5.6 Consideration on Analysis Results

(1) Discharge Rating Curve

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

However, regarding the stations in the Mongu flooding areas along Zambezi River as shown in Table-5.6, the established rating curves express the discharge in river channel. The discharge in the flooding zone can not obtained with these curves. See Fig-5.11.

Table-5.6 Flooding Water Level and Discharge

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

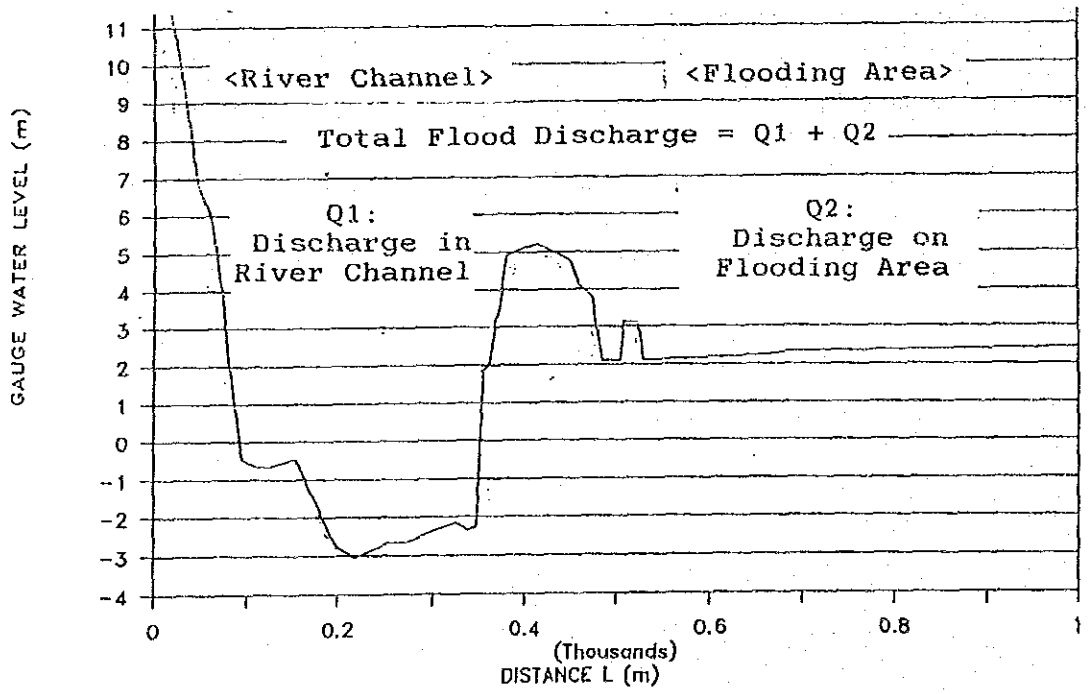

Fig.-5.11 River Channel and Flooding Area

(2) Reservoir Operation of Existing Dams

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

The reservoir simulation result shows that Itezhi-tezhi Dam is operated effectively for hydropower generation at Kafue Gorge Dam. Fig.-5.12 shows the annual ratio of hydropower generation (= 100 x (Discharge for generation / Total outflow discharge)). Regarding the last 10 years, full outflow from both dams has been used for hydropower generation, except for 4 years (1985/86 - 1988/89). During that period, hydropower generation at Kafue Gorge Dam was stopped due to the failure of facilities.

