B2 PRESENT CONDITION OF PROJECT AREA AND AVAILABILITY OF METEO-HYDROLOGICAL DATA

B2.1 Present Condition of the Project Area

B2.1.1 Climatic condition

The Tana river basin with a total drainage area of some 10,000 km² originates from the Mount Kenya and flows down for a river course of about 1,000 km to finally pour into the Indian Ocean. In general, the upper areas spreading on left bank of the Tana mainstream are blessed with potentials of water resources development, exhibiting high annual rainfall and lesser evapotranspiration which are attributed to the geographical condition.

Figure B2.1 shows a broad isohyetal map of the whole Tana basin, which was prepared by DHV. According to the isohyetal map, the annual rainfall in the Tana basin varies from more than 2,000 mm in the mountainous areas located around the Mount Kenya to less than 300 mm in the low-lying areas near Garissa in the lower reach of the Tana mainstream. In the downstream reach of Garissa, the annual rainfall increases gradually to the river mouth where annual rainfall amounts to about 1,000 mm.

The areal distribution of annual rainfalls in the project catchment, which is herein defined to be a catchment covered by the Grand Falls dam site or existing stream gauging station 4F13 (SGS 4D13), was prepared based on long-term mean rainfalls at some 160 rainfall stations in and around the project catchment. The locations of these rainfall stations are depicted in Figure B2.2. The detailed isohyetal map for the project catchment thus worked out is illustrated in Figure B2.3. The Figure exhibits that high annual rainfall of more than 2,000 mm takes place in the northern and western areas of the project catchment. In general, it decreases as the altitude goes down toward the Tana mainstream, coming to less than 800 mm in the right bank side area downstream of existing Masinga dam.

Climatorologically, the Tana basin is characterized by the separate two rainy seasons which take place within a year. Usually, the first wet season occurs between March and May, while the second one between November and December. During these wet seasons, the rainy days last consecutively for 30 to 60 days, resulting in the occurrence of flood of long duration in the Tana mainstream. There is a general tendency that a heavier rainfall takes place in the first wet season rather than the later one, but the annual maximum discharges on the Tana mainstream were observed in either of the two wet seasons to date. Especially, this is endorsed by the recorded maximum discharge in the upper Tana basin, which took place in November 1961.

The streamflow of the tributaries in the project catchment are divided into two types, namely the perennial river and seasonal river, being dominated by the rainfall amount as well as the geographical position. The seasonal rivers appear in the area on the right bank side downstream of the Masinga dam, where the annual rainfall is less than 1,000 mm as shown in Figure B2.3. In these seasonal rivers, no surface flow is seen during the dry periods.

The meteorological records observed in the Tana basin are shown in Table B2.1. The annual evaporation in the Tana basin varies largely with altitude, ranging from about 2,700 mm at the Garissa station with altitude of 138 m to 1,400 mm at the Sagana State Lodge station with altitude of 1,846 m. In most parts of the lower reaches, the annual evapotranspiration exceeds two times the annual rainfall, assuming that the annual evapotranspiration of the basin is approximated to be equivalent to 70 % of the annual Pan-A evaporation. Thus, the downstream areas in the Tana basin are completely dried up during the dry season.

B2.1.2 Existing dams in the upper reach

The planned Grand Falls dam site is situated about 300 km upstream of Garissa. It covers a catchment area of 17,234 km^2, which is equivalent to about 17 % of total catchment area of the Tana basin. The Mutonga dam site which occupies a catchment area of 15,365 km^2 is located about 40 km upstream of the Grand Falls dam site. In the reach between these two proposed dam sites, streamflow of the Tana mainstream is augmented by the Kathita river which joins thereto from the left bank side. The water resources in the upper Tana basin have been developed to date mainly for the purpose of hydropower generation. At present, there exist five (5) dams on the upstream reach of the planned Mutonga dam site, of which two existing dams are developed as a reservoir type scheme, as listed below:

Existing Dam on the Upper Reach of the Tana Mainstream

No.	Name of Dam	Catchment Area (km2)	Type of Development	Year of Completion	Effective Storage Volume (Million m3)	Installed Capacity (MW)
1.	Masinga	7,335	Reservoir	1981	1,410.	40.0
2.	Kamburu	9,520	Run-of-River	1974	135.	94.2
3.	Gitaru	9,667	Run-of-River	1968	12.5	145.0
4.	Kindaruma	9,807	Run-of-River	1968	7.5	44.0
5.	Kiambere	11,975	Reservoir	1988	485.	144.0

The table above implies that the streamflow in downstream reach of the Tana mainstream has been regulated by the upstream reservoirs since 1968. Especially, the streamflow at the planned Mutonga and Grand Falls dam sites have been affected by the upstream reservoirs to a considerable extent since completion of the Masinga dam in 1981, or presumably since the commencement of impounding before that. Hence, the runoff analysis for estimating the naturalized flow at the planned Mutonga and Grand Falls dam sites needs to be carried out taking into consideration that the streamflow records at stream gauging station 4F13 have been affected by the reservoir operation of the upstream existing dams after then.

In addition to the aforesaid hydropower development, the following small hydropower stations are provided on the upper reaches.

Existing Small Hydropower Stations in Upper Tana Basin

No.	Name of Power Plan	Commissioning Year	Installed Capacity (MW)
1.	Mesco	1933	0.38
2.	Sagana Falls	1955	1.5
3.	Wanji	1953, 1958	7.4
4.	Tana I	1932, 1950	6.4
	Tana II	1955	8.0

As seen in the above table, the streamflow of the Tana river has been utilized for the hydropower generation since 1930's. At present, the streamflows of upstream tributaries the Masinga dam are diverted in a complex form for the purpose of utilizing them for those small hydropower plants as shown in Figure B2.4.

B2.2 Availability of Meteo-hydrological Data

B2.2.1 Meteorological Data

The meteorological records in Kenya are arranged and preserved by the Kenya Meteorological Department (KMD). KMD set up the computerized data base system to store the daily rainfall records. During the field investigation, the Study Team attempted to collect the whole records of rainfall stations in and around the project catchment by means of copying the original records into floppy diskettes. Unfortunately, however, a complete set of daily rainfall records could not be obtained from the data base of KMD due to break-down of some part of the computer system. Therefore, some parts of the daily rainfall data were copied manually from the original data sheets in the KMD's office.

In addition to the rainfall records collected from KMD in the present hydrological field investigation, those collected through the National Water Master Plan were effectively utilized to supplement in terms of the missing records in the KMD's data base. As a result, daily records at 154 rainfall stations were made available up to the year 1990. The locations of these rainfall stations are shown in Figure B2.2. The available periods of daily rainfall records at those stations are listed in Table B2.2. As seen in the Table, the available periods of the records differ station by station and the availability of the records for the period before the year 1957 is very low.

With regard to other meteorological data than rainfall, only the monthly records were available from the Climatorological Statistics for Kenya published by KMD.

B2.2.2 Hydrological Data

The hydrological data in Kenya are handled by the Ministry of Water Development (MOWD). MOWD also set up the computerized data base which stores the following hydrological data concerning each of stream gauging stations in Kenya:

- Position of station (latitude and longitude)
- Daily stage heights
- Results of discharge measurements
- Stage-discharge rating curves

The above hydrological data were wholly collected for each of the key 15 stream gauging stations which are listed in Table B2.3 together with the available periods of stage height records. The locations of these stream gauging stations are shown in Figure B2.2. In the course of the hydrological data collection, however, a lot of discrepancies in the stage height records were found out. Therefore, the Study Team elaborated to check the stage height records by comparing with the original ones read by the gauge readers so as to correct the wrong data. In such a way, the stage heights in the data base were made complete for every stream gauging station.

In succession, the Study Team plotted the accurate position of each stream gauging station on 1:50,000 scaled topographic maps in accordance with latitude and longitude thereof obtained from the MOWD's data base so as to confirm if the data on catchment areas obtained from MOWD are accurate. Thus, catchment area of each stream gauging station was measured with plannimeter on 1:50,000 scaled topographic maps to compare with the MOWD's data. Concerning the stream gauging stations 4BE2, 4DD1, 4F19, the catchment area plannimetered was adopted for the present hydrological analysis, since a large gap between the catchment areas given by MOWD and measured this time was found out.

In the upper Tana basin, the stream gauging stations have been installed by MOWD on the Tana mainstream and the perennial rivers originating from the mountainous areas on the left bank side and in the western part of the project catchment. On the other hand, there are no stream gauging stations on the seasonal tributaries which flow down from the right bank side to join to the Tana mainstream.

Of the 15 stream gauging stations, located on the Tana mainstream are the following four (4) ones:

Stream Gauging Station on the Tana Mainstream

No. of Stream Gauging Station	Catchment Area (km2)	Available Period of stage heights
4BE2	3,672	1958 - 1981
4ED3	9,520	1951 - 1971
4F13	17,234	1962 - 1990
4G1	32,892	1940 - 1990

The stream gauging station 4ED3 was located adjacent to existing Kamburu dam site, but it was abolished in 1973. Although available period of the stage height records at SGS 4ED3 are as short as 21 years between 1951 and 1971, they are considered to be very useful in analyzing the naturalized flow of the Tana mainstream for the period before completion of the existing upstream dams.

The stream gauging station 4F13 is located close to the proposed Grand Falls dam site. The stage height recording at SGS 4F13 has been performed to date by reading manually those on staff gauges once a day. However, it was suspected that the stage heights thereat would have been more or less affected by the operation mode of the upstream hydropower stations since the completion thereof in the later part of 1960's as explained in the foregoing Subsection B2.1.2. Concerning the stage height records at SGS 4F13 before 1968, in addition, the higher stage records are associated with uncertainty in relation to the sloped staff gauges as discussed in the succeeding Subsection B3.4.2.

The stream gauging station 4G1 is situated at Garissa, far downstream of the Grand Falls dam site. The catchment area covered by SGS 4G1 is 32,892 km^2, which is equivalent to about 1.9 times that by SGS 4F13. It appears that the meteo-hydrological condition of the downstream catchment of SGS 4F13 is much different from that of SGS 4F13, owing to the lesser basin rainfall and higher evapotranspiration as compared with those in the upper catchment.

Table B2.1 Meteorological Records in the Tana Basin (1/5)

(1) Name of Meteorological Station : Embu Met. Station

Station No. : 90.37/202
Location : Latitude ; 00° 30' S, Longitide ; 37° 27' E
Altitude : 1508 m

Month	Temperature (1977 - 80) Means (°C) Max.	Min.	Extremes (°C) Highest	Lowest	Dew Point (°C) at GMT: 6:00	12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1977 - 80) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Thunder	Monthly Evaporation (1977-80) (mm)	Wind Speed (1977-80) (knots)
Jan.	24.4	12.1	28.4	9.0	13.5	15.0	86	71	61	65	28.5	7	3	158	6
Feb.	26.0	13.1	29.7	7.9	14.5	14.5	86	74	54	60	53.6	4	4	159	7
Mar.	26.3	14.0	31.4	10.5	15.2	14.3	88	78	52	111	40.0	11	4	163	7
Apr.	24.8	15.4	29.3	12.7	16.4	15.9	95	88	68	322	83.4	20	5	143	5
May	23.7	14.9	27.5	11.2	15.4	15.4	95	85	63	189	48.8	15	4	131	4
Jun.	22.2	13.3	25.8	9.5	13.6	14.2	92	86	60	25	33.4	4	1	96	3
Jul.	20.8	12.6	25.0	9.4	12.7	12.6	94	85	64	38	17.6	9	0	77	3
Aug.	21.7	12.1	25.8	8.5	12.8	12.7	94	88	61	44	13.3	10	1	93	4
Sep.	24.7	12.7	28.9	8.6	13.1	11.4	92	83	46	40	45.6	4	4	128	4
Oct.	25.8	13.9	29.5	9.4	14.3	12.1	93	82	48	157	89.4	12	2	146	5
Nov.	23.6	13.6	26.4	8.5	15.3	15.7	93	83	66	259	74.0	17	4	134	7
Dec.	23.8	12.8	26.9	8.7	14.5	15.7	90	75	65	54	26.3	10	2	145	7
Year	24.0	13.4	31.4	7.9	14.3	14.1	92	82	59	1364	89.4	123	34	1573	5

(2) Name of Meteorological Station : Embu, Mwea Experimental Station

Station No. : 90.37/112
Location : Latitude ; 00° 41' S, Longitide ; 37° 20' E
Altitude : 1159 m

