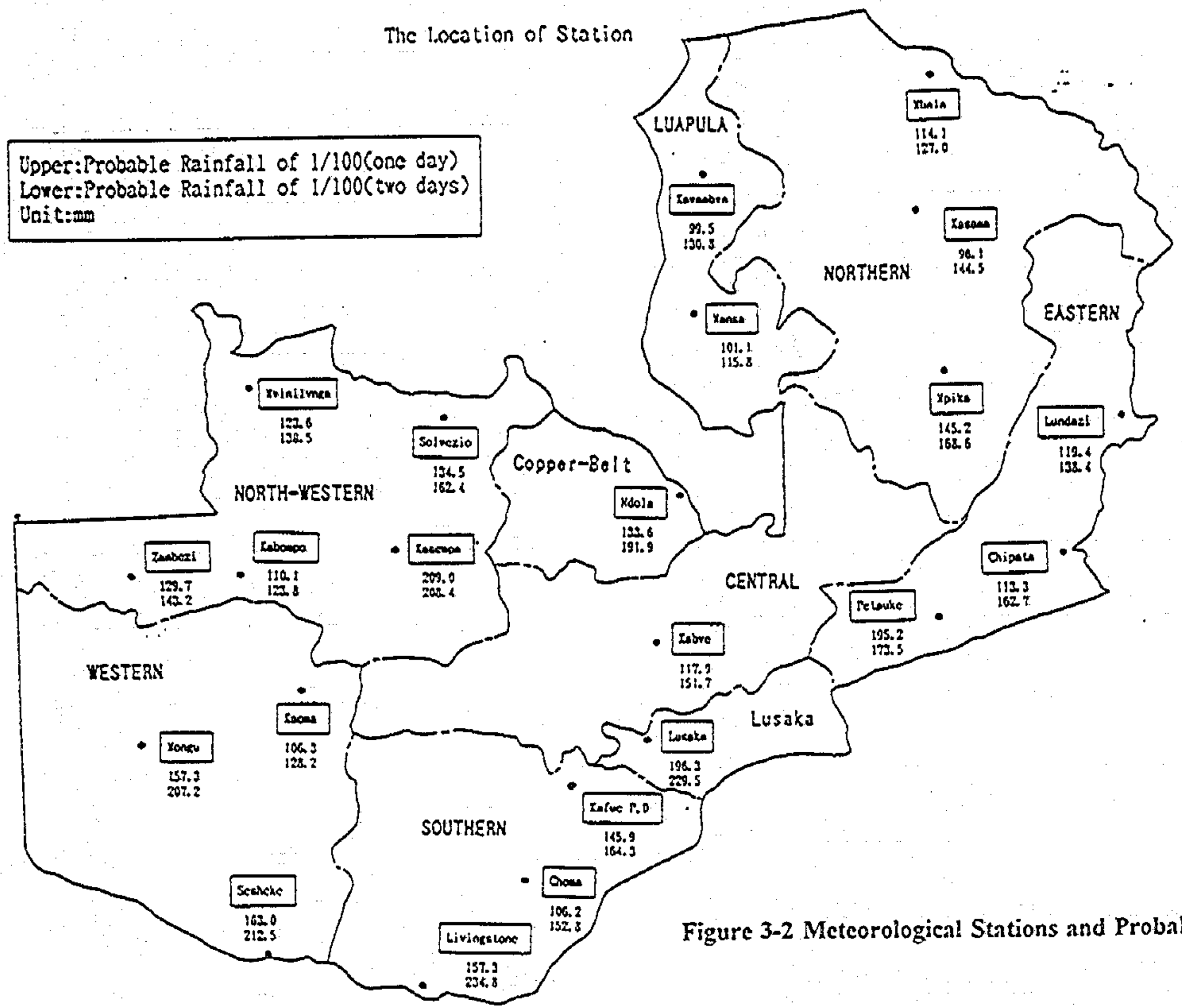


Figure 3-2 Meteorological Stations and Probable Rainfall

(4) Duration curve

Figure 3-3 shows the depth-duration curve for 8 stations.