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

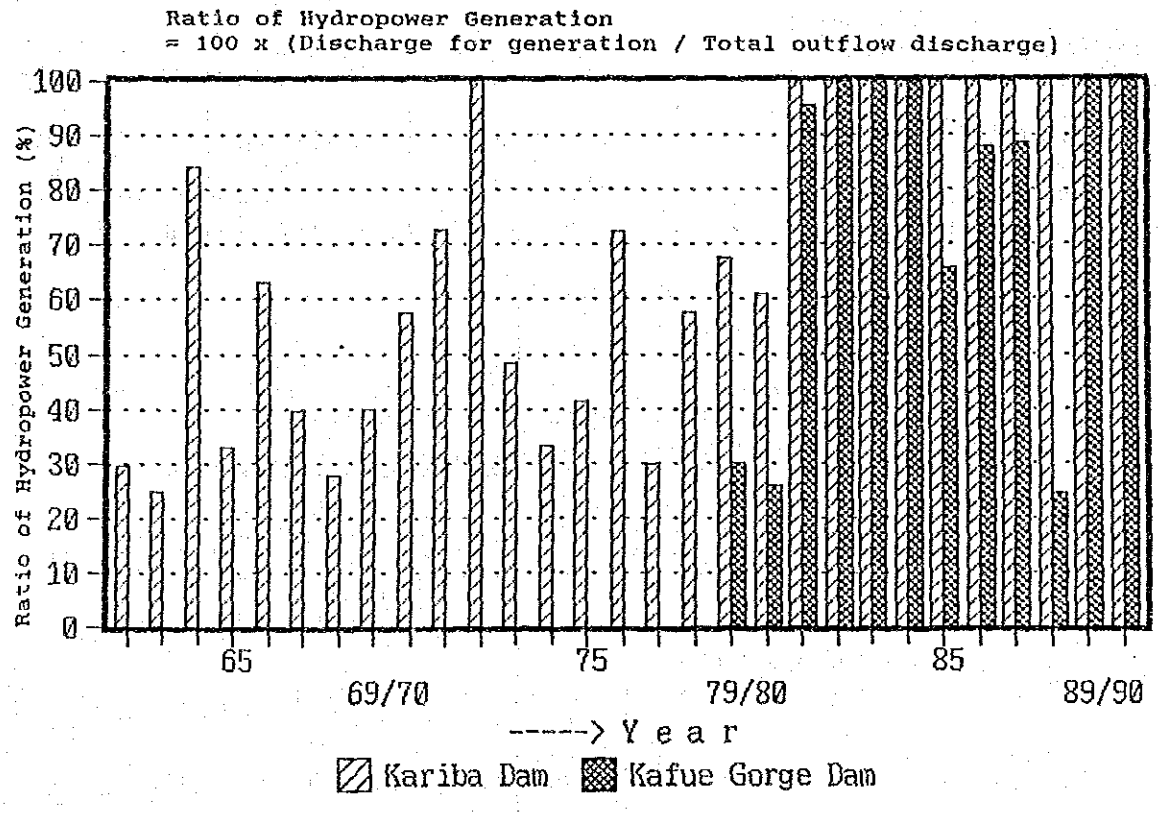

Fig.-5.12 Ratio of Hydropower Generation

(3) River Flow Balance in Flooding Areas

Along the main stream of upper Zambezi River there exists an extensive flood plain. Including the flood discharge, the river flow balance in this flooding area is estimated as shown in Table-5.7. Refer to Fig.-5.13. The values of discharge on the flooding area at Zambezi and Kalabo are assumed to be 5% and 20% of the channel discharge respectively. For the estimation of discharge from the areas (a, b and c in Table-5.10) where no measurement is done, the specific discharge of each area is assumed considering that of Kalabo Station.

Table-5.7 River Flow Balance on Mongu Flooding Area

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

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

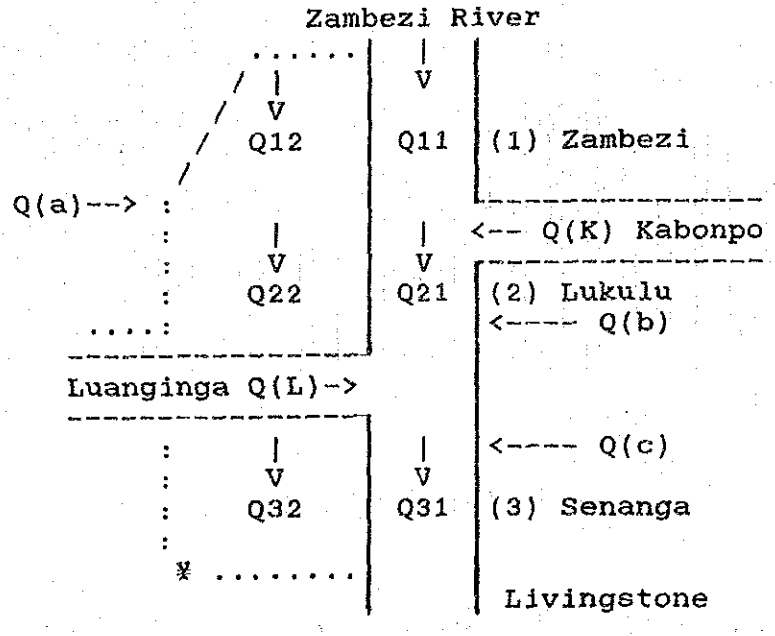

Fig.-5.13 Flooding Model in Mongu Plain

(4) Hydrologic Water Balance

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

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

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

Where,

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

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

$$R = Qo + Ev$$

Where,

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

Table-5.8 gives the hydrologic water balance of Kafue River basin over the last 10 years (1979/80 - 1988/89). Refer to Fig.-5.14.