Month	Temperature (1955 - 77) Means (°C) Max.	Min.	Extremes (°C) Highest	Lowest	Dew Point (°C) at GMT: 6:00	12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1960 - 70) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain		Monthly Evaporation (1963-77) (mm)
Jan.	28.7	13.7	33.9	7.2	14.9	14.4	-	66	44	41	19.3	4	207	-
Feb.	30.3	14.3	34.7	7.8	14.8	13.4	-	66	38	34	45.7	3	212	-
Mar.	30.4	16.3	35.6	10.0	16.5	14.6	-	69	42	64	50.8	7	223	-
Apr.	28.6	17.4	33.3	10.6	17.5	16.3	-	76	51	218	110.0	13	179	-
May	27.2	17.2	31.7	12.0	16.7	16.4	-	74	54	139	90.7	10	149	-
Jun.	26.4	15.6	31.1	9.9	14.8	15.3	-	74	52	21	63.5	3	132	-
Jul.	25.1	15.2	30.6	8.3	14.0	13.8	-	77	53	28	88.9	3	121	-
Aug.	25.4	15.2	31.7	8.9	13.7	13.6	-	75	51	11	48.3	4	143	-
Sep.	28.2	15.8	35.0	8.9	14.0	13.0	-	70	42	17	31.6	2	186	-
Oct.	29.5	16.9	36.1	8.9	15.4	13.4	-	70	40	86	80.0	8	214	-
Nov.	27.5	16.4	32.8	10.0	16.9	15.9	-	78	53	189	78.5	15	158	-
Dec.	27.2	14.7	33.3	9.3	16.0	15.9	-	72	53	45	66.8	5	179	-
Year	27.9	15.7	36.1	7.2	15.4	14.7	-	72	48	893	110.0	77	2103	-

(3) Name of Meteorological Station : Garissa Met. Station

Station No. : 90.39/000
Location : Latitude ; 00° 28' S, Longitide ; 39° 38' E
Altitude : 138 m

Month	Temperature (1940 - 80) Means (°C) Max.	Min.	Extremes (°C) Highest	Lowest	Dew Point (°C) at GMT: 6:00	12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1931 - 80) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Thunder	Monthly Evaporation (1962-80) (mm)	Wind Speed (1941-80) (knots)
Jan.	35.3	22.3	38.7	16.1	20.8	19.2	87	74	43	13	50.2	2	2	206	6
Feb.	36.2	23.0	39.6	18.5	21.0	19.4	83	74	42	7	35.6	1	2	206	6
Mar.	36.7	24.2	41.4	20.0	22.1	20.0	85	75	42	38	125.7	4	2	243	5
Apr.	35.7	24.4	39.6	20.3	22.8	20.9	89	76	46	68	132.0	6	3	224	6
May	34.5	23.3	38.4	19.4	21.3	19.8	85	73	45	20	118.7	2	1	234	9
Jun.	33.0	21.7	37.5	16.2	19.9	17.8	85	73	44	8	22.9	2	0	229	10
Jul.	32.3	21.0	36.9	12.8	19.1	16.9	84	73	42	3	13.9	1	0	231	11
Aug.	32.4	21.2	37.5	16.4	19.1	16.7	85	73	42	8	35.1	2	1	247	11
Sep.	33.6	21.6	37.2	13.9	19.5	17.1	85	72	40	7	14.0	1	1	254	10
Oct.	34.8	22.8	38.4	18.4	20.6	18.1	85	72	41	24	113.3	3	2	254	9
Nov.	34.5	23.5	38.5	19.4	22.0	20.2	90	76	47	79	127.0	8	3	208	5
Dec.	34.0	22.9	38.2	18.4	21.9	20.5	90	75	50	77	95.2	5	2	176	5
Year	34.4	22.7	41.4	12.8	20.8	18.9	86	74	44	352	132.0	37	19	2712	8

Data Source : Climatological Statistics for Kenya, Kenya Meteorological Department

Table B2.1 Meteorological Records in the Tana Basin (2/5)

(4) Name of Meteorological Station : Kindaruma Fisheries

Station No. : 89.37/176
Location : Latitude ; 00° 48' S, Longitide ; 37° 48' E
Altitude : 792 m

Month	Temperature (1973 - 80)						Relative Humidity			Rainfall (1973 - 80)		Number of Days of		Monthly Evaporation (1973-80) (mm)
	Means (°C)		Extremes (°C)		Dew Point (°C) at GMT:		(%) at GMT :			Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Rain		
	Max.	Min.	Highest	Lowest	6:00	12:00	3:00	6:00	12:00					
Jan.	30.8	15.5	35.2	6.0	17.9	16.3	-	77	47	49	38.9	5	181	-
Feb.	37.8	16.9	39.0	8.0	19.2	18.0	-	79	42	37	64.4	2	191	-
Mar.	33.3	18.1	36.5	12.5	18.9	16.3	-	74	43	49	50.0	4	216	-
Apr.	31.8	18.9	36.5	16.0	19.6	18.5	-	77	51	152	96.0	10	172	-
May	31.0	18.0	35.5	14.0	18.2	17.6	-	71	52	58	43.7	5	151	-
Jun.	30.5	17.0	33.5	12.3	16.3	15.1	-	69	43	12	50.8	1	146	-
Jul.	29.5	16.7	33.6	12.3	15.5	13.9	-	72	43	4	5.4	1	152	-
Aug.	30.0	17.0	33.9	11.8	14.5	12.7	-	63	38	4	3.3	2	164	-
Sep.	58.1	17.3	34.6	12.3	16.1	12.8	-	71	35	21	33.7	4	197	-
Oct.	33.0	18.4	36.7	12.5	17.2	13.4	-	68	34	21	45.7	3	227	-
Nov.	30.2	18.4	34.5	14.5	19.9	19.2	-	81	61	201	89.4	14	149	-
Dec.	29.3	17.1	31.9	12.3	18.4	17.9	-	78	59	78	40.9	8	163	-
Year	33.8	17.4	39.0	6.0	17.6	16.0	-	73	46	686	96.0	59	2109	-

(5) Name of Meteorological Station : Meru Met. Station

Station No. : 89.37/065
Location : Latitude ; 00° 05' S, Longitide ; 37° 39' E
Altitude : 1555 m

Month	Temperature (1975 - 80)						Relative Humidity			Rainfall (1975 - 80)		Number of Days of		Monthly Evaporation (1976-80) (mm)	Wind Speed (1975-80) (knots)
	Means (°C)		Extremes (°C)		Dew Point (°C) at GMT:		(%) at GMT :			Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Rain	Thunder		
	Max.	Min.	Highest	Lowest	6:00	12:00	3:00	6:00	12:00						
Jan.	23.4	11.4	26.0	6.4	14.4	14.3	92	79	67	80	75.6	7	6	120	8
Feb.	24.7	11.9	28.3	6.9	14.8	14.7	91	78	50	39	28.7	6	7	129	8
Mar.	25.7	13.0	29.8	9.2	15.1	14.3	91	78	55	126	91.3	8	8	157	8
Apr.	24.1	14.3	28.6	10.6	16.0	16.2	95	81	67	282	102.2	17	11	134	8
May	22.8	13.7	25.5	8.9	15.4	16.4	95	83	71	86	54.4	10	5	117	9
Jun.	22.1	12.0	25.2	7.0	13.4	14.1	94	81	63	5	6.3	3	1	115	10
Jul.	21.5	11.9	24.6	7.5	12.7	12.4	95	84	61	10	7.5	3	2	115	11
Aug.	22.1	12.0	26.2	8.5	12.3	11.9	93	83	56	8	6.1	3	1	133	10
Sep.	24.4	12.3	28.7	7.8	12.9	11.8	93	78	49	16	19.9	4	3	148	11
Oct.	25.1	13.5	30.0	9.0	14.3	11.9	93	79	49	140	105.5	9	2	170	9
Nov.	22.8	13.1	25.7	9.2	15.2	15.5	96	83	71	328	93.0	17	8	110	7
Dec.	22.7	12.0	25.7	8.0	15.1	16.1	95	81	73	139	90.1	12	7	111	7
Year	23.5	12.6	30.0	6.4	14.3	14.1	94	81	61	1259	105.5	99	61	1559	9

(6) Name of Meteorological Station : Nyeri Met. Station

Station No. : 90.36/288
Location : Latitude ; 00° 26' S, Longitide ; 36° 58' E
Altitude : 1815 m

Month	Temperature (1976 - 80)						Relative Humidity			Rainfall (1978 - 80)		Number of Days of		Monthly Evaporation (1977-80) (mm)	Wind Speed (1976-80) (knots)
	Means (°C)		Extremes (°C)		Dew Point (°C) at GMT:		(%) at GMT :			Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Rain	Thunder		
	Max.	Min.	Highest	Lowest	6:00	12:00	3:00	6:00	12:00						
Jan.	24.7	10.3	28.8	5.7	12.4	12.9	-	76	54	103	38.5	8	4	127	9
Feb.	25.7	11.0	30.3	4.7	12.9	12.7	-	77	50	68	29.5	7	4	137	10
Mar.	25.8	11.8	31.4	5.5	13.3	13.1	-	77	51	91	61.0	11	8	143	10
Apr.	24.0	14.0	28.0	11.5	14.9	14.8	-	85	64	93	29.9	14	9	117	10
May	22.6	14.1	26.2	9.5	14.8	14.7	-	88	65	213	56.0	16	2	123	9
Jun.	21.2	12.5	24.0	8.7	13.0	13.5	-	85	65	41	28.7	6	1	94	8
Jul.	20.0	11.9	24.5	8.3	12.2	12.6	-	90	66	20	10.7	6	2	79	9
Aug.	20.6	11.8	25.3	6.3	12.2	12.2	-	90	68	31	22.3	7	2	94	9
Sep.	23.3	12.4	29.1	7.3	12.3	11.4	-	82	50	19	28.2	4	4	136	10
Oct.	24.5	13.1	27.4	8.0	13.3	11.9	-	79	50	120	44.7	10	2	161	10
Nov.	23.0	12.4	27.0	6.7	14.0	13.9	-	82	65	152	44.2	14	6	109	8
Dec.	23.5	11.4	28.8	4.1	13.4	14.3	-	79	64	72	25.7	10	6	118	8
Year	23.2	12.2	31.4	4.1	13.2	13.2	-	83	59	1023	61.0	113	50	1438	9

Data Source : Climatological Statistics for Kenya, Kenya Meteorological Department

Table B2.1 Meteorological Records in the Tana Basin (3/5)

(7) Name of Meteorological Station : Sagana Fish Cultural Farm

Station No. : 90.37/096
Location : Latitude ; 00° 40' S, Longitide ; 37° 12' E
Altitude : 1220 m

Month	Temperetuer (1971 - 80) Means (°C) Max.	Min.	Extremes (°C) Highest	Lowest	Dew Point (°C) at GMT: 6:00	12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1977 - 80) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Monthly Evaporation (1977-80) (mm)
Jan.	27.6	14.3	32.6	9.8	15.1	15.4	-	67	51	36	27.9	5	159
Feb.	28.6	14.9	31.9	9.0	18.6	14.7	-	67	45	46	56.0	3	165
Mar.	28.5	15.7	32.8	8.5	16.1	15.1	-	68	49	86	32.0	9	181
Apr.	27.6	17.2	35.4	10.4	18.0	17.3	-	80	57	397	98.7	17	146
May	26.7	17.0	29.9	12.0	17.2	17.3	-	80	60	213	55.6	18	149
Jun.	25.5	15.4	35.0	9.1	15.8	16.0	-	82	61	26	24.5	5	112
Jul.	24.5	14.7	32.8	9.5	14.5	14.9	-	81	60	14	9.0	4	107
Aug.	24.9	14.4	32.5	7.0	14.4	14.9	-	81	58	18	8.0	4	114
Sep.	26.9	14.8	30.6	5.5	15.2	14.8	-	77	51	26	27.4	4	152
Oct.	28.0	15.8	32.2	6.2	16.2	15.1	-	75	49	134	89.5	11	183
Nov.	26.7	15.6	31.2	11.4	17.2	16.7	-	79	59	267	51.6	15	162
Dec.	26.8	15.1	33.0	10.2	16.4	16.9	-	73	59	77	58.9	7	146
Year	26.9	15.4	35.4	5.5	16.2	15.8	-	76	55	1340	98.7	102	1776

(8) Name of Meteorological Station : Sagana State Lodge

Station No. : 90.37/158
Location : Latitude ; 00° 22' S, Longitide ; 37° 04' E
Altitude : 1846 m

Month	Temperetuer (1971 - 80) Means (°C) Max.	Min.	Extremes (°C) Highest	Lowest	Dew Point (°C) at GMT: 6:00	12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1971 - 80) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Thunder	Monthly Evaporation (1971-80) (mm)
Jan.	25.4	8.8	29.5	2.0	11.8	13.3	-	73	55	49	37.1	7	-	123
Feb.	26.2	9.0	31.2	2.4	12.0	12.6	-	73	50	58	82.0	8	-	119
Mar.	26.3	9.8	31.2	1.5	12.8	13.3	-	74	53	52	53.5	7	-	134
Apr.	24.2	12.3	29.9	5.5	14.6	14.8	-	82	66	116	42.3	15	-	102
May	22.8	13.1	25.7	7.5	14.3	14.7	-	82	66	115	82.0	13	-	111
Jun.	21.8	11.8	25.5	5.5	12.9	13.5	-	82	64	17	29.8	6	-	99
Jul.	21.1	11.4	26.3	4.3	12.0	11.5	-	84	65	21	21.5	4	-	94
Aug.	21.7	11.3	28.8	4.9	11.4	11.9	-	81	61	12	10.3	5	-	109
Sep.	24.2	11.5	29.8	4.0	11.7	11.2	-	77	50	29	26.3	4	-	139
Oct.	24.9	12.0	28.5	6.2	13.0	12.2	-	78	52	79	29.1	8	-	128
Nov.	23.4	11.2	27.5	5.7	13.2	13.9	-	77	66	125	75.1	15	-	100
Dec.	24.3	9.3	28.0	1.7	12.8	14.4	-	75	63	88	40.2	11	-	109
Year	23.9	11.0	31.2	1.5	12.7	13.1	-	78	59	761	82.0	103	-	1367