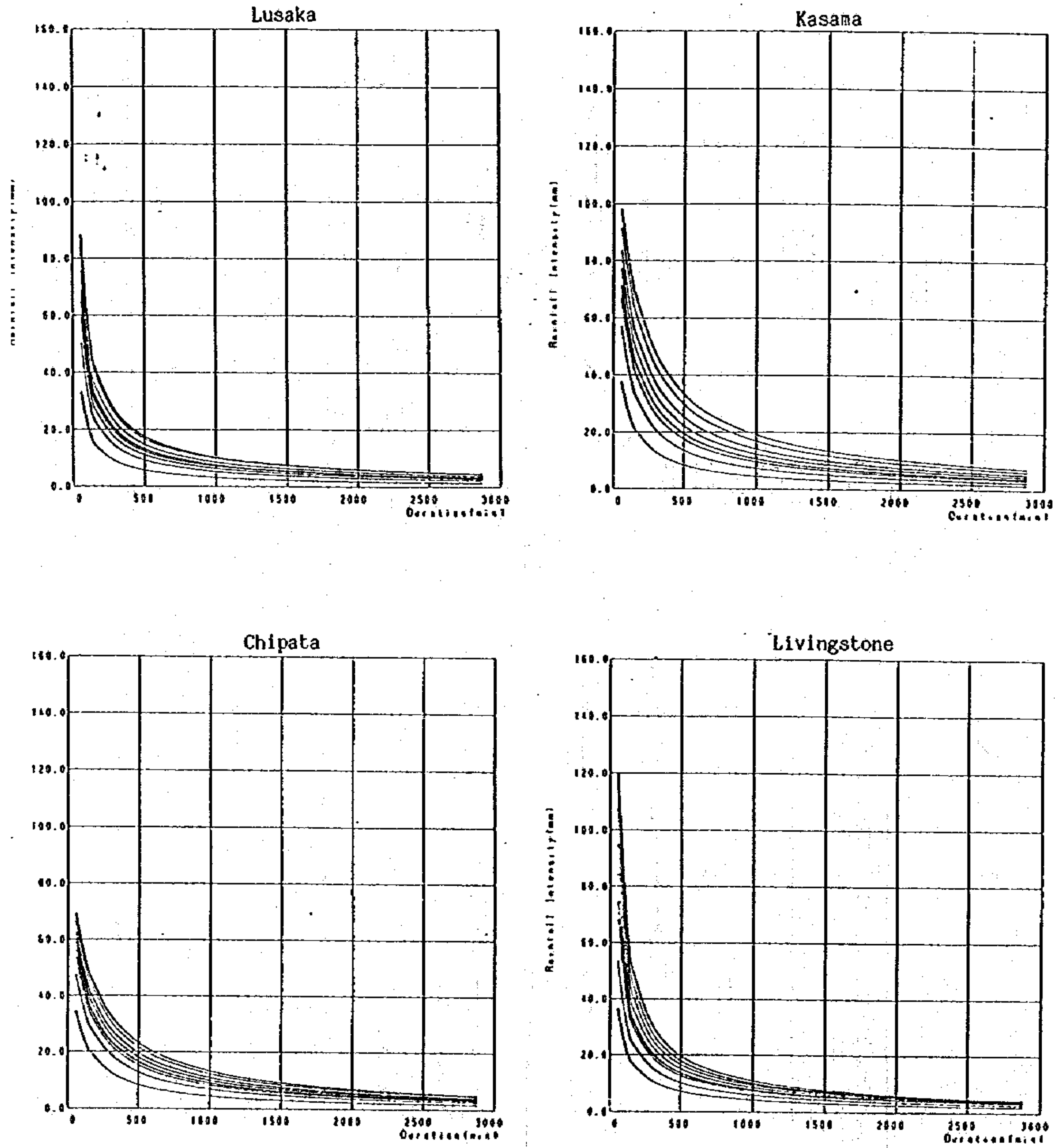


Figure 3-3(1) Rainfall Duration Curve

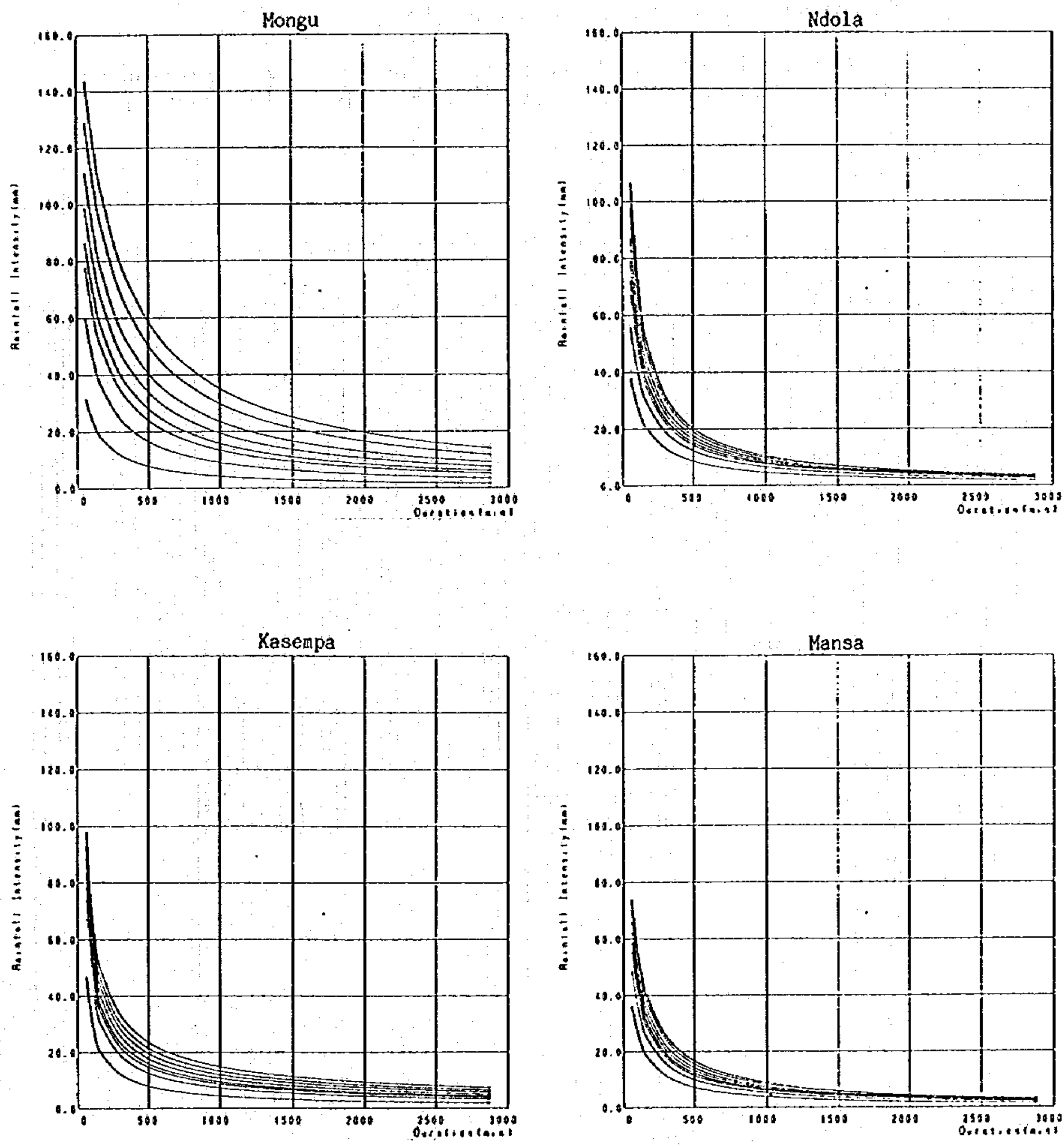


Figure 3-3 (2) Rainfall Duration Curve

3.2.2 Probable Discharge

Probable discharge is used for design of dam and river improvement, and obtained on the basis of recorded discharge data or calculated discharge from probable rainfall.

(1) Collection of maximum records of discharge in each year.

There are 42 reporting discharge stations (Figure 3-4) whose daily discharge data are available. Table 3-7 shows the maximum annual discharges recorded at each station.

Table 3-7 (1) Annual Maximum Discharge

Zambezi		Mwinilunga		Kabompo		Watopa Pontoon		Lukulu		Kalabo	
Date of occurrence	discharge	Date of occurrence	discharge	Date of occurrence	discharge	Date of occurrence	discharge	Date of occurrence	discharge	Date of occurrence	discharge
1947 3 26	3852.0	1954 3 24	144.3	1951 2 15	456.0	1958 9 14	50.0	1951 3 2	4313.0	1958 3 16	380.4
1948 3 20	3114.0	1955 3 30	91.5	1952 3 8	985.0	1959 3 6	666.0	1952 3 7	4392.0	1959 3 22	154.9
1949 4 13	550.0	1956 4 25	145.1	1953 4 7	610.0	1960 3 15	615.0	1953 3 16	4123.0	1960 2 24	311.5
1950 2 25	4302.0	1957 3 23	354.7	1954 3 25	336.0	1961 3 31	1076.0	1954 3 31	3327.0	1961 3 24	358.0
1951 2 26	4037.0	1958 3 17	158.4	1955 3 15	376.0	1962 4 9	1184.0	1955 3 22	3360.0	1962 3 3	550.4
1952 3 8	3351.0	1959 3 7	183.0	1956 4 12	538.0	1963 3 22	1144.0	1956 5 4	4510.0	1963 3 16	372.7
1953 4 2	3411.0	1960 3 25	355.1	1957 3 4	612.0	1964 2 26	697.0	1957 3 2	4587.0	1964 2 22	189.0
1954 3 27	3820.0	1961 3 28	502.0	1958 2 20	418.0	1965 2 28	677.0	1958 3 4	4195.0	1965 4 3	188.0
1955 4 1	1033.0	1962 4 17	356.7	1959 3 15	338.0	1966 3 14	1018.0	1959 3 17	3853.0	1966 3 16	737.4
1956 5 2	4155.0	1963 3 25	244.3	1960 3 31	320.0	1967 4 8	735.0	1960 4 3	4450.0	1967 5 13	131.4
1957 3 1	4142.0	1964 3 18	356.7	1961 4 3	1054.0	1968 3 25	952.0	1961 4 6	4681.0	1968 1 30	389.7
1958 3 3	4170.0	1965 3 13	269.1	1962 4 7	1083.0	1969 4 4	1022.0	1962 3 21	4665.0	1969 3 28	882.3
1959 3 15	3408.0	1966 3 17	318.7	1963 3 23	735.0	1970 2 22	1172.0	1963 2 28	4823.0	1970 2 24	580.8
1960 3 31	4303.0	1967 3 16	354.7	1964 2 27	559.0	1971 2 25	917.0	1964 2 19	3210.0	1971 3 5	324.8
1961 4 5	4455.0	1968 3 26	374.7	1965 3 19	520.0	1972 3 21	505.0	1965 2 28	3509.0	1972 4 8	311.5
1962 3 28	4406.0	1969 3 26	605.1	1966 3 13	633.0	1973 3 14	332.0	1966 3 24	4426.0	1973 3 29	42.5
1963 3 28	4281.0	1970 3 6	238.5	1967 4 1	638.0	1974 2 24	478.0	1967 4 8	4024.0	1974 2 26	311.5
1964 3 18	2271.0	1977 4 9	278.0	1968 1 2	418.0	1975 3 30	924.0	1968 3 25	4752.0	1975 3 13	661.7
1965 3 20	2733.0	1978 4 2	265.4	1969 2 22	1219.0	1976 4 22	1079.0	1969 4 2	5657.0	1976 3 22	668.4
1966 3 26	3813.0	1979 3 21	444.5	1970 2 21	1219.0	1977 3 17	673.0	1970 3 8	4611.0	1977 3 18	258.9
1967 4 7	3637.0	1980 4 17	288.4	1971 2 23	488.0	1978 4 6	1338.0	1971 3 8	3663.0	1978 3 22	824.6
1968 3 31	4142.0	1981 3 17	288.0	1972 3 20	418.0	1979 4 6	1382.0	1972 4 14	2141.0	1979 4 5	354.1
1969 3 30	5350.0	1982 3 16	143.8	1973 3 13	326.0	1980 3 15	685.0	1973 3 15	1917.0	1980 3 17	369.3
1970 3 5	4522.0	1983 3 27	345.1	1974 4 10	348.0	1981 3 30	1032.0	1974 4 15	2833.0	1981 3 23	431.8
1971 3 5	2518.0	1984 3 10	88.1	1975 3 28	786.0	1982 3 18	581.0	1975 3 21	4460.0	1982 3 26	49.9
1972 4 14	1661.0	1985 4 1	152.2	1976 4 28	833.0	1983 4 4	585.0	1976 3 24	4435.0	1983 2 16	215.0
1973 4 3	1430.0	1988 3 23	145.0	1977 4 15	555.0	1984 3 12	365.0	1977 4 23	3725.0	1984 4 2	102.0
1974 4 15	2238.0	1988 10 29	40.4	1978 4 6	1371.0	1985 4 15	835.0	1978 4 12	5113.0	1985 2 25	200.1
1975 3 31	3427.0	1991 1 13	93.2	1979 3 24	1238.0	1986 3 31	740.0	1979 4 5	5113.0	1986 4 16	271.7
1976 4 25	3162.0	1992 2 20	0.0	1980 3 13	612.0	1987 2 25	713.0	1980 1 9	3020.0	1987 3 23	38.1
1977 4 21	3873.0			1981 3 31	970.0	1988 3 29	832.0	1981 4 14	4135.0	1988 4 2	504.0
1978 4 18	4288.0			1982 3 28	270.0	1989 4 8	548.0	1982 3 17	2451.0	1989 2 14	949.2
1979 3 25	3287.0			1983 4 8	561.0	1990 4 14	478.0	1983 4 2	1643.0	1990 4 4	110.0
1980 1 8	2923.0			1984 3 11	295.0	1991 2 12	688.0	1984 3 1	2743.0	1991 2 23	200.1
1981 4 18	3323.0			1985 4 13	504.0	1992 4 12	238.0	1985 4 18	2725.0	1992 4 18	46.4
1982 3 20	1638.0			1986 3 31	647.0	1993 4 12	711.0	1986 4 7	4035.0	1993 4 14	344.6
1983 2 28	731.0			1987 3 31	716.0	1994 2 28	554.0	1987 3 9	3281.0		
1984 2 28	2258.0			1988 4 5	436.0			1988 3 28	3285.0		
1985 3 13	1947.0			1989 4 11	359.0			1989 2 28	2824.0		
1986 4 4	3611.0			1990 4 14	443.0			1990 4 15	1877.0		
1987 3 8	2533.0			1991 3 31	573.0			1991 2 18	3241.0		
1988 3 21	2434.0			1991 10 24	82.0			1992 2 16	1434.0		
1989 4 13	3465.0			1993 4 12	1135.0			1993 4 11	4848.0		
1990 4 13	973.0										
1991 2 28	2444.0										
1992 2 24	1315.0										
1993 4 20	2608.0										
1993 12 31	158.0										