Table-5.8 Hydrologic Water Balance of Kafue River Basin

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

<<< Kafue River Basin >>>

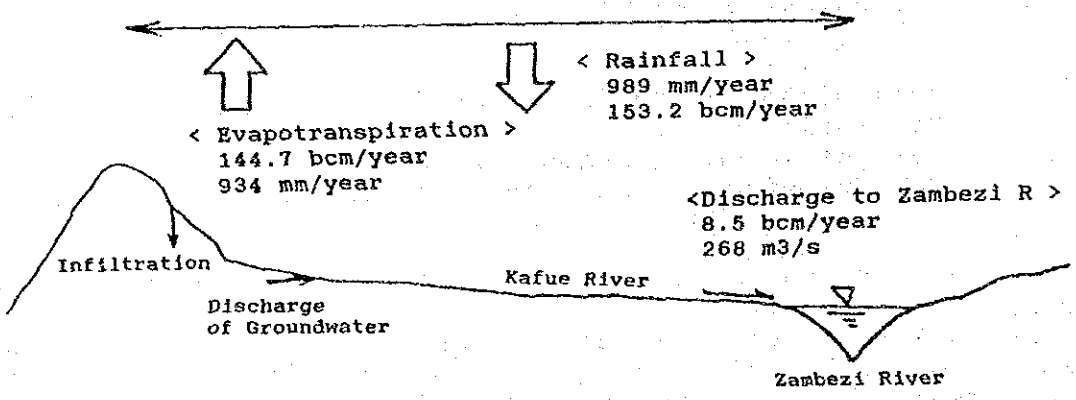

Fig.-5.14 Hydrologic Water Balance of Kafue River Basin

(5) Annual Fluctuation of Rainfall and Discharge

Annual volumes of rainfall and discharge change periodically due to the global climatological variation. One example is shown in Fig.-5.15 that illustrates the annual fluctuation of rainfall (at Solwezi) and discharge (at Kafue Hook Bridge) in the Kafue River Basin. Regarding the index "fluctuation coefficient" that shows the degree of fluctuation, The fluctuation coefficient of annual mean discharge is bigger than that of annual rainfall. This is because the runoff coefficient is changed in proportion to the amount of rainfall.

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

Fig.-5.16 shows the fluctuation coefficients of annual discharge at the main points covered by the Study. These coefficients are distributed from 0.2 - 0.6, showing larger values according to larger catchment area. This is because the storage and control effect of the area (for example, temporal storage of groundwater and its discharge to river) become larger in proportion to the catchment area.