(9) Name of Meteorological Station : Thika Horticultural Res. Station

Station No. : 90.37/130
Location : Latitude ; 00° 59' S, Longitide ; 37° 04' E
Altitude : 1549 m

Month	Temperetuer (1962 - 74) Means (°C) Max.	Min.	Extremes (°C) Highest	Lowest	Dew Point (°C) at GMT: 6:00	12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1954 - 74) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Monthly Evaporation (1963-74) (mm)
Jan.	26.2	13.1	31.7	5.6	14.9	15.3	-	76	53	55	50.0	4	194
Feb.	27.3	13.4	33.3	6.1	15.2	13.9	-	76	47	47	91.4	4	188
Mar.	27.1	15.5	32.2	8.9	15.8	14.4	-	80	49	119	43.2	9	194
Apr.	24.5	16.3	32.2	11.0	16.5	16.2	-	84	61	207	73.2	16	152
May	25.0	15.2	31.7	8.3	15.8	15.9	-	84	64	168	86.6	11	145
Jun.	23.5	13.4	31.1	7.2	14.0	15.0	-	82	64	35	33.7	4	98
Jul.	22.7	12.6	32.6	6.7	12.7	13.8	-	79	63	27	49.5	4	96
Aug.	23.0	12.8	29.0	5.6	13.1	13.9	-	84	62	27	36.3	5	101
Sep.	25.2	12.8	30.0	6.1	13.3	13.8	-	78	53	14	56.0	2	144
Oct.	26.3	14.5	33.3	8.9	15.1	14.6	-	80	52	75	37.6	5	180
Nov.	24.7	15.1	32.2	11.0	15.7	16.3	-	84	63	164	63.8	15	142
Dec.	25.5	13.9	31.7	8.9	15.5	15.9	-	79	59	66	89.7	7	171
Year	25.1	14.1	33.3	5.6	14.8	14.9	-	81	58	1004	91.4	86	1805

Data Source : Climatological Statistics for Kenya, Kenya Meteorological Department

(10) Name of Meteorological Station : Tebere C.R. Station

Station No. : 90.37/179
Location : Latitude ; 00° 37' S, Longitide ; 37° 20' E
Altitude : 1159 m

Month	Temperature (1974 - 80) Means (°C) Max.	Means (°C) Min.	Extremes (°C) Highest	Extremes (°C) Lowest	Dew Point (°C) at GMT: 6:00	Dew Point (°C) at GMT: 12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1974 - 80) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Thunder	Monthly Evaporation (1974-80) (mm)
Jan.	28.4	13.7	32.0	9.3	15.6	15.1	-	-	-	32	34.0	6	-	-
Feb.	29.7	14.7	32.7	9.8	16.2	15.1	-	-	-	37	42.0	5	-	-
Mar.	30.0	16.3	33.5	10.0	17.3	15.5	-	-	-	72	65.0	6	-	-
Apr.	27.9	17.4	32.5	14.0	18.2	16.7	-	-	-	286	125.8	15	-	-
May	26.8	16.9	30.0	13.0	17.3	16.7	-	-	-	122	48.1	9	-	-
Jun.	25.5	15.8	28.5	10.5	15.2	14.8	-	-	-	36	54.5	5	-	-
Jul.	24.3	15.3	28.5	9.0	14.4	14.4	-	-	-	43	52.4	5	-	-
Aug.	24.9	15.1	29.7	9.5	14.2	13.3	-	-	-	15	19.3	4	-	-
Sep.	27.5	15.5	32.5	10.5	14.6	13.4	-	-	-	27	35.7	4	-	-
Oct.	28.8	16.3	32.0	8.0	16.5	14.7	-	-	-	85	67.2	6	-	-
Nov.	26.9	16.1	30.5	11.0	17.5	16.4	-	-	-	218	104.2	13	-	-
Dec.	26.9	14.7	30.5	11.0	16.8	16.2	-	-	-	41	22.1	7	-	-
Year	27.3	15.7	33.5	8.0	16.2	15.2	-	-	-	1014	125.8	85	-	-

(11) Name of Meteorological Station : Hola, Tana River Irrigation Scheme

Station No. : 91.40/006
Location : Latitude ; 01° 28' S, Longitide ; 40° 00' E
Altitude : 91 m

Month	Temperature (1966 - 80) Means (°C) Max.	Means (°C) Min.	Extremes (°C) Highest	Extremes (°C) Lowest	Dew Point (°C) at GMT: 6:00	Dew Point (°C) at GMT: 12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1957 - 80) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Monthly Evaporation (1966-80) (mm)
Jan.	34.6	22.3	39.8	14.2	21.6	20.3	-	75	49	27	80.0	3	203
Feb.	35.8	22.8	39.8	14.0	21.7	19.7	-	76	44	17	46.9	3	195
Mar.	35.9	23.7	39.5	19.0	22.6	20.4	-	74	46	37	37.6	6	211
Apr.	35.0	24.0	39.6	20.0	23.3	21.8	-	77	54	70	85.5	7	196
May	33.4	22.7	39.5	18.2	22.3	21.2	-	77	59	47	87.1	6	194
Jun.	32.0	20.6	38.6	14.8	20.8	19.8	-	76	55	37	111.7	4	192
Jul.	31.8	20.0	39.8	15.5	20.2	18.8	-	76	54	18	35.3	3	186
Aug.	31.9	19.9	37.5	16.4	20.1	18.3	-	76	51	18	42.2	4	202
Sep.	32.8	20.3	37.0	15.3	20.2	17.8	-	72	46	29	85.6	2	215
Oct.	34.1	21.7	39.6	12.6	21.3	19.1	-	73	47	30	42.2	4	227
Nov.	34.3	23.0	38.8	19.6	22.8	20.5	-	77	51	86	54.7	8	176
Dec.	34.1	22.6	39.4	18.6	22.5	20.7	-	79	52	55	55.7	5	169
Year	33.8	22.0	39.8	12.6	21.6	19.9	-	76	51	471	111.7	55	2366

(12) Name of Meteorological Station : Mariene Coffee Sub - Station

Station No. : 90.37/124
Location : Latitude ; 00° 00' S, Longitide ; 37° 39' E
Altitude : 1615 m

Month	Temperature (1961 - 80) Means (°C) Max.	Means (°C) Min.	Extremes (°C) Highest	Extremes (°C) Lowest	Dew Point (°C) at GMT: 6:00	Dew Point (°C) at GMT: 12:00	Relative Humidity (%) at GMT: 3:00	6:00	12:00	Rainfall (1961 - 80) Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)	Number of Days of Rain	Thunder	Monthly Evaporation (1966-80) (mm)
Jan.	24.2	11.5	28.4	3.0	14.7	16.0	-	74	66	70	95.0	6	-	141
Feb.	25.4	11.5	30.2	7.6	15.0	15.8	-	75	68	64	114.3	5	-	143
Mar.	25.6	12.1	30.0	7.0	15.5	15.9	-	76	65	145	80.1	10	-	161
Apr.	24.2	12.7	29.5	5.5	16.3	16.9	-	80	71	363	126.1	18	-	175
May	22.9	11.9	28.0	7.5	15.4	16.4	-	80	72	174	117.0	11	-	157
Jun.	21.8	10.5	25.9	5.0	13.7	15.0	-	75	67	19	53.3	3	-	113
Jul.	20.9	10.5	25.5	2.5	12.9	13.8	-	80	67	15	76.2	4	-	110
Aug.	21.5	10.6	26.2	4.2	12.7	12.8	-	80	61	17	36.3	4	-	123
Sep.	24.1	10.6	28.4	4.4	12.9	12.6	-	75	51	31	106.7	4	-	160
Oct.	24.6	12.4	31.0	7.2	14.5	13.6	-	76	55	298	125.7	13	-	195
Nov.	22.9	12.8	28.0	6.6	15.2	16.1	-	79	72	417	146.1	21	-	165
Dec.	23.2	11.9	28.0	8.5	15.1	16.4	-	77	72	141	88.2	12	-	129
Year	23.4	11.6	31.0	2.5	14.5	15.1	-	77	66	1754	146.1	111	-	1772

Data Source : Climatological Statistics for Kenya, Kenya Meteorological Department

Table B2.1 Meteorological Records in the Tana Basin (5/5)

(13) Name of Meteorological Station : Thika Agromet Res. Station

Station No. : 91.37/048
Location : Latitude ; 01° 01' S, Longitide ; 37° 06' E
Altitude : 1477 m

Month	Temperature (1976 - 80)						Relative Humidity			Rainfall (1941 - 80)		Number of Days of Rain	Monthly Evaporation (1976-80) (mm)	Wind Speed (1976-80) (knots)
	Means (°C)		Extremes (°C)		Dew Point (°C) at GMT:		(%) at GMT :			Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)			
	Max.	Min.	Highest	Lowest	6:00	12:00	3:00	6:00	12:00					
Jan.	26.2	13.3	29.8	7.5	14.5	12.5	-	77	47	46	55.6	6.0	-	10
Feb.	27.2	13.6	30.6	8.0	14.9	12.5	-	77	43	40	61.8	4.0	-	11
Mar.	27.6	13.7	31.6	7.5	15.8	13.3	-	81	46	111	84.3	8.0	-	12
Apr.	25.8	15.1	28.7	10.1	16.3	14.7	-	84	54	210	90.9	16.0	-	9
May	25.0	14.5	28.2	10.0	15.5	14.7	-	82	57	129	72.3	11.0	-	8
Jun.	23.9	12.3	27.2	8.0	13.5	12.8	-	78	53	25	33.4	4.0	-	6
Jul.	22.6	11.2	25.8	6.8	12.9	12.0	-	84	55	18	38.0	4.0	-	6
Aug.	23.6	10.9	27.8	6.8	12.7	11.6	-	82	51	16	16.9	5.0	-	8
Sep.	26.5	12.6	30.4	8.5	13.2	10.9	-	78	41	22	62.0	4.0	-	9
Oct.	27.2	13.4	30.5	9.0	14.3	11.1	-	74	40	60	33.0	6.0	-	9
Nov.	25.2	13.7	28.5	10.4	15.3	14.7	-	81	50	158	80.5	14.0	-	9
Dec.	25.0	13.1	28.2	9.0	15.4	14.2	-	80	54	70	44.0	8.0	-	10
Year	25.5	13.1	31.6	6.8	14.5	12.9	-	80	49	905	90.9	90	-	9

(14) Name of Meteorological Station : Marima Nti, Meru

Station No. : 90.37/160
Location : Latitude ; 00° 09' S, Longitide ; 37° 59' E
Altitude : 587 m

Month	Temperature (1971 - 80)						Relative Humidity			Rainfall (1971 - 80)		Number of Days of Rain	Monthly Evaporation (1971-80) (mm)
	Means (°C)		Extremes (°C)		Dew Point (°C) at GMT:		(%) at GMT :			Monthly Rainfall (mm)	Max. 24 Hour Rain-fall (mm)		
	Max.	Min.	Highest	Lowest	6:00	12:00	3:00	6:00	12:00				
Jan.	31.9	18.4	36.9	13.9	-	-	-	75	52	50	118.2	4	159
Feb.	33.8	19.8	37.4	12.6	-	-	-	72	49	21	33.4	3	177
Mar.	34.6	20.9	38.2	17.0	-	-	-	71	46	68	87.6	4	225
Apr.	33.1	21.4	37.8	17.4	-	-	-	75	59	272	117.1	12	181
May	32.2	20.8	39.5	17.0	-	-	-	74	54	112	129.2	6	166
Jun.	31.7	19.2	35.6	14.5	-	-	-	64	46	7	24.5	2	168
Jul.	31.0	19.4	35.5	14.5	-	-	-	64	44	4	7.4	2	180
Aug.	31.3	19.5	35.2	15.5	-	-	-	60	40	4	5.1	1	208
Sep.	33.2	20.0	36.6	14.6	-	-	-	57	41	11	21.0	1	242
Oct.	34.2	21.1	36.9	17.2	-	-	-	64	42	70	122.4	4	254
Nov.	30.0	20.3	36.6	16.4	-	-	-	81	59	223	91.3	12	173
Dec.	30.9	18.9	35.1	14.1	-	-	-	80	61	5	110.3	6	154
Year	32.3	20.0	39.5	12.6	-	-	-	70	49	847	129.2	57	2287