Table 3-7(2) Annual Maximum Discharge

Senanga			
Date of occurrence			discharge
1948	3	13	1051.0
1949	4	23	1872.0
1950	2	27	2664.0
1951	3	23	2645.0
1952	3	10	3194.0
1953	3	23	3835.0
1954	4	12	2639.0
1955	3	31	2615.0
1956	5	14	3033.0
1957	3	13	3597.0
1958	2	28	3560.0
1959	3	26	2765.0
1960	4	9	2765.0
1961	4	13	3059.0
1962	4	7	3133.0
1963	3	16	3742.0
1964	3	12	2355.0
1965	4	7	2337.0
1966	3	11	2854.0
1967	4	24	2590.0
1968	4	3	3113.0
1969	4	5	3312.0
1970	3	14	3058.0
1971	3	24	2568.0
1972	4	30	2789.0
1973	4	28	3159.0
1974	4	30	2168.0
1975	4	5	2988.0
1976	4	5	2828.0
1977	5	7	2397.0
1978	4	28	3322.0
1979	4	21	3221.0
1980	5	1	2335.0
1981	4	28	2656.0
1982	4	15	1630.0
1983	3	26	1298.0
1984	4	2	1837.0
1985	5	3	1921.0
1986	4	20	2421.0
1987	3	23	2101.0
1988	4	15	2335.0
1989	5	5	2664.0
1990	5	21	1247.0
1991	4	1	1149.0
1992	3	30	1141.0
1994	3	28	2020.0

Kalomo-Dam-Site			
Date of occurrence			discharge
1958	3	24	1.9
1961	1	27	228.9
1962	2	3	397.3
1963	2	24	592.0
1964	2	21	192.7
1964	10	6	1.9
1966	3	14	247.7
1967	1	8	43.4
1968	2	10	132.7
1969	3	27	152.3
1969	12	27	143.6
1971	1	25	41.6
1972	2	3	267.5
1973	3	10	45.6
1974	2	14	323.5
1975	2	18	174.9
1976	4	12	218.5
1977	2	21	45.6
1978	2	24	247.0
1979	3	4	71.9
1979	12	10	177.4
1981	2	25	174.9
1982	1	8	33.6
1983	2	7	43.9
1984	2	9	26.2

Raglan-Farm			
Date of occurrence			discharge
1960	3	24	183.2
1961	3	27	182.8
1962	3	30	201.5
1963	3	2	148.7
1964	3	19	33.5
1965	3	11	72.1
1966	3	17	30.8
1967	4	8	146.2
1968	3	15	81.0
1969	3	2	172.5
1970	3	1	145.3
1971	3	18	151.4
1972	4	1	134.1
1973	3	26	34.1
1974	4	8	33.1
1975	4	8	121.2
1976	4	13	157.0
1977	3	22	137.0
1978	3	30	267.4
1979	4	5	211.3
1980	4	17	133.6
1981	4	2	121.7
1982	3	1	77.4
1983	2	13	131.4
1984	3	8	83.1
1985	4	14	92.0
1986	3	24	144.8
1987	2	28	115.1
1988	3	24	111.8
1989	4	18	93.1
1990	4	8	52.5
1991	3	28	33.1
1992	1	23	23.4

Kafironda			
Date of occurrence			discharge
1960	3	15	133.5
1961	3	26	131.4
1962	4	3	278.1
1963	1	5	165.7
1964	1	30	186.8
1965	3	4	58.2
1966	3	6	95.1
1967	3	31	131.7
1968	3	15	181.1
1969	3	17	229.6
1970	3	1	184.4
1971	4	1	140.5
1972	4	3	153.5
1973	3	11	38.5
1974	4	5	76.8
1975	3	28	150.8
1976	4	11	222.6
1977	3	17	232.7
1978	3	14	414.1
1979	4	18	237.4
1980	3	8	144.8
1981	3	23	121.5
1982	2	17	118.3
1983	2	17	150.5
1984	2	20	113.8
1985	2	13	128.2
1986	3	22	207.9
1987	3	28	131.7
1988	3	25	162.4
1989	4	2	137.6
1990	4	14	74.2
1991	3	8	111.1

Smith's-Bridge			
Date of occurrence			discharge
1960	3	18	223.8
1961	3	26	197.6
1962	4	3	356.6
1963	1	6	276.7
1964	1	19	205.9
1965	3	12	159.9
1966	3	6	172.5
1967	3	31	286.1
1968	3	28	282.6
1969	3	17	316.2
1970	3	2	250.7
1971	3	15	328.8
1972	4	4	241.9
1973	3	12	118.7
1974	4	4	175.2
1975	3	15	281.6
1976	3	28	382.3
1977	3	20	281.0
1978	3	28	541.0
1979	4	3	316.2
1980	4	13	218.4
1981	3	11	231.3
1982	2	18	289.0
1983	2	17	289.0
1984	3	1	199.9
1985	2	14	236.3
1986	3	25	159.5
1987	3	28	229.0
1988	3	25	274.2
1989	2	18	237.1
1990	4	9	110.4
1991	3	30	232.7
1992	1	20	209.8