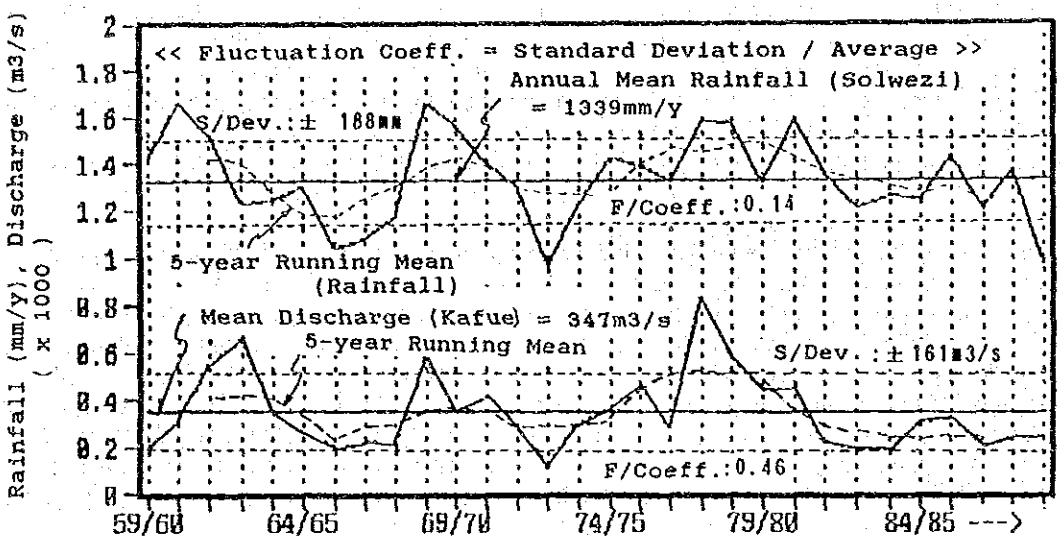

Fig.-5.15 Fluctuation of Annual Rainfall and Discharge

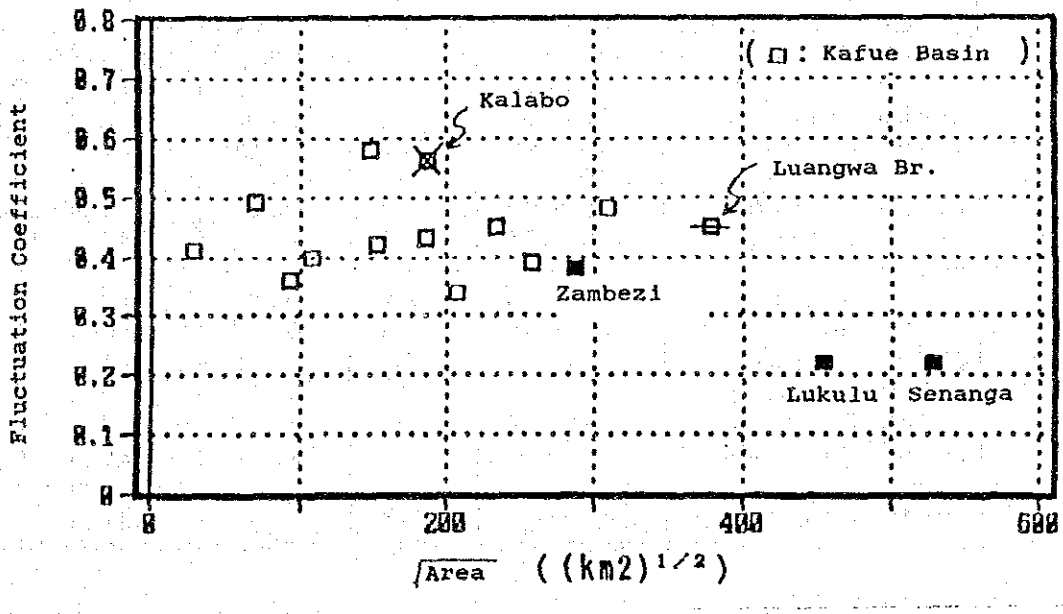

Fig.-5.16 Fluctuation Coefficient of Annual Mean Discharge

(6) Development Potential of River Water

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

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

The development potential of river water is assumed as follow. The maximum and minimum development potential of river water are low discharge (275 days discharge) and drought discharge (355 days discharge) respectively at each point of river. These values at each hydrometric station are as shown in Table-5.4. The low discharge is a discharge to secure for 275 days a year in average. The drought discharge is a discharge to secure for 355 days a year in average. Table-5.9 shows the development potential of river water at the main points. See Fig.-5.17. The potential includes the obligation discharge to downstream.