Data Source : Climatological Statistics for Kenya, Kenya Meteorological Department

Table B2.2 Available Periods of Daily Rainfall Data in and around the Grand Falls Catchment (1/5)

No.	ID	Position
1	8937000	Meru
2	8937002	Meru
3	8937014	Kazita
4	8937019	Kazita
5	8937021	Kazita
6	8937038	Meru
7	8937053	Kazita
8	8937060	Kazita
9	8937062	Meru
10	8937065	Meru
11	8937066	Kazita
12	8937072	Kazita
13	8937099	Kazita
14	9036017	Tana
15	9036025	Tana
16	9036043	Tana
17	9036052	Thika
18	9036072	Tana
19	9036104	Thika
20	9036106	Tana
21	9036127	Tana
22	9036128	Tana
23	9036144	Tana
24	9036152	Tana
25	9036157	Tana
26	9036164	Tana
27	9036188	Thika
28	9036191	Thika
29	9036212	Thika
30	9036217	Tana
31	9036220	Thika
32	9036233	Thika

Table B2.2 Available Periods of Daily Rainfall Data in and around the Grand Falls Catchment (2/5)

No.	ID	Position
33	9036246	Tana
34	9036247	Tana
35	9036251	Tana
36	9036259	Tana
37	9036268	Tana
38	9036271	Tana
39	9036273	Tana
40	9036274	Tana
41	9036275	Tana
42	9036282	Tana
43	9036283	Thika
44	9036286	Thika
45	9036288	Tana
46	9036291	Tana
47	9036292	Tana
48	9036293	Tana
49	9036297	Tana
50	9036302	Tana
51	9036303	Thika
52	9036314	Tana
53	9036315	Tana
54	9037001	Thika
55	9037002	Tana
56	9037008	Ena
57	9037010	Thika
58	9037011	Meru
59	9037015	Tana
60	9037018	Thika
61	9037027	Meru
62	9037028	Thika
63	9037031	Ena
64	9037034	Ena

Table B2.2 Available Periods of Daily Rainfall Data in and around the Grand Falls Catchment (3/5)

No.	ID	Position
65	9037037	Masinga
66	9037039	Ena
67	9037042	Tana
68	9037044	Thika
69	9037047	Thika
70	9037050	Ena
71	9037053	Ena
72	9037061	Masinga
73	9037063	Thika
74	9037064	Naromoru
75	9037065	Meru
76	9037069	Tana
77	9037072	Ena
78	9037074	Meru
79	9037075	Tana
80	9037077	Ena
81	9037085	Kazita
82	9037086	Meru
83	9037096	Tana
84	9037099	Tana
85	9037100	Tana
86	9037102	Meru
87	9037103	Ena
88	9037109	Tana
89	9037109	Tana
90	9037110	Ena
91	9037112	Ena
92	9037115	Ena
93	9037120	Tana
94	9037123	Ena
95	9037124	Meru
96	9037127	Ena

Table B2.2 Available Periods of Daily Rainfall Data in and around the Grand Falls Catchment (4/5)

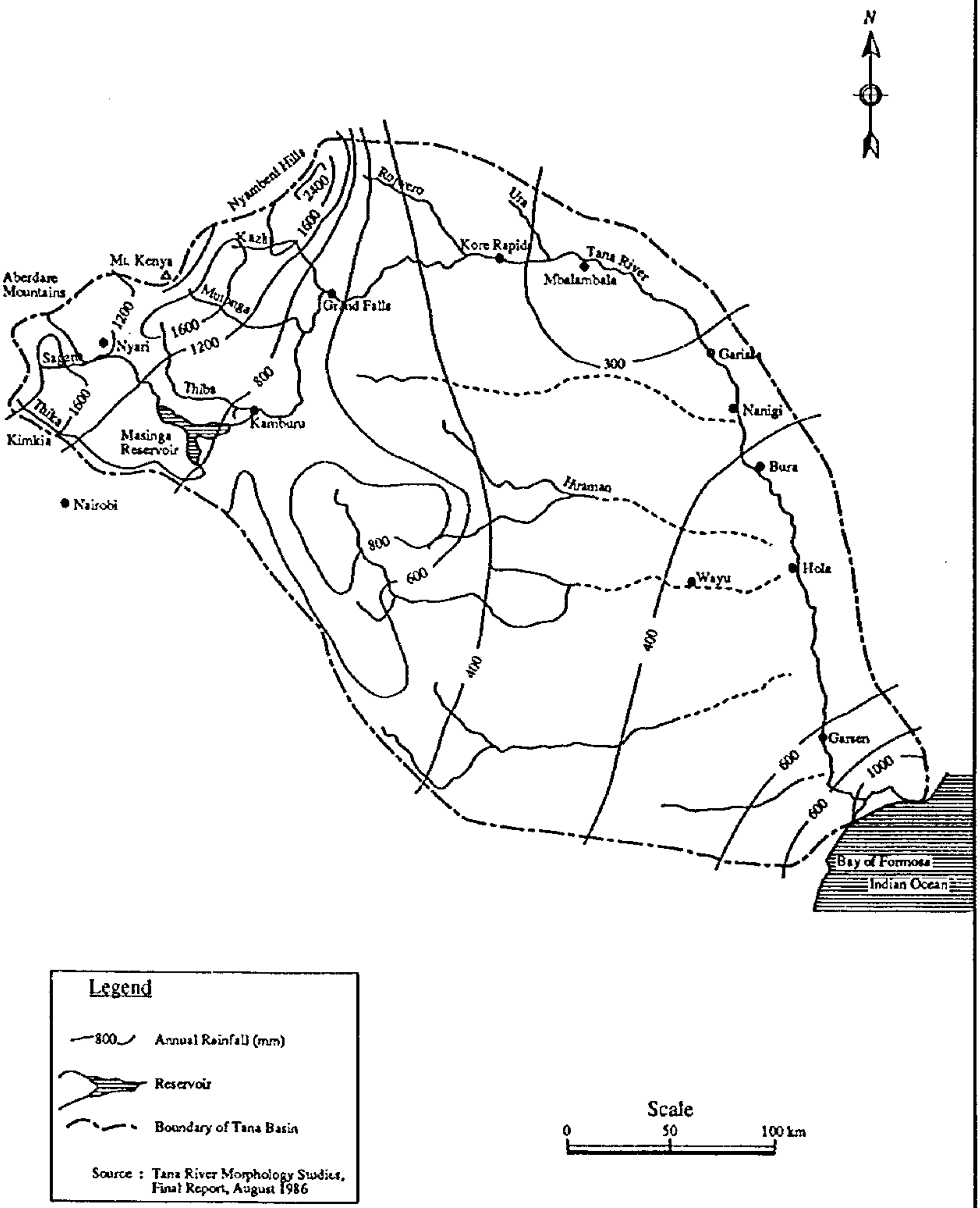
No.	ID	Position
97	9037129	Ena
98	9037131	Tana
99	9037133	Ena
100	9037134	Ena
101	9037135	Mutonga
102	9037137	Ena
103	9037142	Ena
104	9037146	Kithioka
105	9037147	Ena
106	9037150	Meru
107	9037153	Ena
108	9037157	Tana
109	9037160	Kazita
110	9037161	Mutonga
111	9037163	Mutonga
112	9037164	Ena
113	9037165	Ena
114	9037166	Ena
115	9037167	Mutonga
116	9037169	Ena
117	9037170	Mutonga
118	9037171	Ena
119	9037172	Ena
120	9037179	Ena
121	9037181	Tana
122	9037183	Masinga
123	9037185	Meru
124	9037186	Meru
125	9037187	Mutonga
126	9037192	Masinga
127	9037193	Ena
128	9037195	Ena

Table B2.2 Available Periods of Daily Rainfall Data in and around the Grand Falls Catchment (5/5)

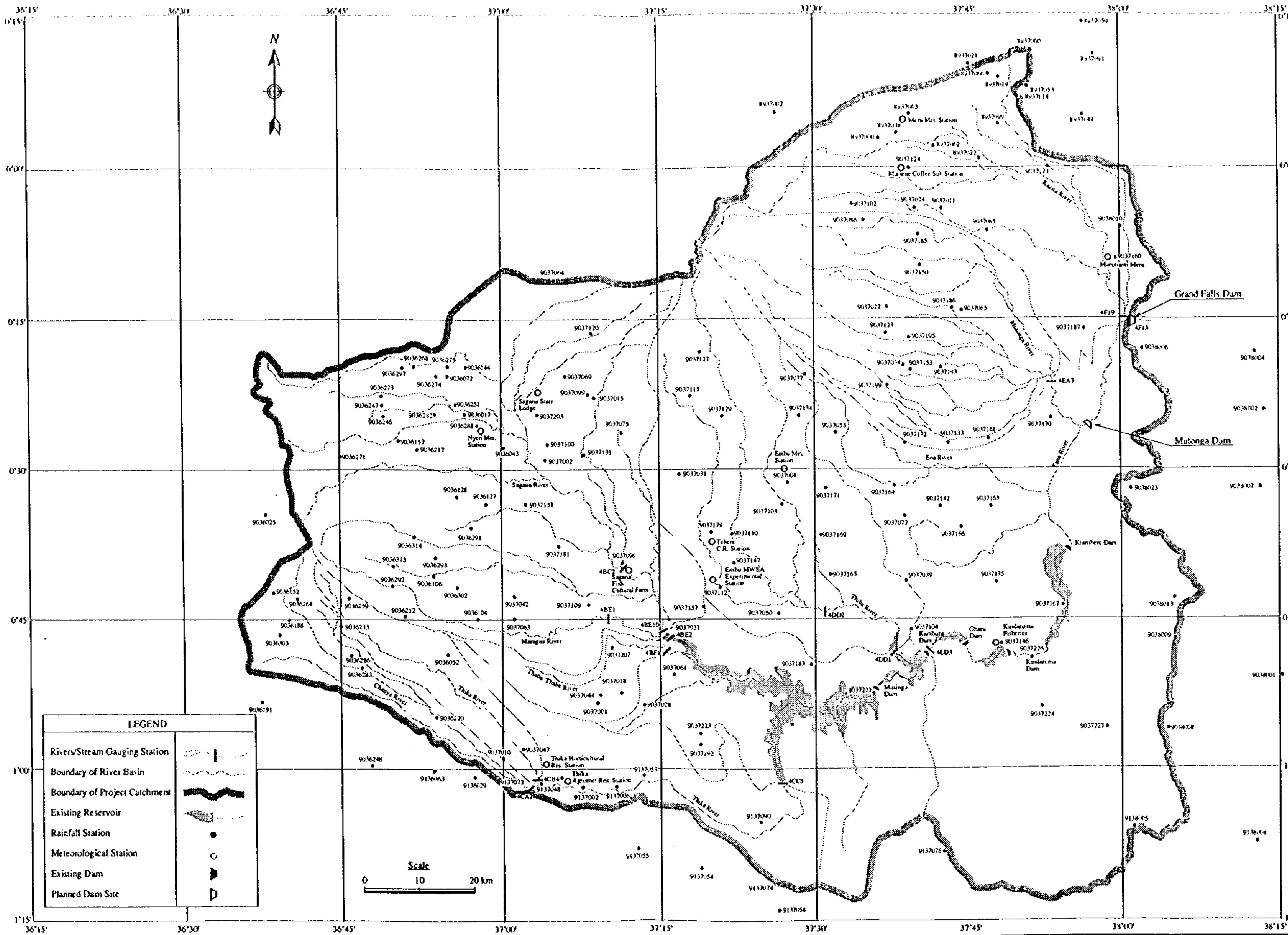
No.	ID	Position
129	9037199	Ena
130	9037203	Tana
131	9037207	Thika
132	9037221	Kazita
133	9037222	Masinga
134	9037223	Masinga
135	9037224	Kithioka
136	9037226	Kithioka
137	9037227	Kithioka
138	9038006	Mutonga
139	9038008	Kithioka
140	9038009	Kithioka
141	9038010	Kazita
142	9038013	Mutonga
143	9038023	Mutonga
144	9136029	Thika
145	9136063	Thika
146	9137002	Thika
147	9137006	Thika
148	9137048	Thika
149	9137053	Thika
150	9137054	Masinga
151	9137074	Masinga
152	9137076	Masinga
153	9137090	Masinga
154	9138005	Kithioka