Mpatamato			
Date of occurrence			discharge
1951	3	13	384.0
1952	3	3	572.0
1953	4	2	202.2
1954	3	12	202.2
1955	3	11	244.7
1956	3	25	438.1
1957	3	17	476.8
1958	2	28	131.7
1959	3	9	197.5
1960	3	10	302.8
1961	3	25	335.9
1962	3	24	560.2
1963	3	14	468.4
1964	2	18	339.9
1965	1	17	214.0
1966	3	6	293.2
1967	3	24	262.1
1968	3	16	251.2
1969	2	9	438.1
1970	2	7	324.0
1971	2	8	406.8
1972	4	5	274.7
1973	3	3	134.3
1974	4	6	289.3
1975	3	18	333.4
1976	4	10	482.8
1977	3	21	398.5
1978	3	22	507.1
1979	4	1	478.8
1980	3	31	347.1
1981	3	9	483.4
1982	2	19	240.4
1983	2	19	355.3
1984	3	1	227.9
1985	2	15	413.9
1986	3	27	432.9
1990	6	18	31.5
1991	1	31	415.4
1992	1	30	148.8

Masaiti Road Bridge			
Date of occurrence			discharge
1972	3	10	34.2
1973	3	1	31.0
1974	3	2	36.0
1975	3	15	30.5
1976	4	8	31.6
1977	3	8	37.5
1978	2	1	53.4
1979	1	28	42.9
1980	2	5	41.5
1981	5	3	49.8
1982	2	28	33.0
1983	1	28	45.8
1984	2	24	38.5
1985	2	13	42.3
1986	2	18	52.2
1987	2	16	32.1
1988	3	24	53.3
1989	2	10	54.0
1990	2	18	41.5
1991	1	28	67.2
1992	1	23	18.0
1993	3	4	51.1

Machiya Ferry			
Date of occurrence			discharge
1963	3	15	436.7
1964	2	28	494.0
1965	1	25	323.6
1966	3	15	343.3
1967	4	7	339.3
1968	2	4	293.9
1969	2	28	714.9
1970	2	26	433.7
1971	3	3	542.5
1972	3	19	337.0
1973	3	5	165.8
1974	3	31	414.2
1975	3	25	496.3
1976	4	16	603.6
1977	3	27	544.3
1978	4	2	413.6
1979	4	2	389.4
1980	3	20	481.6
1981	3	16	635.9
1982	2	25	376.6
1983	2	28	388.5
1984	3	9	578.3
1985	2	21	578.3
1986	4	4	569.5
1987	4	6	344.5
1988	4	5	417.0
1989	2	28	417.0
1990	2	22	219.5
1991	2	14	370.1
1992	2	5	187.5
1993	3	4	649.0

Chilenga			
Date of occurrence			discharge
1962	4	22	268.0
1963	3	13	892.0
1964	2	27	696.0
1965	2	26	443.0
1966	3	28	398.0
1967	4	12	452.0
1968	2	16	314.0
1969	3	29	978.0
1970	3	3	549.0
1971	2	22	601.0
1972	4	11	422.0
1973	3	5	218.0
1974	3	18	622.0
1975	4	6	622.0
1976	4	22	461.0
1977	3	25	742.0
1978	4	12	1118.0
1979	4	18	1001.0
1980	3	25	644.0
1981	3	18	461.0
1982	3	3	458.0
1983	3	10	446.0
1984	3	18	384.0
1985	3	6	659.0
1986	4	11	691.0
1987	3	18	434.0
1988	4	5	561.0
1989	3	6	573.0
1990	2	27	259.0
1991	2	28	382.0
1992	4	7	128.0

Luburgu			
Date of occurrence			discharge
1951	6	12	45.0
1952	3	6	911.0
1953	3	8	462.0
1954	3	23	382.0
1955	3	21	455.0
1956	4	10	740.0
1957	3	12	870.0
1958	3	1	523.0
1959	3	14	469.0
1960	3	25	396.0
1961	3	27	677.0
1962	4	13	832.0
1963	3	13	1256.0
1964	2	18	704.0
1965	2	8	462.0
1966	3	15	396.0
1967	4	4	424.0
1968	2	18	316.0
1969	3	29	1118.0
1970	2	17	589.0
1971	2	20	648.0
1972	4	3	424.0
1973	3	15	396.0
1974	2	23	588.0
1975	3	22	659.0
1976	3	19	1069.0
1977	4	4	560.0
1978	2	24	918.0
1979	4	4	963.0
1980	3	10	579.0
1981	3	15	833.0
1982	2	24	455.0
1983	3	10	387.0
1984	4	4	326.0
1985	2	16	653.0
1986	4	25	579.0
1987	4	2	349.0
1988	3	22	502.0
1989	3	28	435.0
1990	2	11	273.0
1991	3	21	345.0
1992	2	15	101.0

Solwezi			
Date of occurrence			discharge
1972	3	31	6.4
1973	1	7	3.1
1974	3	14	3.1
1975	1	8	6.1
1976	3	10	6.3
1977	4	3	8.3
1978	3	24	7.4
1979	3	14	10.1
1980	1	13	10.1
1981	3	2	7.4
1982	1	23	12.4
1983	2	8	4.2
1984	3	3	3.9
1985	2	25	3.4

Chifumpa Pontoon			
Date of occurrence			discharge
1954	2	13	181.0
1955	1	29	283.0
1956	5	3	449.0
1957	2	16	483.0
1960	3	25	433.0
1961	3	27	680.0
1962	4	5	1088.0
1963	3	17	765.0
1964	2	17	531.0
1965	2	9	265.0
1966	3	22	198.0
1967	4	1	281.0
1968	3	16	218.0
1969	3	25	1155.0
1970	2	11	517.0
1971	3	7	267.0
1972	3	13	165.0
1973	2	26	75.0
1974	3	18	200.0
1975	3	22	319.0
1976	3	26	434.0
1977	3	23	351.0
1978	3	31	1743.0
1979	5	2	266.0
1980	3	9	326.0
1981	3	14	467.0
1982	2	24	212.0
1983	2	12	125.0
1983	12	25	449.0
1984	11	18	529.0
1986	5	1	451.0
1987	2	17	227.0
1988	3	26	646.0
1989	2	18	238.0
1990	4	8	239.0
1991	2	18	337.0
1992	4	11	80.0
1993	3	7	691.0
1994	1	23	204.0

Table 3-7(3) Annual Maximum Discharge

Kasempa-P.H.

Date of occurrence	discharge
1964 2 18	38.0
1965 3 7	15.4
1966 3 7	35.4
1967 3 14	88.7
1968 3 13	56.3
1969 3 22	129.5
1969 12 19	42.2
1971 1 5	65.1
1972 3 18	16.3
1973 2 27	8.7
1974 2 11	14.4
1975 3 22	21.2
1976 4 9	53.0
1977 3 8	51.7
1978 4 21	150.3
1979 3 8	51.7
1979 12 10	48.9
1981 3 9	65.3
1982 1 31	11.8
1983 2 11	18.5
1984 2 14	7.3
1985 3 20	20.0
1986 2 13	10.9
1987 1 30	17.0
1988 1 22	13.8
1988 11 7	6.9
1990 4 8	30.5
1991 2 15	44.3
1992 2 9	4.4
1993 3 12	43.4
1994 1 11	10.1

Kafue Hook Bridge

Date of occurrence	discharge
1958 3 11	567.0
1959 3 24	2066.0
1970 2 11	1393.0
1971 3 6	967.0
1972 3 20	541.0
1973 3 15	272.0
1974 2 22	1644.0
1975 3 27	1252.0
1976 4 16	1020.0
1977 3 22	650.0
1978 4 7	1405.0
1979 3 31	1972.0
1980 3 18	1314.0
1981 3 16	1714.0
1982 2 24	862.0
1983 3 10	492.0
1984 3 10	492.0
1985 2 16	1322.0
1986 4 25	974.0
1987 2 14	608.0
1988 3 24	1258.0
1989 2 23	759.0
1990 2 12	602.0
1991 2 20	517.0
1992 4 14	179.0
1993 2 14	1327.4
1994 2 25	968.0