Table-5.9 Development Potential of River Water

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

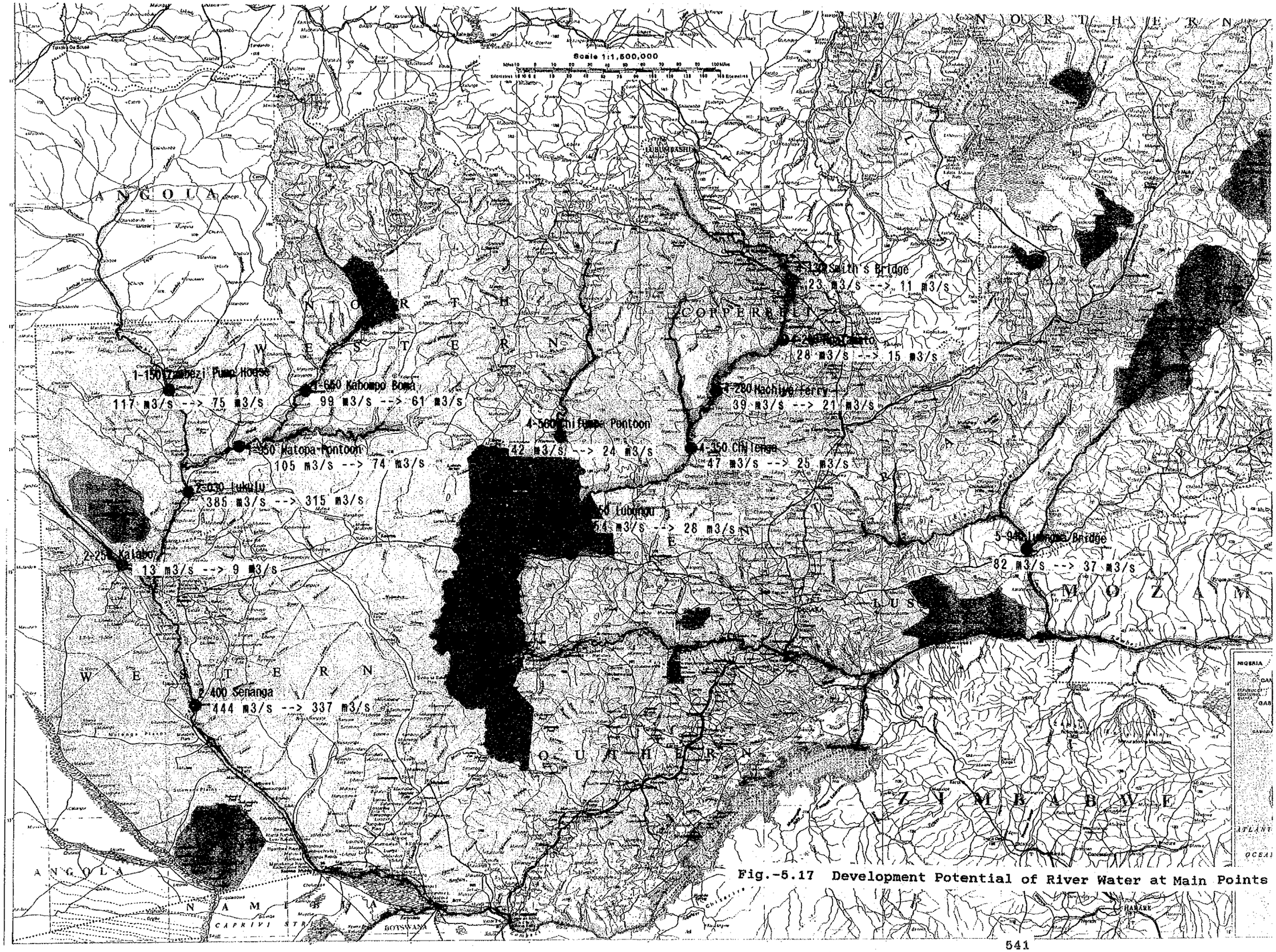

Fig.-5.17 Development Potential of River Water at Main Points

CHAPTER - 6 HYDROLOGIC OBSERVATION PLAN

6.1 General

(1) Objectives

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

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

(2) Contents

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

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

(3) Application

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

6.2 Activities

The work of hydrological observation comprises the following activities:

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

- Activity results for current year
- Activity plan for following year

7) Publication of Hydrological Year Book

(1) Hydrological Observation

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

< Observation of River Water Level >

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

< Measurement of Discharge >

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

< Sediment Sampling and Analysis >

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

<Investigation of Water Quality>

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

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

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

(2) Data Processing and Archiving

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

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

(3) Basic Hydrological Analysis

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

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

(4) Maintenance of Equipment and Station

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

(5) Training

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

(6) Reporting

< Activity Results for Current Year >

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

< Activity Plan for Following Year >

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

(7) Publication of Hydrological Year Book

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

6.3 Organization and Responsibilities

(1) General Organization

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

The Regional Hydrological Offices, belonging to DWA Provincial Offices, execute actual field observation in each Province. The Regional Hydrological Officer heads this office. The activities of this office are coordinated and supervised by DWA Hydrological Section. The gauge readers belong to each Regional Hydrological Office. Refer to Fig.-6.1.

(2) Responsibilities of Organization and Staff

The responsibilities of the organization and staff regarding hydrological observation are as shown in Table-6.1.

(3) Number of Staff

To fulfill the responsibilities of each organization the necessary number of main staff is as shown in Table-6.1.