Table B2.3 Available Periods of Discharge Data Related to the Project

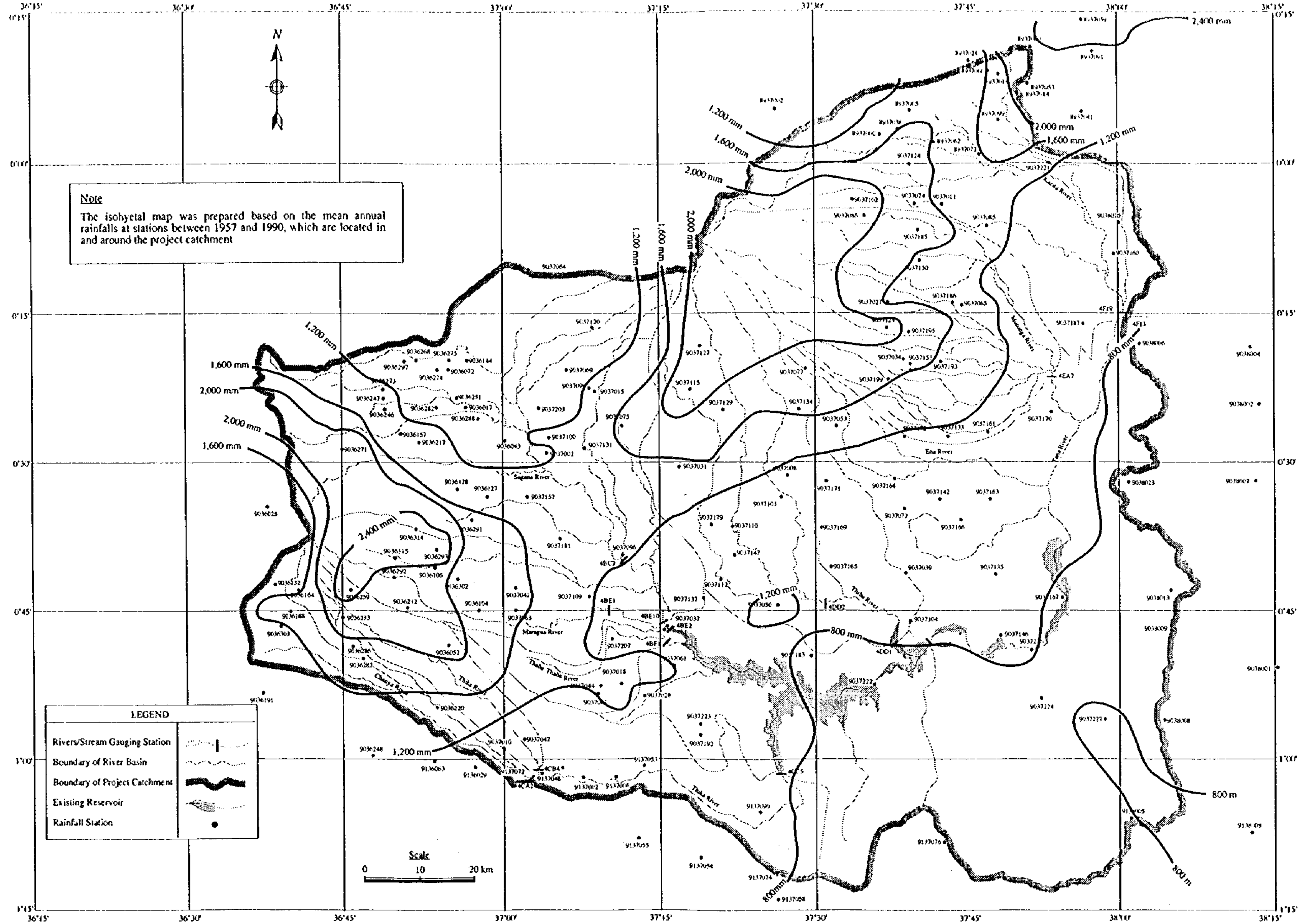
No.	SGS No.	Name of River	Catchment Area (km2)	1940's	1950's	1960's	1970's	1980's	90's
1	4BC2	Sagana	518						
2	4BE1	Maragua	414						
3	4BE2	Sagana-Mathioya	3,672						
4	4BE10	Tana Mainstream	3,256						
5	4BF1	Thaba-Thaba	252						
6	4CA2	Thika-Chanya	518						
7	4CB4	Thika	316						
8	4CC5	Thika	1,700						
9	4DD1	Thiba	1,961						
10	4DD2	Thiba	1,500						
11	4EA7	Mutonga	1,880						
12	4ED3	Tana Mainstream	9,520						
13	4F13	Tana Mainstream	17,234						
14	4F19	Kathita	1,673						
15	4G1	Tana Mainstream	32,892						



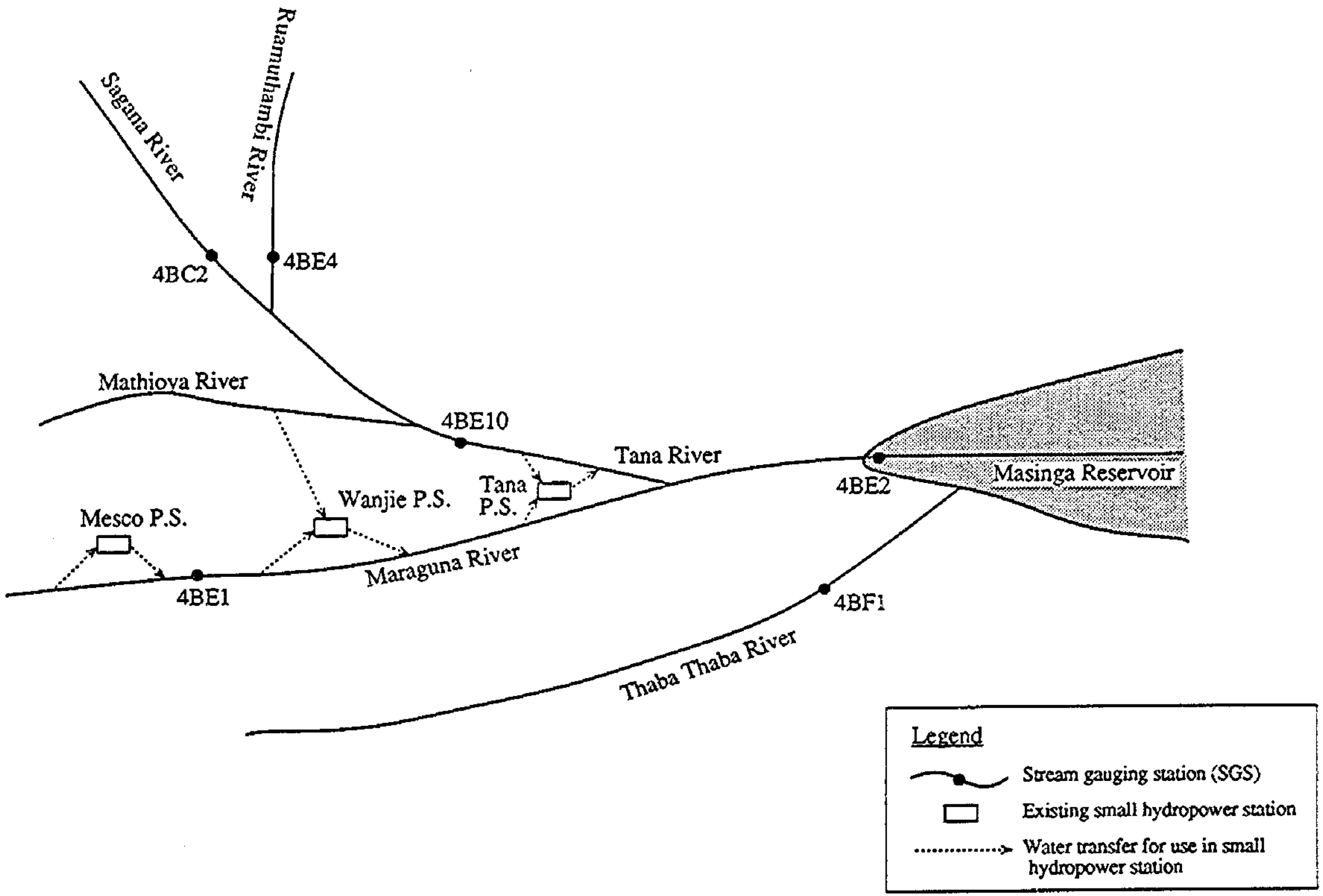
JAPAN INTERNATIONAL COOPERATION AGENCY	Isohyetal Map for Whole Tana Basin, Prepared by DHV	Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT		B2.1



JAPAN INTERNATIONAL COOPERATION AGENCY	Location of Meteo-Hydrological Stations	Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT		B2.2



JAPAN INTERNATIONAL COOPERATION AGENCY	Isohyetal Map for Project Catchment	Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT		B2.3



Data Source: Information obtained from KPLC

JAPAN INTERNATIONAL COOPERATION AGENCY
REPUBLIC OF KENYA
MUTONGA/GRAND FALLS HYDROPOWER PROJECT

Schematic Map on Water Transfer among Tributaries Upstream of Masinga Reservoir

Fig. No. B2.4

B3 RUNOFF ANALYSIS

B3.1 Method Adopted for Runoff Analysis

The runoff analysis principally aims to estimate the naturalized long-term runoff data at the planned Mutonga and Grand Falls dam sites as well as the existing five dams located upstream of those planned dams, which were ultimately utilized for the reservoir operation therefor, taking into account the artificial floods planned to improve the environmental condition in the downstream areas. To accurately examine the effective storage capacities of the planned dams required for the artificial floods, the runoff analysis needs to be carried out on a daily data basis.

Taking into the existing meteo-hydrological data related to the project catchment, the methods applicable to the runoff analysis for estimating the naturalized long-term mean daily discharges at the planned dam sites are conceived as follows:

i) To estimate and adopt the mean daily discharges observed at stream gauging station 4F13 for the period from 1962 to 1990,

ii) To estimate the mean daily discharges released from the upstream reservoirs based on reservoir storage capacity curves, and the long-term records of the reservoir operation which include the records of power generation, reservoir water levels, gate operation and reservoir evaporation,

iii) To apply the rainfall-discharge simulation model to the respective subbasins so as to generate daily runoff data from daily rainfall data over the period when the rainfall data became completely available. In the method, the long-term runoff at the planned dam sites are estimated to be a sum of those of the respective subbasins for the period, which are to be derived through the simulation model.

Regarding the method i) above, it was considered that the availability of hydrological data were very low with respect to the availability of the stage-discharge rating curves in the present study stage as explained in the succeeding Subsection B3.4.2. Even though the stage-discharge rating curves will be made available consistently through the intensive current metering from now on, however, the other approaches will have to be introduced to estimate the long-term naturalized mean daily runoff data before 1968 and 1980's for the following reasons:

a) There are no sufficient data for relating the present stage heights in higher portions to those before 1968, which were measured with sloped staff gauges.

b) After 1968, the streamflow of the Tana mainstream at the Mutonga and Grand Falls dam sites is affected by the regulation effect of upstream reservoirs. Especially, the streamflow has been significantly regulated by the completion of the Masinga reservoir which was created in 1981.

In case of ii) above, the hourly records related to the reservoir operation of the upstream reservoir are required to accurately restore the inflow series to the existing reservoirs. During the field investigation period, the Study Team could not get such a detail records of reservoir operation on the upstream dams which suffice the requirements for the method.

The method iii) above was considered to be more effective way, as compared with the former two methods, taking into consideration that there are a sufficient number of rainfall station in and around the project catchment as mentioned in the foregoing Chapter B2.

Taking into account the comparatively high availability of rainfall data as well as the short period of stage height records in the project catchment, it was determined that the long-term naturalized mean daily discharges be estimated by means of the rainfall-discharge simulation model based on the meteo-hydrological data in the project catchment. As the simulation model, the Tank Model method was selected to generate runoff data from rainfall data. The Tank Model was originally developed by Dr. Sugawara in Japan and have been widely and successfully utilized not only for river basins in Japan, but also for those in other countries for the simulation purpose. It was verified through the present runoff analysis that the Tank Model was applicable to the Tana basin with the sufficient accuracy.

B3.2 Division of Project Catchment into Subbasins

As discussed in the succeeding Section B3.4, seven (7) stream gauging stations were selected as the key ones for the runoff analysis. To make the low flow analysis consistently, at first, the project catchment area of 17,234 km2, which is covered by the Grand Falls dam site, was divided into the following fourteen (14) subbasins in consideration of locations of existing dam sites and those of the selected key stream gauging stations which are discussed in the succeeding Subsection B3.4.3:

Subbasins Set up for Runoff Analysis

No.	Name of Subbasin	Catchment Area (km2)
1	4BE2	3,672
2	4CB4	316
3	4CA2	518
4	MASI-RL	2,829
5	4DD1	1,961
6	KAMB-RL	224
7	GITA-RL	147
8	KIND-RL	140
9	KIAM-RL	2,168
10	MUTO-L	1,045
11	MUTO-R	465
12	4EA7	1,880
13	GRAF-RL	196
14	4F19	1,673
Total (Grand Falls dam site)		17,234

The above subbasins are depicted in Figure B3.1. Of the 14 subbasins above, seven (7) subbasins, 4BE2, 4CB4, 4CA2, 4DD1, 4EA7 and 4F19, are covered by the stream gauging station. Thus, these subbasins were categorized into the "gauged subbasin", while the other seven (7) subbasins into the "ungauged subbasin". On the other hand, a catchment of the stream gauging station 4ED3 with an area of 9,520 km^2 is formed by four (4) gauged subbasins, 4BE2, 4CB4, 4CA2, 4DD1, and two (2) ungauged subbasins, MASI-RL and KAMB-RL as depicted in Figure B3.1.