Itezhi-Tezhi Dam

Date of occurrence	discharge
1952 1 7	1400.0
1953 3 27	4372.0
1954 3 12	3349.0
1955 3 4	3137.0
1956 3 21	1430.0
1957 3 15	1233.0
1958 2 25	2209.0
1959 3 7	2437.0
1960 3 21	774.0
1961 3 31	1603.0
1962 3 1	2515.0
1963 3 15	2752.0
1964 2 22	1519.0
1965 2 12	838.0
1967 4 3	749.0
1968 3 10	845.0
1969 3 24	2618.0
1970 2 13	1457.0
1971 2 5	1451.0
1972 4 5	642.0
1973 3 17	243.0
1974 2 24	1370.0
1975 3 8	1657.0
1976 4 18	1331.0
1977 3 30	1617.0
1978 4 27	1374.0
1979 4 22	1533.0
1980 3 20	1005.0
1981 3 4	1689.0
1982 2 28	731.0
1983 3 27	320.0
1984 3 27	351.0
1985 4 22	666.0
1986 4 27	920.0
1988 12 16	566.0
1988 3 27	1440.0
1989 3 8	726.0
1990 2 16	786.0
1991 4 21	452.0
1992 4 28	280.0
1992 10 11	197.0

Mutaza Rapids

Date of occurrence	discharge
1963 12 10	37.6
1964 12 17	132.4
1965 2 27	145.2
1967 1 22	38.6
1968 2 10	35.4
1969 3 22	245.0
1970 1 20	114.0
1971 2 18	88.0
1971 11 16	185.6
1973 2 25	568.4
1974 2 20	782.3
1975 3 2	75.4
1976 4 11	177.5
1977 3 27	47.0
1978 4 16	554.0
1979 2 21	65.0
1980 3 3	477.2
1981 2 23	211.1
1982 2 2	273.1
1983 2 4	184.5
1984 3 28	545.4
1984 12 31	188.6
1986 2 16	124.2
1988 12 4	43.3

Shibuyunji

Date of occurrence	discharge
1963 3 13	258.7
1964 2 21	31.0
1965 1 27	18.5
1966 3 18	23.9
1967 3 8	39.6
1968 2 22	9.2
1969 1 11	35.5
1970 1 8	14.0
1971 1 27	43.4
1972 2 3	31.0
1973 2 26	6.1
1974 3 1	13.3
1975 2 22	33.4
1976 3 30	112.7
1977 3 11	14.9
1978 1 22	112.7
1978 12 31	20.4
1980 3 3	57.7
1981 2 25	165.0
1982 2 28	16.5
1983 2 18	11.3
1984 2 18	4.0
1985 2 12	57.7
1986 4 23	188.6
1987 2 1	8.9
1988 2 4	9.8
1989 2 7	133.2
1990 2 15	13.3
1991 2 11	43.8
1992 4 1	1.1

Mgwezure

Date of occurrence	discharge
1978 1 3	1.1
1978 12 27	1.1
1980 2 28	2.3
1981 2 15	2.5
1982 2 9	3.3
1983 1 26	1.0
1984 2 28	0.8
1985 2 9	1.9
1986 4 21	3.2
1986 12 13	2.0
1987 12 5	0.6
1989 2 20	4.3
1990 2 1	2.3
1991 1 18	3.2
1991 11 24	0.2

Chongwe

Date of occurrence	discharge
1969 2 9	16.9
1976 3 20	82.0
1977 3 19	45.3
1978 2 4	175.2
1978 12 17	96.4
1980 3 3	181.1
1981 2 16	132.4
1982 2 9	127.2
1983 1 28	30.2
1984 2 27	6.8
1985 2 11	58.9
1986 4 22	136.4
1987 1 25	80.4
1988 2 15	27.1
1989 2 20	131.9
1990 2 8	60.4
1991 2 14	70.0
1991 11 25	7.0
1993 2 27	35.6

Rosor Farm

Date of occurrence	discharge
1959 12 29	28.0
1961 1 17	13.1
1962 2 15	0.4
1963 3 3	0.8
1964 1 27	1.5
1965 2 13	3.0
1966 1 30	0.3
1967 2 28	3.5
1967 12 28	0.2
1969 2 15	0.5
1970 3 21	0.0
1971 1 22	7.3
1971 11 30	1.2
1973 1 11	1.0
1974 3 8	0.3
1975 2 18	7.0
1976 3 26	2.5
1977 2 17	0.4
1978 3 21	2.6
1978 12 15	13.3
1980 2 27	2.6
1981 2 13	9.7
1982 2 8	3.3
1983 1 22	1.5
1984 1 31	0.3
1985 1 29	1.7
1986 4 28	6.0
1987 1 17	1.0
1988 3 20	0.0
1989 3 20	1.3
1990 2 14	1.0
1991 1 13	0.1
1992 1 20	0.1
1993 1 10	1.0

Nadziacya Quarry

Date of occurrence	discharge
1971 2 18	77.1
1972 2 29	15.5
1973 2 26	10.4
1974 2 7	44.6
1975 1 3	19.3
1976 2 20	44.6
1977 2 27	30.7
1978 3 9	128.3
1979 2 24	33.5
1980 4 17	45.5
1981 2 22	83.5
1982 2 7	51.0
1983 2 18	51.6
1985 2 8	35.5
1986 2 2	85.0
1987 2 25	11.3
1988 2 18	118.9
1989 1 18	68.0
1990 4 8	18.2
1991 1 30	17.2
1992 3 25	2.4

Lutembe

Date of occurrence	discharge
1970 12 18	6.2
1972 5 1	4.4
1973 1 29	1.0
1985 2 7	4.4

Lusiwashi

Date of occurrence	discharge
1966 2 21	43.1
1967 4 3	20.9
1968 3 14	18.1
1969 2 10	41.3
1970 2 7	37.0
1971 2 24	50.3
1972 3 8	32.5
1973 2 25	28.3
1974 4 4	82.9
1975 3 14	42.0
1976 3 20	85.3
1977 3 2	53.7
1978 3 21	54.0
1979 3 16	61.3
1980 3 8	66.3
1981 3 27	39.1
1982 1 31	21.4
1983 2 16	84.5
1984 2 27	15.6
1985 2 14	37.0
1986 3 9	50.7
1987 1 19	21.5
1988 1 22	42.0
1989 1 31	43.2
1990 1 19	47.5
1991 1 27	30.7
1991 12 26	17.5
1994 1 26	30.2

M'kushi Scea

Date of occurrence	discharge
1962 3 28	1.3
1963 2 17	20.3
1963 12 7	14.3
1965 2 12	21.0
1966 2 28	25.0
1967 2 22	13.5
1968 2 11	23.5
1969 2 8	27.4
1969 12 24	7.3
1971 2 3	6.1
1972 1 17	9.0
1973 2 10	3.9
1974 3 2	23.5
1975 3 14	5.3
1976 3 12	18.2
1977 3 7	19.4
1978 3 21	18.9
1978 12 30	12.8
1980 3 12	13.9
1981 3 12	19.9
1982 2 8	20.3
1983 2 14	11.5
1987 1 29	18.6
1986 3 30	11.5
1991 2 8	9.9
1991 12 23	11.2

Table 3-7(4) Annual Maximum Discharge

Ndera-C.

Date of occurrence	discharge
1981 2 25	224.0
1982 2 21	74.0
1983 2 18	271.0
1984 3 7	33.0
1985 2 8	160.0
1986 2 12	221.0
1987 1 28	33.0
1988 3 26	136.0
1989 2 8	182.0

Luangwa Road Bridge

Date of occurrence	discharge
1948 1 11	2115.0
1949 2 10	185.0
1950 2 25	4182.0
1951 2 26	1817.0
1952 3 6	6283.0
1953 2 6	2683.0
1954 12 25	1170.0
1955 1 18	39.0
1956 4 8	5531.0
1957 2 22	5427.0
1958 2 28	7028.0
1959 3 4	6031.0
1960 3 17	2075.0
1961 3 15	3882.0
1962 2 1	5482.0
1963 3 21	4767.0
1964 2 8	4787.0
1965 2 22	3968.0
1966 3 2	4348.0
1967 3 26	2487.0
1968 2 14	2588.0
1969 2 4	2681.0
1970 2 8	3278.0
1971 2 25	4264.0
1972 3 3	3788.0
1973 3 2	2133.0
1974 4 6	6292.0
1975 3 14	3692.0
1976 3 26	5333.0
1977 3 5	3402.0
1978 3 27	7772.0
1979 3 18	3251.0
1980 3 13	3668.0
1981 2 25	5552.0
1982 2 9	4202.0
1983 2 18	5821.0
1984 2 27	1870.0
1985 2 5	5457.0
1986 1 12	5240.0
1987 1 20	3846.0
1988 2 17	4998.0
1989 2 8	5772.0
1990 3 7	8078.0
1991 1 15	2223.0
1992 9 18	4468.0
1993 4 3	10213.0
1994 4 2	3918.0