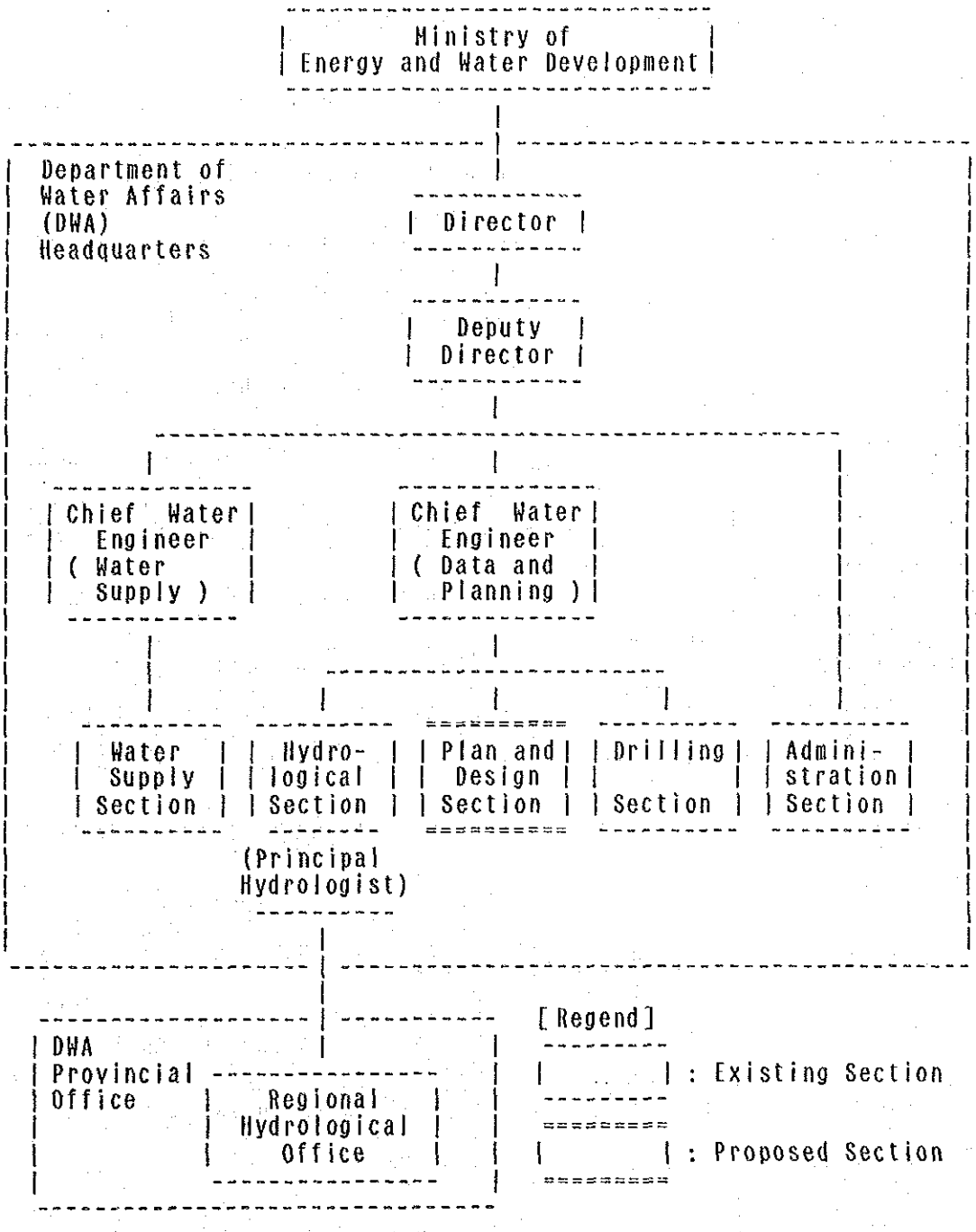

Fig.-6.1 General Organization for Hydrological Observation

Table-6.1 Responsibilities of Organization and Staff

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

6.4 Frequency of Observation

(1) Frequency of River Water Level Gauging

In principal, the daily gauging of the river water level is done at all the stations registered by DWA. Daily observations are done two (2) times a day, in morning and in evening. The average of these two data is recorded as a daily water level. The recording of river water level is executed, in principal, during the rainy season (from December to May).

(2) Frequency of Flow Measurement

The flow measurement is done at all the stations where it is necessary to know flow discharge. In principle, the frequency of flow measurement at each station is twice a year (once in wet season, once in dry season). To execute effective measurements with the limited budget, the frequency of measurements will be decided on the basis of the standard shown in Table-6.2 classified by the importance of station. Refer to Table-6.3.

Table-6.2 Frequency of Flow Measurement

Classification	Minimum Frequency	Standard Frequency
Class - A	Twice / Year	Twice / Year
Class - B	Once / Year	(Once / wet season) (Once / dry season)
Class - C	Once / 2 years	
Class - D	Closed at the moment	

(3) Frequency of Sediment Sampling and Analysis

The sediment sampling and analysis are done at the stations selected among the registered stations and other points. The sediment sampling and analysis are executed at the time of flow measurement with the same frequency of flow measurement.