Climatorogically, the ungauged subbasins located downstream of SGS 4ED3, which lie on the right bank side of the Tana mainstream, are characterized by the seasonal flow with smaller annual rainfalls in comparison with those in the gauged subbasins, called "Lagas".

B3.3 Rainfall Analysis

B3.3.1 Infilling of Daily Rainfall Data

As seen in Table B2.2 presented in the foregoing Chapter B2, the rainfall stations on which the rainfall data before 1957 are available are very less. Taking into consideration the available periods of daily rainfall data at the 154 stations located in and around the project catchment, it was determined that the simulation was to be made using the Tank Model to generate the runoff data for 34 years between 1957 and 1990.

On the other hand, there are a lot of interrupted periods of rainfall observation at the 154 rainfall stations for the period from 1957 to 1990 as seen in Table B2.2. In utilizing the rainfall data for the Tank Model to generate discharge from rainfall, the daily rainfall data need to be made complete throughout the period for which the simulation is made. Hence, the frequency analysis was made to infill the daily rainfall data for the interrupted period of rainfall observation.

Prior to the frequency analysis, the correlation analysis was made concerning the following data at the neighboring two rainfall stations:

- Daily rainfall
- Monthly rainfall
- Yearly rainfall

Concerning each of the 154 rainfall stations, the other rainfall station which show the higher correlation coefficients was selected to be applied to the regression analysis to infill the daily rainfall data for the interrupted periods. The combinations of the two rainfall stations thus selected are shown in Table B3.1 together with the estimated correlation coefficients.

To infill the daily rainfall data for the interrupted periods, the following linear regression formula was derived based on the rainfall data observed for the concurrent periods:

$$R(a)=A \cdot R(b)$$

where, R(a) : Daily rainfall at Station - A
R(b) : Daily rainfall at Station - B
A : Coefficient estimated through the regression analysis

Through the aforesaid correlation and regression analyses, the daily rainfall data at the 154 stations were made available throughout the period between 1957 and 1990.

B3.3.2 Estimate of Basin Average Rainfall

To estimate the basin average rainfall for the project catchment as well as each of the subbasins for 34 years from 1957 to 1990 , the Thiessen's polygons were worked out for the entire project catchment as shown in Figure B3.2.

With regard to each of the project catchment and subbasin, the basin average rainfall was calculated applying the weightnesses of the respective rainfall stations whose polygons lie in the catchment. The weightnesses of the respective rainfall stations for each subbasin are summarized in Table B3.2.

The annual basin average daily rainfalls between 1957 and 1990 were estimated applying the Thiessen's polygons for each of the fourteen (14) subbasins. The estimated annual monthly rainfalls are shown in Tables B3.3 to B3.16. As a result, the basin average rainfall for the project catchment with an area of 17,234 km^2 was derived to be about 1,249 mm/year as shown in the following table:

Basin Average Rainfall of Subbasin between 1957 and 1990

No.	Name of Subbasin	Catchment Area (km2)	Nos. of Rainfall Stations Applied	Basin Average Rainfall (mm)
1	4BE2	3,672	58	1,477.3
2	4CB4	316	12	1,835.8
3	4CA2	518	16	1,619.8
4	MASI-RL	2,829	22	967.9
5	4DD1	1,961	24	1,494.4
6	KAMB-RL	224	4	704.0
7	GITA-RL	147	5	773.4
8	KIND-RL	140	5	707.2
9	KIAM-RL	2,168	10	767.1
10	MUTO-L	1,045	18	1,063.2
11	MUTO-R	465	6	802.5
12	4EA7	1,880	24	1,605.3
13	GRAF-RL	196	4	855.8
14	4F19	1,673	25	1,380.2
Total	Grand Falls Catchment	17,234	154	1,249

In the Water Master Plan of Kenya, the basin average rainfall for the Grand Falls catchment is estimated to be about 1,050 mm/year for 32 years from 1959 to 1990. However, the previous study was carried out at a level of master planning applying the quite limited number of rainfall stations to estimate the basin average rainfall, while in the present study it was estimated applying the rainfall data at a total of 154 rainfall stations.

B3.4 Estimate of Observed Mean Daily Discharges

B3.4.1 Stage-Discharge Rating Curve

MOWD is responsible for collection and preservation of hydrological data in Kenya and is engaged in construction of stage-discharge rating curves based on the current metering results to process the stage height records into mean daily discharges at the respective stream gauging stations. Concerning every stream gauging station, MOWD adopts the following exponential equation as the stage-discharge rating curve:

$$Q=(H+a)^b$$

where, Q : Discharge in m^3/sec
H : Stage height in m
a, b : Coefficients

MOWD modified the stage-discharge rating curve as required when a change therein is judged to occur based on the current metering results. The stage-discharge rating curves at the 15 stream gauging stations in the project catchment, which were constructed by MOWD, are shown in Figures B3.3 to B3.10.

B3.4.2 Reliability of Runoff Data at Stream Gauging Station 4F13, Grand Falls Dam Site

The stream gauging station 4F13 is located about 2 km upstream of the proposed Grand Falls dam site. The stage height reading on staff gauge has been done once a day from 1963 to date with some interruption. Needless to say, it is the most recommendable that the long-term runoff at the proposed dam sites are determined based on the runoff data at SGS 4F13 taking into account the geographical condition, provided that the runoff data are verified to be consistent.

First of all, the long-term observed mean daily runoff at SGS 4F13 were computed applying the stage-discharge rating curves to the mean daily stage heights. Consequently, the mean discharge at SGS 4F13 is derived to be 226 m^3/sec based on the observed runoff data for the period from 1963 to 1990 as summarized in Table B3.17. The mean discharge for the 28 years corresponds to 413 mm/year. Figure B3.11 shows the annual runoff depths and evapotranspirations for the project catchment together with those for catchment of SGS 4ED3. As seen in the Figure, the annual evaporations for a catchment of SGS 4ED3, which were derived from the observed runoff at SGS 4ED3 and the basin average rainfall, fall within a definite range. On the other hand, some of the annual rainfalls for the project catchment (SGS 4F13) deviate from the range. In particular, of the annual evapotranspirations before the year 1968, only that in 1967 falled within the range. Furthermore, those in 1967 and 1968 deviate from the range to a considerable extent, showing quite small annual values. The small values of annual evapotranspiration appear in the years when the comparatively large-scale floods occurred. Judging from these facts, it appears that the higher runoff depth is caused by the overestimate of discharge at the high stages.

During the field investigation, the Study Team attempted to gather the data and information on the stream gauging station 4F13 to clarify the previous state thereof. It was informed by the Engineer of MOWD that the inclined staff gauges were installed thereat until they were released by vertical ones in 1968. Figure B3.12 shows the inclined staff gages used up to the year 1968. Although the four (4) staff gauges were installed with different incineration along the left bank, MOWD utilized the rating curves for stage heights read on the sloped staff gauges. In principle, the stage heights need to be converted to vertical ones to construct the consistent rating curves. On the other hand, the Study Team could not get the data and information on how the staff gauges higher than those ones were installed. For the time being, thus, it is too hard to revise the stage-discharge rating curves for the higher stages accurately.

Concerning the runoff data at the stream gauging station 4F13 after 1968, the stage heights would have been more or less dominated by the reservoir or pondage operation of upstream hydropower stations. As mentioned in the foregoing Chapter B2, the Gitaru and Kindaruma hydropower projects were completed in the end of 1960's. While, these projects are of run-of-river scheme with a comparatively small storage capacity which allows the daily regulation of inflow to pondage. Accordingly, these projects might not have a significant influence on the natural flow at SGS 4F13 except for the case that the peak power operation be done during the dry periods.

After completion of these run-river-type hydropower plants, the reservoir type schemes were constructed on the Tana mainstream, namely the Gitaru dam in 1974, the Masinga dam in 1981 and the Kiambere dam in 1988. Of these reservoir schemes, it is obvious that the Masinga dam with an outstandingly large effective reservoir storage volume of 1,410 million m^3 have changed significantly the natural flow at SGS 4F13. This situation was clarified by comparing the runoff series observed at SGS 4F13 with those obtained through the simulation with the Tank Model as discussed in the succeeding Subsection B3.4.

Taking into account the aforesaid conditions, it was considered that the availability of the runoff data at SGS 4F13 was considerably low. In the present runoff analysis, therefore, the runoff data at SGS 4F13 were used to assess the reliability of low flow series estimated by means of the Tank Model.

B3.4.3 Estimate of Observed Natural Streamflow at Stream Gauging Stations

Concerning each of the fifteen (15) stream gauging stations, recorded stage heights were wholly converted into mean daily discharges applying the MOWD's stage-discharge rating curves to compare with the annual basin average rainfall estimated the Thiessen's Polygons mentioned in the foregoing Section B3.3.

The Study Team checked those existing stage-discharge rating curves carefully and modified them if they are judged necessary to do so. As a result, the following stream gauging stations were selected as the key stream gauging stations to be used for the runoff analysis from the point of view of their geographical positions as well as the consistency of the processed runoff data in comparison with the basin average rainfall:

Selected Stream Gauging Stations for Runoff Analysis

No. of Stream Gauging Station	Catchment Area (km2)	Available Period of stage heights	Mean of Observed Discharge (m3/sec)
4CA2	518	1947 - 1990	8.47
4CB4	316	1945 - 1990	6.61
4BE2	3,672	1957 - 1981	67.12
4DD1	1,961	1947 - 1992	25.69
4ED3	9,520	1951 - 1972	109.33
4EA7	1,880	1966 - 1990	30.32
4F19	1,673	1966 - 1990	15.20

The estimated annual mean monthly discharges at those key stream gauging stations are shown in Tables B3.18 to B3.24. The catchment areas covered by four stream gauging stations 4CA2, 4CB4 4BE2 and 4DD1 lie in that of SGS 4ED3.

Table B3.25 and Figure 3.13 show a relation between the annual rainfall and evapotranspiration for a catchment covered by each of the stream gauging stations. These Figures exhibit the general tendency that the evapotranspirations in these gauged subbasins, which are blessed with the comparatively large annual rainfalls, almost fall within a range of 700 to 1,500 mm/year, depending on the annual rainfall amount. Thus, the runoff data at these key stream gauging stations are judged to be consistent as a whole in a view that annual runoff depth increased with the basin average rainfall as shown in Figure B3.13.

B3.5 Simulation by the Tank Model

B3.5.1 Concept of the Tank Model

The basic component of the tank model is a simple tank with holes to pass the water content. The outflow from each hole is proportionate to the height between the hole and water surface. Provided that a tank is accommodated with one bottom hole and two side holes, as shown in Figure B3.14, the rule for outflow computation is as follows:

$$yn = 0 \qquad (Xn \le h_1)$$
$$yn = \alpha_1(Xn - h1) \qquad (h_1 < Xn \le h_2)$$
$$yn = \alpha_2 (Xn - h_2) + \alpha_1 (Xn - h_1) \qquad (h_2 < Xn),$$

$$zn = \beta Xn,$$
$$Xn' = Xn - yn - zn,$$
$$Zn + 1 = Xn' + xn{+}1 \qquad \text{.......... (1)}$$

where,
- Xn : water depth of stage n,
- yn : outflow from side holes of stage n,
- zn : outflow from bottom hole of stage n,
- xn : inflow of stage n,
- α_1, α_2 : coefficient of side holes, and
- β : coefficient of bottom hole.

Normally, a tank model combining several tanks in a series makes a better simulation results. In Japan, a number of river basins are successfully analyzed by the tank model consisting of four tanks in a series. In such models, each tank interacts in the manner described in the above equation (1). The top tank receives the rainfall as inflow to the tank, while the tanks below get the supply from the bottom holes of the tank directly above. The last, or the bottom tank only has a side hole. The aggregated outflow from all the side holes of the tanks constitutes the inflow into the river course. The basic model above is illustrated in Figure B3.14.

Out of the above simulation models, the simple model of four tanks is the most applicable to the basin where the river flows scarcely dry up. However, in the basin where there are dry seasons regularly and the river flows deminish to a conceivably low level or completely dry up, it is difficult to simulate such conditions in the above simple model.