Chambeshi Old Pontoon

Date of occurrence	discharge
1953 3 16	59.0
1954 3 16	187.0
1955 3 8	354.0
1956 4 7	765.0
1957 4 4	492.0
1958 3 31	329.0
1960 4 2	597.0
1961 3 31	195.0
1962 4 4	1445.0
1963 4 5	1199.0
1964 3 24	1159.0
1965 3 31	653.0
1966 4 8	346.0
1967 4 12	260.0
1968 3 23	869.0
1969 4 8	539.0
1970 3 23	847.0
1971 3 17	838.0
1972 3 18	345.0
1973 4 21	316.0
1974 4 18	373.0
1975 4 11	672.0
1976 4 11	633.0
1977 4 10	258.0
1978 4 1	1129.0
1979 4 3	1113.0
1980 4 28	80.0
1981 4 5	650.0
1982 3 25	283.0
1983 3 21	574.0
1984 3 10	528.0
1985 3 30	776.0
1986 3 21	833.0
1987 3 28	765.0
1988 3 28	484.0
1989 4 8	814.0
1990 4 3	358.0
1991 4 8	432.0
1992 4 8	338.0
1994 3 24	422.0

Chishimba Falls

Date of occurrence	discharge
1957 5 1	39.5
1958 3 26	56.0
1959 4 7	34.0
1960 2 25	50.2
1961 1 28	40.7
1962 12 15	90.0
1963 3 21	124.0
1964 3 20	156.5
1965 3 11	80.3
1966 3 24	89.3
1967 4 18	60.7
1968 4 12	124.6
1969 3 25	62.0
1970 3 22	98.6
1982 4 5	58.8
1983 3 31	135.9
1984 3 5	86.7
1985 4 18	83.1
1986 1 21	88.7
1987 2 19	124.4
1988 3 30	67.2
1989 4 7	41.4

Chembe Ferry

Date of occurrence	discharge
1955 11 15	131.0
1957 4 2	32.0
1958 3 23	600.0
1959 4 14	658.0
1960 4 8	1088.0
1961 4 8	888.0
1962 4 4	4224.0
1963 3 21	3808.0
1964 2 27	3174.0
1965 3 11	1508.0
1966 3 19	1148.0
1967 4 5	859.0
1968 3 21	1016.0
1969 3 22	2456.0
1970 3 28	1073.0
1971 3 15	2301.0
1972 4 4	1596.0
1973 4 18	800.0
1974 4 13	947.0
1975 3 26	1956.0
1976 4 13	2199.0
1977 2 28	925.0
1978 3 27	3892.0
1979 4 1	2912.0
1980 4 21	2183.0
1981 3 31	2828.0
1983 12 1	182.0
1985 4 30	5.0
1987 4 17	12.0
1991 3 22	318.0
1992 3 31	177.0
1994 3 3	428.0

Mwenda-Kashiba-B.S.

Date of occurrence	discharge
1970 3 21	115.2
1971 2 15	85.3
1972 3 28	182.6
1973 2 28	81.5
1974 4 12	185.8
1975 3 15	99.0
1976 4 11	120.8
1977 3 21	90.3
1978 3 26	122.1
1979 3 25	139.8
1980 4 22	116.0
1981 3 31	124.0
1982 3 16	37.3
1983 2 16	108.3
1985 2 28	67.8
1986 4 5	103.0
1987 11 30	28.5
1988 2 23	58.7
1989 4 22	72.0
1990 4 12	102.6
1992 4 1	69.6

Chipili

Date of occurrence	discharge
1971 2 9	53.1
1972 4 2	65.1
1973 2 23	38.3
1974 3 6	61.4
1975 3 18	118.6
1976 4 4	122.7
1977 3 11	48.5
1978 3 25	118.0
1979 1 25	174.6
1980 3 6	88.6
1981 1 27	75.8
1982 1 20	12.4
1983 2 17	67.8
1984 1 17	57.8
1985 4 10	98.2

Kashiba

Date of occurrence	discharge
1956 2 5	687.0
1957 4 3	3860.0
1958 3 18	1859.0
1959 3 19	886.0
1960 3 22	1522.0
1961 4 5	1788.0
1962 4 12	4821.0
1963 3 23	3731.0
1964 2 25	3684.0
1965 3 12	2419.0
1966 4 1	1728.0
1967 4 5	1265.0
1968 3 28	2401.0
1969 3 30	3290.0
1970 3 20	1874.0
1971 3 15	3332.0
1972 4 7	2188.0
1973 4 15	1169.0
1974 4 8	1488.0
1975 3 23	1665.0
1976 4 15	3854.0
1977 3 22	2867.0
1978 4 6	3784.0
1979 3 28	4071.0
1980 5 1	3675.0
1982 6 1	403.0
1983 2 29	4138.0
1984 10 1	181.0
1985 12 28	3555.0
1988 3 28	1122.0
1989 2 14	1611.0
1990 4 15	704.0
1991 4 18	562.0
1992 4 3	548.0

Kaso Falls

Date of occurrence	discharge
1958 3 30	281.8
1959 3 26	113.7
1960 3 31	626.7
1961 3 28	152.0
1962 1 8	725.4
1963 3 19	452.2
1964 3 24	669.1
1965 3 30	246.6
1966 3 22	483.8
1967 4 28	192.2
1968 3 25	584.9
1969 3 21	261.0
1970 3 27	285.5
1971 3 19	425.2
1972 3 19	425.2
1973 3 17	268.7
1974 4 21	88.8
1975 3 28	282.4
1976 4 4	173.4
1977 4 13	115.4
1978 4 1	389.3
1979 3 22	487.3
1980 4 28	218.7
1981 1 31	83.2
1982 3 24	58.3
1983 1 1	333.3
1984 3 18	378.4
1985 4 18	218.4
1986 4 1	139.2
1987 3 21	285.5
1988 4 3	218.4
1989 4 9	721.1
1990 4 11	243.3
1991 3 13	58.9
1992 3 5	159.0

Nara Ferry

Date of occurrence	daily discharge
1991 3 28	2598.0
1992 4 15	1385.0
1993 4 30	1243.0

Kunda Falls

Date of occurrence	discharge
1971 3 13	298.0
1972 3 23	230.0
1973 3 12	309.0
1974 4 9	304.0
1975 3 23	241.0
1976 4 5	389.0
1977 3 19	232.0
1978 4 5	395.0
1979 4 1	536.0
1980 4 20	444.0
1981 4 1	447.0
1982 4 18	187.0
1983 2 7	341.0
1984 3 19	481.0
1985 4 18	48.0
1986 3 30	323.0
1987 3 19	355.0
1988 3 24	344.0
1989 4 14	389.0
1990 4 9	418.0
1991 4 11	487.0
1992 3 10	287.0

Kasanga-Road Bridge

Date of occurrence	discharge
1970 6 24	49.0
1971 3 11	270.0
1972 2 29	179.0
1973 3 28	190.0
1974 4 6	170.0
1975 3 21	283.0
1976 3 22	185.0
1977 4 7	140.0
1978 3 18	260.0
1979 3 30	336.0
1980 4 15	274.0
1982 4 8	159.0
1983 3 4	232.0
1984 3 3	219.0
1985 4 10	238.0
1986 2 18	231.0
1987 2 24	275.0
1988 3 26	203.0
1989 4 13	202.0
1990 2 27	148.0
1991 4 2	260.0
1992 3 24	224.0
1993 3 21	212.0
1994 1 31	65.0