(4) Frequency of Water Quality Investigation

<Investigation by Regional Hydrological Office>

This investigation is carried out twice a year (in wet and dry seasons) by the observation team at the hydrometric stations of Class A belonging to the Office and the other problematic points.

<Investigation by Hydrological Section>

This investigation is carried out twice a year (in wet and dry seasons) by the water quality investigation team belonging to the Hydrological Section in Lusaka at all the hydrometric stations of Class A in Zambia.

6.5 Classification of Hydrometric Stations

The hydrometric stations covered by this plan are all the stations registered in DWA, belonging to each of the Regional Hydrological Offices and are specified as follows.

1) Station No. and Name
2) Regional Hydrological Office in Charge
3) Observation Items
   - Daily water level : (all stations)
   - Recording) water level : Yes or No
   - Flow measurement : Yes or No
   - Sediment sampling and analysis: Yes or No
   - Water quality : Yes or No
   - Others (meteorology etc.) : Yes or No
4) Classification : A or B or C or D

The classification of station is decided according to the importance of station in view point of discharge calculation, availability of rating curve and number of discharge measurement, as shown in Table-6.3.

The Class-A station is an important station to know the discharge of main stream channel. At this Class-A station, periodic measurements of discharge, sediment and water quality besides daily water level observation should be executed.

When the Class-D station, temporally closed at the moment, reopens, the classification for this stations should be done according to the standard shown in Table-6.3. In Table-6.4 the numbers of stations for each Regional Hydrological Office are shown. Details are given in the Supporting Report.

Table-6.3 Classification of Hydrometric Stations

Evaluation Items		Score	Standard of Classification
Class of River	Main	0	
	Sub	1	<Class-A>:
	Local	2	Main channel and
Operation	Open	0	operational
	Close	1	<Class-B>:
Availability of Rating Curve	No	0	Total score = 0, 1, 2
	Yes	1	<Class-C>:
Number of Discharge Measurement	Few	0	Total score = 3, 4
	Many	1	<Class-D>:
			Closed station
			at the moment

Table-6.4 Number of Hydrometric Stations

Regional Hydrological Office	Total.	Auto. Recording	Flow Measument	* Sedi. & Water Quality	Classification			
					A	B	C	D
1) Lusaka	33	1	20	2	2	9	9	13
2) Copperbelt	33	3	16	4	4	4	8	17
3) N/Western	36	0	15	2	2	1	12	21
4) Western	17	0	11	2	2	5	4	6
5) Southern	35	2	11	2	2	5	4	24
6) Eastern	20	0	18	4	3	10	5	2
7) Northern	34	0	31	2	2	8	21	3
8) Luapula	35	0	24	2	2	8	14	11
[Total]	243	6	146	19	19	50	77	97

[Note] * The number shows the number of hydrometric stations for sediment sampling and water quality test. It does not include the number of other measurement points.

CHAPTER - 7 RECOMMENDATION

(1) Recognition and Enlightenment of Importance of Hydrologic Observation

There is a proverb "Those who control rivers control nations" in China. This is proved by the fact that the advanced nations in the world are flourishing by receiving the benefit of water resources development.

Water resources development brings various benefits such as supply of drinking water and industrial water, generation of hydroelectric power and so on. It is indispensable and essential theme for social and economic development. In connection with the development of water resources, there are other important themes to be solved: conservation of groundwater, water quality and environment. Groundwater, being closely related to the river water, is precious water resources as well as river water. Contamination of river water, being caused by the growth of cities and industries, is problem in view point of water use. The recent global phenomena: acid rainfall, drought and flood, are brought to the fore.

The above mentioned development of water resources and conservation of groundwater, water quality and environment, become important themes for the future development of Zambia. To take measures for these themes, the hydrological observation is fundamental and indispensable. It is not too much to say that the hydrological observation, executed correctly and continuously, is the most important factor to secure the future prosperity of Zambia.

"The Ministry of Energy and Water Development" responsible for water resources development and "The Department of Water Affairs" in charge of hydrologic observation in Zambia, should first recognize the importance of hydrologic observation. Next, they should try bring about an awareness of the importance of this to the related agencies and to each generation of the population through official publications, mass-communication and so on. This is one of the effective means to educate the young generation in the schools using educational material, who are to bear the destiny of Zambia on their shoulders about the importance of water resources development and hydrologic observation.

(2) Improvement of Hydrological Observation System

The useful hydrological data are those which are continuously and exactly collected and processed by effective organizations. In this view point, the present system of hydrological observation in Zambia should be improved. The Study Team recommend that DWA establish the substantial system for hydrological observation according to the plan proposed by the Study Team, considering the following matters.