To effectively trace such dry conditions in the non-humid basin, several modifications are made on the basic model. The model is firstly facilitated with a structure to simulate the moisture content in the top tank. This sub-model is composed of two moisture-bearing zones, which contain moisture up to the capacities of saturation. The moisture contents in the two zones are expressed as the height, XP and XS, which are called the primary and secondary soil moisture depth. Between the above two zones, transfer of water contents takes place, as expressed below:

$$T2 = TC\ (XP/PS - XS/SS) \quad \text{.......... (2)}$$

where,

T2	:	Transfer of moisture between primary and secondary zones (if positive, transfer occurs from primary to secondary, and vice versa)
PS	:	Primary soil moisture capacity
SS	:	Secondary soil moisture capacity
XP	:	Primary soil moisture depth
XS	:	Secondary soil moisture depth
TC	:	Constant

If the primary soil moisture is not saturated, i.e., XP < PS, water is supplied to the primary moisture zone from the lower tanks as a result of the capillary action, amount of which is computed as below.

$$T1 = TB\ (1 - XP/PS) \quad \text{..........}$$

where,

T1	:	Transfer of capillary action from lower tanks
TB	:	Constant

For the purpose of simulating the area distribution of soil moisture, the drainage area is divided into four sub-areas. In the beginning of the dry season, the area at the outermost fringe dries up, and the dried area extends inwards until the innermost area becomes arid. Four basic models are combined in parallel, as shown in Figure B3.14.

The tank model thus configurated has been used successfully in a lot of projects not only in Japan, but also in other countries which include the arid basins in the Middle East Region.

The simulation model thus constructed is calibrated with the observed daily runoff and rainfall data for each of the gauged subbasins. Trial-and-error method needs to be done for determining the tank parameters which make the difference between the observed and estimated runoffs minimize.

B3.5.2 Methodology and procedure for Determining of Parameters of Tank Model for Each Sub-Basin

In the present runoff analysis, it was attempted to construct the Tank Model for each of the 14 sub-basins. Of those subbasins, 6 ones, namely, SGS 4BE2, 4CB4, 4CA2, 4DD1, 4EA7, 4F19, are categorized to be the gauged zone where runoff data applicable to the Tank Model are available, as explained in the foregoing Section B3.2. Taking into account the availability of the runoff data, the parameters for each subbasin were determined in the following steps:

Step-1 : At first, the tank parameters for each of the gauged areas were worked out through the trial calculations to get the best coincidence of the mean daily discharges observed and simulated for their concurrent periods. The extent of the coincidence of the observed and simulated runoff was assessed by comparing with the hydrographs and flow duration curves, derived therefrom respectively on a daily data basis.

Step-2 : The parameters for the ungauged two subbasins located upstream of SGS 4ED3, MASI-RL and KAMB-RL, were attempted to be determined so that the two hydrographs of mean daily discharges at SGS 4ED3, which were derived from the different two sources of runoff data, became almost coincident in the low flow portions as a whole. Of these two hydrographs, one was a hydrograph derived based on the mean daily discharges at SGS 4ED3 and further extended by means of the Tank Model. The other is a hydrograph derived by summing up the mean daily discharges of the six subbasins constituting a catchment of SGS 4ED3, which were partly extended for the gauged subbasins and wholly generated for ungauged ones by means of the Tank Model. Again, the parameters for the ungauged two subbasins MASI-RL and KAMB-RL were determined so that the mean daily discharges derived by synthesizing those in the upstream subbasins of SGS 4ED3 coincided with the mean daily discharges derived based principally on those observed at SGS 4ED3.

Step-3 : The parameters for the ungauged areas in the downstream subbasins of SGS 4ED3 were first assumed making reference to those of the gauged ones downstream of SGS 4ED3, namely SGS 4EA7 and 4F19. The appropriateness of the parameters assumed for the downstream ungauged areas were assessed by the extent of the coincidence of the low flows in hydrographs of mean daily discharges observed at SGS 4F13 and of the mean daily discharges derived by summing up those of the whole of the 14 subbasins, which constitute a catchment of SGS 4F13, the Grand Falls dam site.

B3.5.3 Simulation of Daily Runoff of Gauged Sub-Basins

Through a number of trial calculations, a combination of the tank parameters which gave the best coincidence of the observed and simulated mean daily discharges at the seven (7) stream gauging stations were derived as shown in Tables B3.26 and B3.33.

Figures B3.15 to B3.21 shows comparison of the two hydrographs of mean daily discharges, of which one is constructed based on observed mean daily discharges, the other on simulated mean daily discharges, with respect to each of the 7 stream gauging stations. As seen in these Figures, the simulated mean daily discharges well coincide with the observed ones at stream gauging station, especially during the dry periods.

The extent of the coincidence of the mean daily discharges observed and simulated by the Tank Model was further assessed through comparison of flow durations curves constructed based on each of these different two series of daily runoff data for the concurrent period. The flow duration curves thus derived for each of the 7 stream gauging stations are illustrated in Figure B3.22. These Figures reveal the distinguished coincidence of the observed and simulated mean daily discharges concerning every stream gauging station.

In principle, the long-term naturalized mean daily discharges for the gauged subbasins were derived adopting the simulated discharges for the periods in which the observed ones are not available. The long-term mean discharges of the subbasins thus estimated between 1957 and 1990 are summarized in the following table:

Results of Simulation by Tank Model for Gauged Subbasins

Name of Subbasin	Catchment Area (km2)	Basin Average Rainfall (mm/year)	Mean Discharge between 1957 and 1990 (m3/sec)	Runoff Coefficient (%)
4CA2	518	1,620	8.79	33.1
4CB4	316	1,836	7.11	38.8
4BE2	3,672	1,477	64.37	37.5
4DD1	1,961	1,494	26.60	28.7
4EA7	1,880	1,605	28.85	29.0
4F19	1,673	1,380	15.67	21.0
(Total)	10,020			
SGS 4ED3	9,520	1,351	118.11	29.0

The estimated long-term mean monthly discharges for the six (6) gauged subbasins are summarized in Tables B3.27 to B3.32.

B3.5.4 Simulation of Daily Runoff of Ungauged Sub-Basins

(1) Ungauged 2 subbasins located upstream of SGS 4ED3 (MASI-RL and KAMB-RL)

The drainage area of SGS 4ED3 comprises those of six (7) subbasins, namely 4BE2, 4CA2, 4CB4, 4DD1, MASI-RL and KAMB-RL, of which the latter two subbasins MASI-RL and KAMB-RL are categorized into the ungauged subbasin. As explained in the foregoing Subsection B3.5.3, the long-term daily runoff data at SGS 4ED3 were consistently derived for the period from 1957 to 1990 through the simulation analysis using the Tank Model. As well, those at the four gauged subbasins 4BE2, 4CA2, 4CB4 and 4DD1 were made available applying the same method.

The tank parameters for a catchment of 4ED3 were determined by means of the trial calculations applying the observed daily runoff and average basin rainfall as shown in Table B3.33. The simulated mean daily discharges are compared with the observed ones in terms of their hydrographs and flow duration curves at SGS 4ED3 as shown in Figures B3.19 and B3.22, respectively. As seen in these Figures, the observed and simulated mean daily discharges exhibit the reasonable coincidence. Thus, the long-term annual mean monthly discharges at SGS 4ED3 were derived through the same procedure adopted for the gauged subbasins as mentioned in the foregoing Subsection B3.5.3 as listed in Table B3.34.

With regard to the ungauged subbasin MASI-RL and KAMB-RL, the trial calculations by means of the Tank Model method were made by varying the Tank parameters in order to find the most suitable ones therefor, which resulted in the satisfactory coincidence of the daily runoff data at 4ED3 and sum of those of the six subbasins constituting the catchment of SGS 4ED3. As a result of the trial calculations, the tank parameters for the ungauged two subbasins were derived as shown in Table B3.33. The long-term mean daily discharges derived by summing up the runoff values of the four subbasins were compared with those estimated based on the observed ones at SGS 4ED3 in terms of their hydrographs and flow duration curves as shown in Figures B3.24 and B3.25, respectively. These Figures reveal that these two series of runoff data are consistently coincident with each other. Accordingly, it was determined that the daily runoff data for the ungauged subbasin MASI-RL and KAMB-RL be generated applying the tank parameters shown in Table B3.33 to the Tank Model.

The following table summarizes the calculation results for the ungauged subbasin MASI-RL and KAMB-RL:

Comparison of Long-Term Mean Runoff for a Catchment of SGS 4ED3 (C.A.=9,520 km2)

Case-1 : Estimate by Summing up Daily Runoff in Each Subbasin				Case-2 : Estimate Based on Observed Runoff at SGS 4ED3			
No.	Name of Subbasin	Catchment Area (km2)	Mean Runoff between 1957 and 1990 (m3/sec)	No.	Name of SGS	Catchment Area (km2)	Mean Runoff between 1957 and 1990 (m3/sec)
1	4BE2	3,672	64.37				
2	4CA2	518	8.79	1	4ED3	9,520	118.11
3	4CB4	316	7.11				
4	4DD1	1,961	26.60				
5	MASI-RL	2,829	11.01				
6	KAMB-RL	224	0.15				
Total		9,520	118.03			9,520	118.11

The estimated mean monthly discharges in the subbasin MASI-RL and KAMB-RL between 1957 and 1990 are shown in Tables B3.35 and B3.36, respectively. The mean annual runoff coefficients for these subbasins are derived to be 15.9 and 3.1%, which are considerably low as compared with those in the other four gauged subbasins which range between 21 and 39%. This is attributed to the smaller rainfall in the catchment than those in the gauged subbasins as discussed in the foregoing Subsection B3.3.2.

(2) Ungauged 6 sub-basins located downstream of SGS 4ED3 (GITA-RL, KIND-RL, KIAM-RL, MUTO-L, MUTO-R, GRAF-RL)

There are five ungauged subbasins in the catchment enclosed by the two stream gauging stations 4ED3 and 4F13 on the mainstream. During the field investigation, it was informed by the local inhabitants that no surface water was observed in the tributaries draining the basins of the right bank side during the dry periods when they were utilizing ground water lying beneath the river bed. Thus, the tributaries in these subbasins are of the seasonal rivers.

In the simulation by the Tak Model for these ungaged subbasins, the tank parameters were first assumed making reference to those in the neighboring subbasins to estimate the long-term mean daily runoff at SGS 4F13, the Grand Falls dam site. After then, hydrographs of the estimated mean daily discharges were compared with hydrographs of the observed ones at SGS 4F13 with respect to the dry season's flow for the period from 1962 to 1967 when the natural river flows were observed at SGS 4F13. In case a significant gaps were recognized in the low flow of the observed and synthesized discharges, the same procedures were repeated until the satisfactory results had been obtained.

As a result of the trial calculations, the tank parameters of the ungauged subbasins were determined as summarized in Table B3.37. The hydrographs of observed mean daily runoff at SGS 4F13 and those of synthesized ones of mean daily discharges in the respective subbasins are illustrated in Figure B3.25. The Figure exhibits that the synthesized daily runoff data coincides precisely with the low flow observed at SGS 4F13 between 1962 and 1967. This is also endorsed in Figure B3.26, which shows a precise coincidence of the mean daily discharges derived by the aforesaid different methods with respect to the low flows between 1962 and 1967. On the other hand, there is a large difference between the high flows since the observed discharges were overestimated. Besides, the Figure reveals that the observed runoff data at SGS 4F13 between 1968 and 1990 are obviously affected by the operation of upstream reservoirs.

The long-term mean monthly discharges in the ungauged subbasins are listed in Tables B3.38 to B3.43. The estimated long-term mean discharges therein between 1957 and 1990 are summarized below together with the mean annual runoff coefficients for the same period:

Estimated Naturalized Mean Runoff in Ungauged Subbasins Located Downstream of SGS 4ED3

No.	Name of Subbasin	Catchment Area (km2)	Basin Average Rainfall between 1957 and 1990 (mm/year)	Mean Discharge between 1957 and 1990 (m3/sec)	Runoff Coefficient (%)
1	GITA-RL	147	773	0.23	6.4
2	KIND-RL	140	707	0.20	6.3
3	KIAM-RL	2,168	767	3.21	6.1
4	MUTO-L	1,045	1,063	5.33	15.2
5	MUTO-R	465	803	1.17	10.0
6	GRAF-RL	196	856	0.55	10.3
Total		4,161	848	10.69	9.6

As a result of the simulation analysis carried out by mean of the Tank Model, the runoff coefficients in the ungauged subbasins downstream of SGS 4ED3 are in a range of 6.1% to 15.2%, being by far less than those in the gauged 4F19 and 4EA7 which are located on the right side bank of the Tana mainstream. This is considered to be attributable mainly to the smaller basin average rainfalls in the ungauged subbasins, which are mostly equal to or less than 1,000 mm/year in the mean annual basin average rainfall, while in the gauged subbasins 4F19 and 4EA7 the mean annual basin average rainfalls exceed 1,600 mm/year.

B3.6 Naturalized Mean Daily Runoff at the Planned Mutonga and Grand Falls dam sites

The long-term naturalized mean daily runoff data at existing and Planned Mutonga and Grand Falls dam sites on the Tana mainstream were derived by means of summing up those at the upstream subbasins. The mean monthly discharges thereat thus estimated are shown in Tables B3.44 and B3.45 and summarized below:

Summary of Runoff Analysis for Estimating Naturalized Runoff at Existing/Proposed Dam Sites

No.	Name of Dam	Existing or Planned	Catchment Area (km2)	Estimated Mean Discharge between 1957 and 1990 (m3/sec)
1)	Masinga	Existing	7,335	91.28
2)	Kamburu	Existing	9,520	118.03
3)	Gitaru	Existing	9,520	118.26
4)	Kindaruma	Existing	9,807	118.46
5)	Kiambere	Existing	11,975	121.67
6)	Mutonga	Planned	15,365	157.02
7)	Grand Falls	Planned	17,234	173.24

As seen in table above, the mean discharge at the planned Mutonga and Grand Falls dam site between 1957 and 1990 were estimated to be 157.02 and 173.24 m^3/sec, respectively.