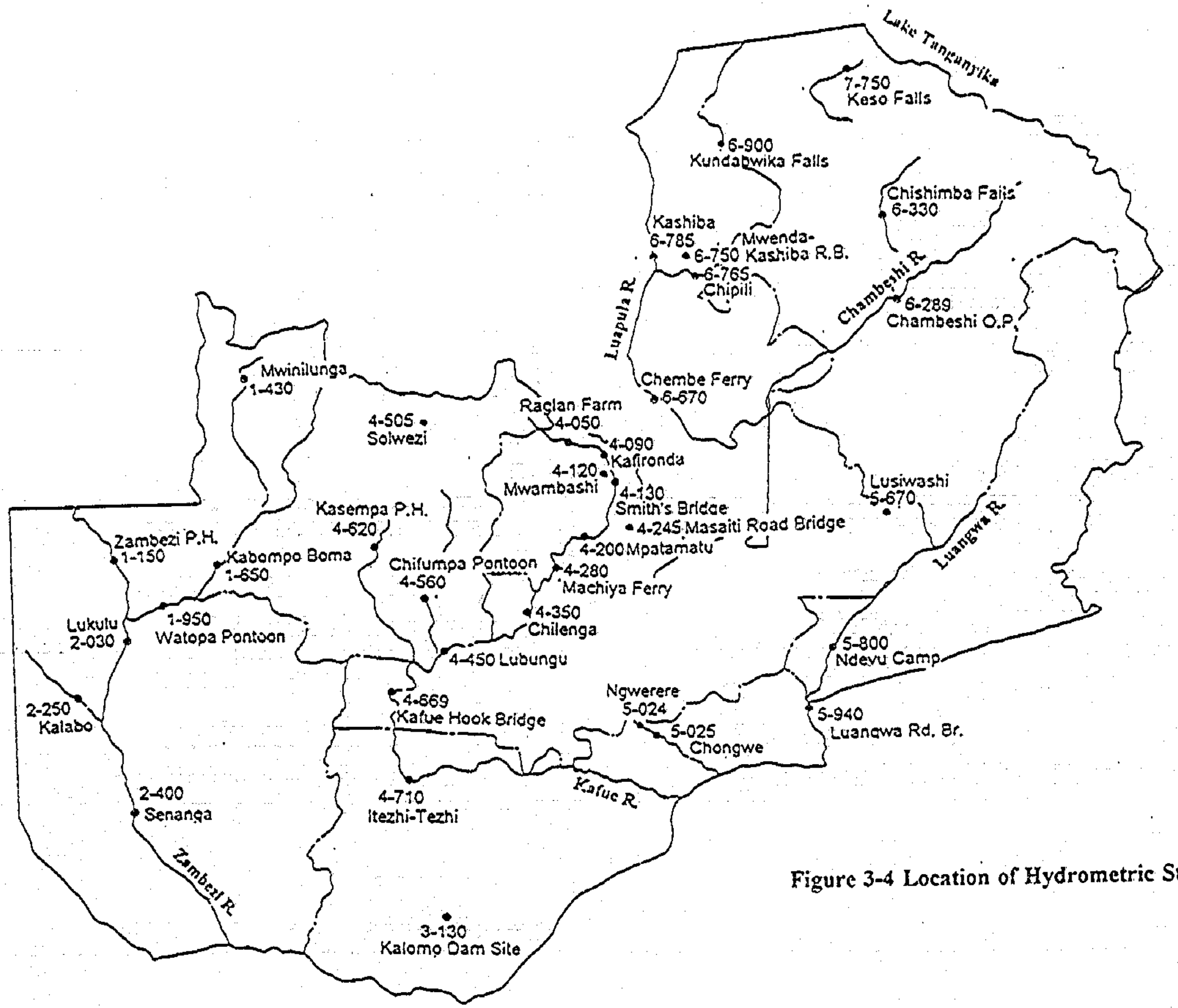


Figure 3-4 Location of Hydrometric Stations

(2) Probable discharge

Concerning discharge, the probable discharge for each stations was analysed. Table 3-8 shows probable discharge of each hydrometric station, obtained from the recorded discharge data.

3.2.3 Specific Discharge

The correlation of catchment area to specific discharge (discharge/catchment area) for the observed discharge and probable discharge (1000-year probability) are shown in Figure 3-5. From these Figures, it can be said that the specific discharge tends to decrease with an increase in catchment area. This is the common phenomenon that the mean rainfall amount in a large-scale catchment shows a decrease due to the localisation of rainfall area distribution. There is little difference between rivers with specific discharge.

Relational expressions have been established based on the envelope curve of the maximum specific discharge. As a safety measure, the relational expression should adopt the maximum value required at present considering that the river discharge is likely to increase with data accumulation in future. These expressions are shown as follows.

Maximum discharge in the past : q = 8.0 x A** (-0.4)
Probable discharge of 1000-year : q = 16.0 x A** (-0.4)
where,
q : Specific discharge ($m^3/s/km^2$)
A : Catchment area (km^2)

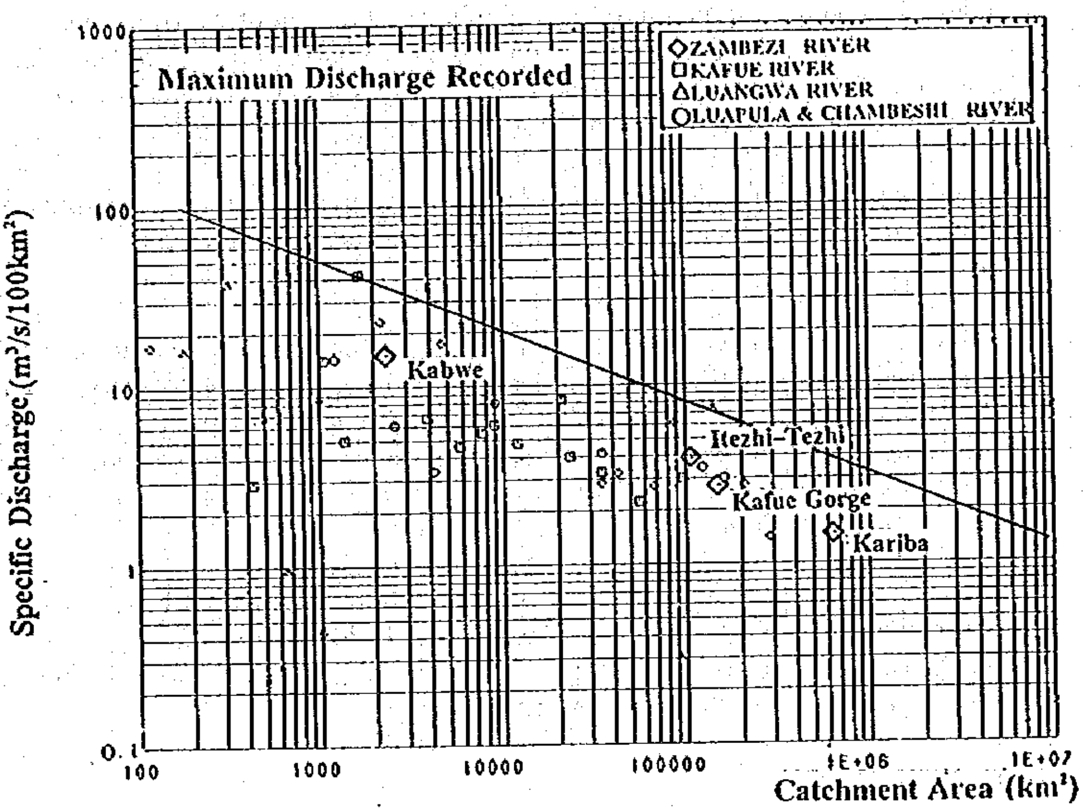
These equations are useful to estimate design flood discharges of rivers with little available data. For reference, the spillway design flood of existing dams are shown below. These numerical values are equal to maximum discharges in the past, and are smaller than those based on the above equations.