1) Clarification of Duties and Responsibilities

To fulfill the hydrological activities without fault, it is necessary to clarify the duties and responsibilities of each organization and personnel as shown in the plan discussed above. According to this clarification, the leader of each organization can clearly check and direct the activities of his organization and the subordinate organization he has to manage or supervise.

2) Reinforcement of Observation Team

Almost all the field activities for hydrological observation are carried out by the observation team in Regional Hydrological Office. To reinforce the team, the following shall be executed.

- Improvement of the technical level of team leaders
- Supply of necessary transport and equipment for hydrological observation
- Assignment of back-up personnel for each gauge reader to avoid lack of data due to gauge reader unavailability
- Improvement of maintenance technology in Regional Office

3) Adoption of Annual Plan and Annual Report

All the hydrological activities should be done according to the annual plans prepared by DWA Hydrological Section and each Regional Hydrological Office and approved by DWA Headquarters. Each organization has to report the annual activities and data. Each regional Office reports the activities and data to DWA hydrological Section. DWA Hydrological Section has to compile the reports from the Hydrological Offices and report the activities including the results of hydrological analysis to DWA Headquarters.

A regular half-year meeting of the officers in DWA Hydrological Section and officers in Regional Hydrological Offices is recommended for the above purposes.

4) Improvement of System for Hydrological Analysis

To improve the present system for hydrological analysis, DWA Hydrological Section should apply the following hydrologic database developed by the Study Team.

- Data processing of discharge measurement: (DB-01, DB-02)
- Preparation of discharge rating curves : (DB-03, DB-04)
- Preparation of W/L - discharge tables : (DB-05, DB-06)
- Calculation of discharge correlation : (DB-07)
- Calculation of station's flow regime : (DB-08)
- Calculation of river flow balance : (DB-09)

5) Periodic Observation of Water Quality

There has been no periodic observation of water quality for the rivers. However, it is necessary, with the view of

securing good water in quality for water use to carry out the periodic observation of river water quality at the designated points.

6) Establishment of Planning Section

Apart from hydrological observation, establishment of new Plan and Design Section in DWA is recommended from the view point of effective use of hydrological observation data. This section is responsible for preparation of water resources development plans and designs. The leader of this section is expected to be water engineer qualified in civil engineering, hydraulics and hydrology. It can be considered to employ a foreign expert qualified in water resources development. His duty is to give technical advice to the existing Hydrological Section and the proposed Planning Section.

7) Reciprocation of Hydrologic Information with International Agencies

The Zambezi River is a international river passing though 6 countries. The hydrologic observation and water resources development for the Zambezi River are executed by each country's agency and international organizations. It will be necessary to reciprocate hydrologic information and adjust development plans with these bodies when the water resources development in the main channel of Zambezi River will be prepared by Zambia.

8) Sufficient Staffing and Introduction of Schematic Training System

The personnel proposed in the Plan should be secured with the DWA's best efforts. Schematic training for all the personnel engaged in the hydrological observation, including new staff, is necessary on regular basis. Especially, the training of observation team leaders and the members for hydrological analysis is essential.

9) Repletion of Budget

To establish the organization and to execute the activities proposed in the Plan, DWA should try to secure the repletion of the budget.

(3) Utilization of Water Resources

In this Study, the outline of potential surface water resources in the Study Area have been comprehended, and abundant and unutilized water resources have been found. The ground water, prevailing universally through Zambia, is also a precious water resource. These abundant and universal water resources are expected to be developed considering the following situations in Zambia.

- The population of Zambia in the beginning of 21st century is estimated to be around 10.7 million on the basis of the latest census data. The increment of population during the coming decade will about 3 million. To cope with these increasing population, supply of drinking water in urban and rural areas will be essential.

- To promote agricultural development, the current main target of the Government, development of irrigation water is inevitable.

- Due to the increment of population, improvement of living standards and development of the country, the demand for electricity will be increased.

As mentioned above, the demand for water resources development is expanding. The background to advance the development of water resources in the Study Area and Zambia is already prepared.

The project of water resources development will bring not only such direct and indirect economic benefit as water supply and hydroelectric power generation after the completion of project, but also produce such other economic benefits as evocation of effective demand, income redistribution, employment promotion and increase of revenue through taxation in the implementation period of projects. To develop water resources is to secure requisitions for living, and is essential in view of civil minimum.

It is recommended that planning for comprehensive water resources development should be started in order to meet the various demands by utilizing the rich water resources to secure comfortable living standards and prosperity in Zambia.