- Itezhi-Tezhi (Kafue river)
  C.A = 107,191km^2, Q = 4,200m^3/s, q = 0.04$m^3/s/km^2$
- Kafue gorge (Kafue river)
  C.A = 153,826km^2, Q = 4,250m^3/s, q = 0.028$m^3/s/km^2$
- Kariba (Zambezi river)
  C.A = 663,880 km^2, Q = 9,500m^3/s, q = 0.014$m^3/s/km^2$
- Kabwe (Luangwa river, Mulungushi river)
  C.A = 2,450km^2, Q = 375m^3/s, q = 0.153$m^3/s/km^2$

Table 3-8 Probable Discharge

No.	Station	A	Qmax	Q200	Q1000	qmax	q200	q1000
		(km^2)	(m^3/s)			($m^3/s/100km^2$)		
1-150	Zambezi	87,275	5,360.0	6,332.9	7,025.8	6.14	7.26	8.05
1-430	Mwinilunga	4,656	805.1	998.3	1,284.6	17.29	21.44	27.59
1-650	Kabompo	42,740	1,371.0	1,862.5	2,302.3	3.21	4.36	5.39
1-950	Watopa Pontoon	67,261	1,822.0	2,021.2	2,403.4	2.71	3.01	3.57
2-030	Lukulu	206,531	5,667.0	8,248.8	9,735.7	2.74	3.99	4.71
2-250	Kalabo	34,621	972.7	1,847.2	2,566.6	2.81	5.34	7.41
2-400	Senanga	284,531	3,982.0	5,499.8	6,466.6	1.40	1.93	2.27
3-130	Kalomo-Dam-Site	2,190	502.8	1,061.9	1,575.0	22.96	48.49	71.92
4-050	Raglan-Farm	5,775	267.4	297.7	352.1	4.63	5.15	6.10
4-090	Kafironda	7,589	414.1	420.3	519.7	5.46	5.54	6.85
4-130	Smith's-Bridge	8,914	541.0	551.5	650.9	6.07	6.19	7.30
4-200	Mpatamatu	12,001	572.0	709.0	795.2	4.77	5.91	6.63
4-245	Masaiti Road Bridge	1,375	69.0	83.0	92.6	5.02	6.04	6.73
4-280	Machiya Ferry	23,065	913.0	1,045.8	1,208.8	3.96	4.53	5.24
4-350	Chilenga	34,451	1,118.0	1,492.3	1,783.8	3.25	4.33	5.18
4-450	Lubungu	55,962	1,256.0	1,580.9	1,912.3	2.24	2.82	3.42
4-505	Solwezi	427	12.4	20.4	26.8	2.90	4.78	6.28
4-560	Chifumpa Pontoon	20,999	1,743.0	2,147.3	3,104.2	8.30	10.23	14.78
4-620	Kasempa-P.H.	1,062	150.3	232.5	346.2	14.15	21.89	32.60
4-669	Kafue Hook Bridge	96,239	2,889.0	4,287.7	5,654.6	3.00	4.46	5.88
4-710	Itezhi-Tezhi Dam	107,191	4,072.0	5,749.2	7,662.1	3.80	5.36	7.15
4-850	Mutama Rapids	1,677	702.3	1,757.6	2,856.7	41.88	104.81	170.35
4-940	Shibuyunji	3,885	259.7	782.1	1,464.6	6.68	20.13	37.70
5-024	Ngwerere	1,002	4.3	7.1	9.3	0.43	0.71	0.93
5-025	Chongwe	1,922	191.9	372.6	512.8	9.98	19.39	26.68
5-029	Romor Farm	118	20.0	41.3	83.8	16.95	35.00	71.02
5-560	Madzimoyo Querry	319	120.3	242.5	348.6	37.71	76.02	109.28
5-561	Lutembwe	650	6.2	49.3	92.4	0.95	7.58	14.22
5-670	Lusiwashi	995	86.1	116.7	142.3	8.65	11.73	14.30
5-755	M'kushi Boma	181	28.9	40.9	48.1	15.97	22.60	26.57
5-800	Ndevu-C.	91,861	271.0	944.9	1,432.8	0.30	1.03	1.56
5-940	Luangwa Road Bridge	140,922	10,213.0	13,004.4	16,235.8	7.25	9.23	11.52
6-289	Chambeshi Old Pontoon	34,745	1,446.0	1,992.2	2,551.4	4.16	5.73	7.34
6-330	Chishimba Falls	2,580	156.5	208.0	248.0	6.07	8.06	9.61
6-670	Chembe Ferry	123,072	4,224.0	10,625.3	16,511.6	3.43	8.63	13.42
6-750	Mwenda-Kashiba-R.B.	4,170	139.8	246.9	303.6	3.35	5.92	7.28
6-765	Chipili	1,220	174.6	225.1	273.2	14.31	18.45	22.39
6-785	Kashiba	161,275	4,821.0	7,693.1	9,963.6	2.99	4.77	6.18
7-750	Keso Falls	9,027	725.4	1,193.2	1,586.7	8.04	13.22	17.58

[Note] A : Catchment Area. Qmax : Maximum Discharge in the past
Q200 : Probable Discharge (1/200year). Q1000 : Probable Discharge (1/1000year)
qmax : Specific Discharge of Qmax. q200 : Specific Discharge of Q200
q1000 : Specific Discharge of Q1000



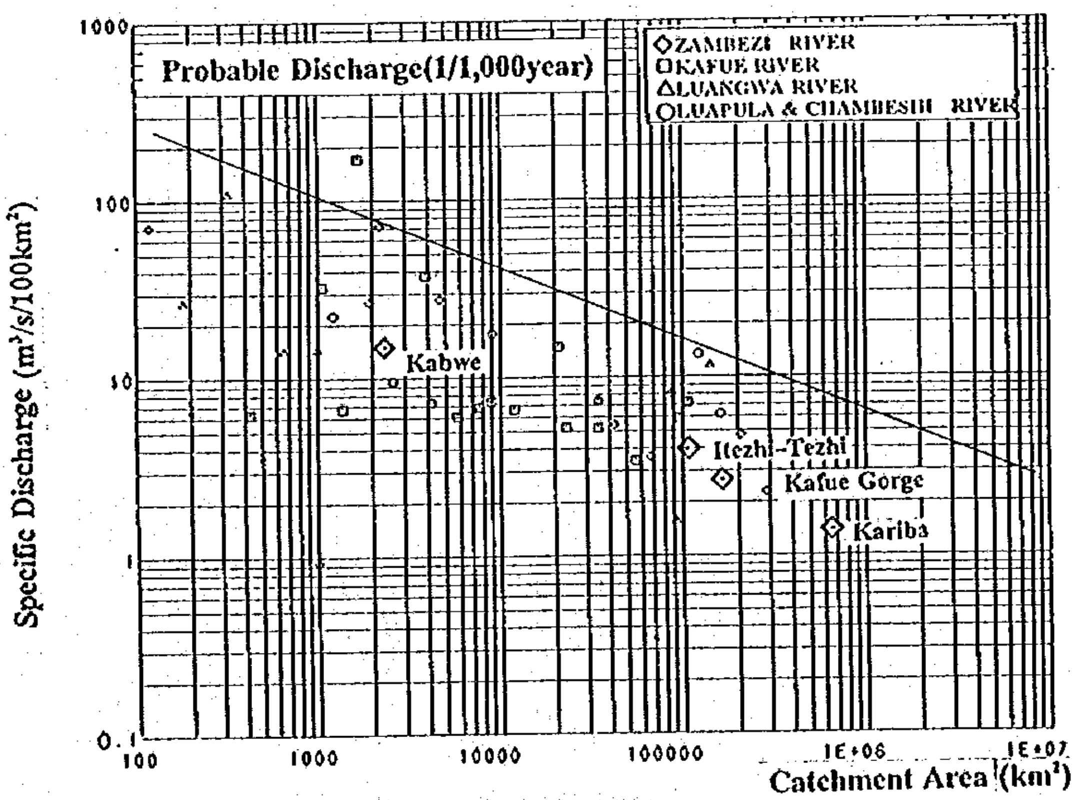


Figure 3-5 Specific Discharge

CHAPTER 4 FUTURE FLOOD CONTROL STRATEGY

Flood control measures are not a priority need in Zambia due to little flood damage on large rivers as described above. Flood control measure have a function of damage mitigation and can also work effectively to control inundation in order to make good use of land along the river. Some flood plains and swamps have fertile soil and irrigation water for those lands can be easily obtained. For this reason, large farms could become in good condition by maintaining a stable river channel. Measures to make river channels stable include channel improvement and raising of embankments in order to improve the discharge capacity of the channel. Other methods include flood control dams and retarding reservoirs to reduce the flood flow.

However, those measures have not been carried out in Zambia. Itezhi-Tezhi Dam has no function of flood control, but actually its large-scale reservoir capacity works on flood mitigation for the downstream area of Kafue Flats. This could be thought as a kind of flood control function. River channels in flood plains and swamps have a large number of branch streams. In this case, raising the discharge capacity of the main channel is more effective than trying to improve each small river channel.

Although the above-mentioned measures may not be easily undertaken because of large-scale construction and associated cost, it is necessary to include suitable measures as part of developments such as electric power generation plans, industrial and drinking water development, agricultural development, and city planning.