B3.7 Comparison of the Present and Previous Runoff Analyses

The results of the present runoff analysis was compared with those of the previous hydrological analyses carried out for the upper and middle Tana basins. For the purpose, the following reports worked out through the previous hydrological studies were referred to concerning the results of runoff analysis:

i) Appraisal Report, Volume 2, Engineering, September 1976, by Watermeyer : The hydrological studies were carried out to estimate the long-term monthly runoff at the Masinga dam site through the runoff analysis on streamflow records at key stream gauging stations, which include SGS 4ED1, 4ED3 (Kamburu dam site),4F13 (Grand Falls dam site) and 4G1 (Garissa) located on the mainstream of the Tana river and 4DD1 on the Thiba river, a tributary flowing down from the left bank side to join to the mainstream upstream of Kamburu. As a result of the runoff analysis, a long-term mean runoff at the Masinga dam site was estimated to be 82.5 m3/sec or 2,602 million m^3/year for the period from 1947/1948 to 1971/1972.

ii) Kiambere Hydroelectric Development, Feasibility Study, Volume 2 of 2 - Appendices, April 1980, by Engineering & Power Developments Consultants (EPDC) Limited : The long-term natural streamflow at the Kiambere dam site was estimated by adding that at the Kamburu dam site to that in the incremental cremental catchment of some 2,400 km^2 to the Kiambere dam site. The streamflow in the incremental catchment was derived from the streamflow at SGS 4F13 before 1968 and those after 1968 which were extended using the streamflow records at 4G1 (Garissa). Consequently, the long-term mean natural flow at the Kiambere dam site was estimated to be about 113 m3/sec for 31 years from 1947 to 1977.

iii) Kenya National Power Development Plan 1986-2006, by Acres International Limited, June 1987 : The hydrological study for the upper Tana basin was carried out at a level of master planning for each of the subbasins which were covered by the key stream gauging station. The study adopted substantially the monthly runoff data estimated through the previous simulation by DELFT for the period from 1947 to 1977 and generated new monthly runoff data between 1978 and 1990 through the regression analysis using the monthly data observed and simulated by DELFT.

The aforesaid runoff analyses are mostly carried out on a monthly data basis. The results of the present runoff analysis were broadly compared with those derived through the analysis by Acores, the latest analysis, as follows:

Comparison of Results of Previous and present Runoff Analyses

(Unit :m3/sec)

Name of SGS or Subbasin	Mean Runoff Estimated by Acores (1947 to 1990)	Mean runoff estimated in the present analysis (1957 to 1990)
1a) 4BE2		64.37
1b) 4BC2+4BC4+4BE1	62.5	
2) 4CA2	10.5	8.79
3) 4CB4	7.9	7.11
4) Ungauged subbasins		11.01
(Masinga dam site)		(91.28)
5a) 4DD1		26.60
5b) 4DD2	26.2	
6) Ungauged subbasins		3.79
(Kiambere dam site)		(121.67)
7) 4EA7	30.4	28.85
8) 4F19	14.9	15.67
9) Ungauged subbasins		7.05
Grand Falls dam site		(173.24)

As seen in the table above, there is no large difference between the mean discharges at each stream gauging station, which were estimated by Acores and in the present runoff analysis, although the previous analysis generated the runoff data for the period from 1947 to 1990. Concerning some of those stream gauging stations, the mean discharge estimated in the present runoff analysis became smaller than that by Acores.

Table B3.1 (1) Results of Regression Analysis for Rainfall Records

No.	Combination of Rainfall Stations Station No. (a)	(b)	Estimated Correlation Coefficient for Rainfall Records Daily	Monthly	Yearly	Regression Formula R(a) = A·R(b) Coefficient A
(For Rainfall Stations Located in and around Thika River Basins)						
1	S9037124	S8937002	0.48	0.87	0.81	0.54
2	S9037124	S9037074	0.58	0.91	0.97	0.95
3	S8937038	S9037124	0.66	0.96	0.97	1.24
4	S8937065	S9037124	0.65	0.95	0.96	1.34
5	S8937038	S9037124	0.66	0.96	0.97	1.12
6	S8937072	S9037124	0.62	0.94	0.94	1.24
7	S8937072	S9037124	0.62	0.94	0.94	1.12
8	S8937014	S8937072	0.55	0.92	0.90	0.73
9	S8937014	S8937019	0.56	0.94	0.96	0.83
10	S8937053	S8937014	0.55	0.84	0.93	1.00
11	S8937014	S8937066	0.41	0.84	0.84	0.72
12	S8937014	S8937099	0.50	0.89	0.91	0.78
13	S8937060	S8937014	0.55	0.93	0.94	0.91
14	S8937060	S8937091	0.56	0.88	0.92	0.98
15	S8937060	S8937059	0.52	0.91	0.85	1.11
16	S8937099	S9037221	0.38	0.85	0.83	0.73
17	S9037221	S8937062	0.43	0.84	0.91	1.13
18	S9037221	S9038010	0.34	0.88	0.84	0.74
19	S9038010	S9037187	0.42	0.89	0.95	1.19
20	S8937099	S8937021	0.36	0.84	0.91	0.88
21	S8937019	S8937021	0.48	0.79	0.74	0.84
22	S9038010	S9037160	0.56	0.88	0.78	1.09
(For Rainfall Stations Located in and around Upper Tana River Basins)						
29	S9037064	S8937002	0.26	0.71	0.66	1.05
30	S8937064	S9037120	0.26	0.72	0.83	1.13
31	S9036025	S9036164	0.33	0.72	0.74	1.32
32	S9036217	S9036025	0.23	0.59	0.78	0.79
33	S9036157	S9036217	0.44	0.77	0.79	0.85
34	S9036271	S9036157	0.54	0.85	0.92	0.82
35	S9037131	S9037157	0.36	0.88	0.94	1.03
36	S9037100	S9037002	0.70	0.95	0.98	0.88
37	S9037100	S9037131	0.52	0.89	0.94	1.06
38	S9037075	S9037131	0.39	0.86	0.85	0.80
39	S9036017	S9036043	0.52	0.85	0.80	1.04
40	S9036017	S9036288	0.60	0.93	0.90	1.03
41	S9036288	S9037203	0.44	0.91	0.91	0.88
42	S9036282	S9036017	0.50	0.81	0.86	0.88
43	S9036251	S9036017	0.52	0.93	0.85	1.15
44	S9037203	S9037100	0.33	0.88	0.94	1.51
45	S9036247	S9036282	0.39	0.81	0.87	0.77
46	S9036247	S9036246	0.56	0.91	0.82	1.03
47	S9036273	S9036247	0.61	0.90	0.86	1.09
48	S9036275	S9036273	0.51	0.85	0.92	1.48
49	S9036275	S9036144	0.59	0.92	0.95	0.94
50	S9036274	S9036275	0.79	0.94	0.99	0.91
51	S9036297	S9036274	0.53	0.85	0.94	0.95
52	S9036072	S9036275	0.62	0.91	0.87	0.98
53	S9036268	S9036297	0.58	0.94	0.97	1.14

Table B3.1 (2) Results of Regression Analysis for Rainfall Records

No.	Combination of Rainfall Stations Station No. (a)	(b)	Estimated Correlation Coefficient for Rainfall Records Daily	Monthly	Yearly	Regression Formula R(a) = A·R(b) Coefficient A
54	S9037099	S9037075	0.60	0.89	0.81	1.41
55	S9037157	S9036291	0.50	0.86	0.93	1.25
56	S9036127	S9036291	0.77	0.90	1.00	1.24
57	S9036128	S9036127	0.42	0.86	0.88	0.99
58	S9036291	S9036293	0.40	0.88	0.90	1.25
59	S9036293	S9036315	0.49	0.92	0.97	1.18
60	S9036315	S9036106	0.48	0.88	0.95	0.80
61	S9036106	S9036302	0.51	0.90	0.93	0.86
62	S9036302	S9037042	0.56	0.92	0.90	0.90
63	S9037181	S9037042	0.58	0.93	0.95	1.10
64	S9037109	S9037042	0.54	0.89	0.75	1.26
65	S9037096	S9037109	0.60	0.94	0.93	1.09
66	S9037109	S9037063	0.52	0.89	0.88	1.24
67	S9036212	S9036259	0.57	0.91	0.96	1.10
68	S9036292	S9036212	0.49	0.87	0.94	1.06
69	S9036314	S9036106	0.40	0.73	0.84	0.82
70	S9037037	S9037050	0.42	0.85	0.87	1.28
71	S9037137	S9037037	0.53	0.85	0.89	1.13
72	S9037137	S9037112	0.51	0.84	0.88	1.08
(For Rainfall Stations Located in and around Masinga River Basins)						
29	S9037207	S9037109	0.52	0.82	0.83	1.18
30	S9037207	S9037001	0.39	0.93	0.92	0.96
31	S9037061	S9037001	0.36	0.91	0.94	0.86
32	S9037028	S9137053	0.55	0.89	0.86	0.83
33	S9037028	S9037223	0.67	0.95	0.98	1.00
34	S9037223	S9037192	0.44	0.83	0.97	0.94
35	S9037192	S9137053	0.44	0.87	0.78	0.88
36	S9037061	S9037001	0.36	0.91	0.94	0.86
37	S9037061	S9037018	0.40	0.87	0.98	1.12
38	S9037183	S9037050	0.37	0.84	0.98	1.75
39	S9037183	S9037222	0.39	0.92	0.92	0.96
(For Rainfall Stations Located in and around Thiba River Basins)						
1	S9037110	S9037181	0.56	0.87	0.80	1.51
2	S9037110	S9037169	0.73	0.94	0.89	0.88
3	S9037110	S9037147	0.55	0.94	0.94	0.96
4	S9037110	S9037112	0.52	0.88	0.93	0.98
5	S9037169	S9037039	0.60	0.91	0.91	1.04
6	S9037169	S9037165	0.60	0.94	0.90	0.95
7	S9037103	S9037110	0.62	0.91	0.90	0.97
8	S9037103	S9037179	0.67	0.93	0.92	0.94
9	S9037112	S9037137	0.46	0.89	0.95	0.93
10	S9037112	S9037050	0.77	0.96	0.93	1.34
11	S9037039	S9037104	0.41	0.94	0.94	0.92
12	S9037008	S9037103	0.46	0.97	1.00	0.89
13	S9037008	S9037171	0.41	0.82	0.81	0.87
14	S9037031	S9037008	0.48	0.87	0.91	0.75
15	S9037134	S9037053	0.48	0.86	0.87	0.86
16	S9037134	S9037077	0.45	0.85	0.86	1.10

Table B3.1 (3) Results of Regression Analysis for Rainfall Records

No.	Combination of Rainfall Stations Station No. (a)	(b)	Estimated Correlation Coefficient for Rainfall Records Daily	Monthly	Yearly	Regression Formula R(a) = A•R(b) Coefficient A
17	S9037129	S9037134	0.38	0.83	0.82	0.93
18	S9037127	S9037129	0.50	0.86	0.64	0.78
(For Rainfall Stations Located in and around Kazita River Basins)						
1	S9037124	S8937002	0.48	0.87	0.81	0.54
2	S8937124	S9037074	0.58	0.91	0.97	0.95
3	S8937038	S9037124	0.66	0.96	0.97	1.24
4	S8937065	S9037124	0.65	0.95	0.96	1.34
5	S8937038	S8937000	0.56	0.94	0.95	1.03
6	S8937072	S9037124	0.62	0.94	0.94	1.12
7	S8937014	S8937072	0.55	0.92	0.90	0.73
8	S8937014	S8937019	0.56	0.94	0.96	0.83
9	S8937053	S8937014	0.55	0.84	0.93	1.00
10	S8937060	S8937014	0.55	0.93	0.94	0.91
11	S8937060	S8937091	0.56	0.88	0.92	0.98
12	S8937060	S8937059	0.52	0.85	0.94	1.11
13	S8937019	S8937021	0.48	0.79	0.74	0.84
14	S8937014	S8937099	0.50	0.89	0.91	0.78
15	S9037221	S8937062	0.43	0.84	0.91	1.13
16	S9037221	S9038010	0.43	0.84	0.91	0.74
17	S9038010	S9037160	0.56	0.88	0.78	1.09
18	S9038010	S9037187	0.42	0.89	0.92	1.19
19	S8937099	S8937021	0.36	0.84	0.91	0.88
(For Rainfall Stations Located in and around Thika River Basins)						
1	S9036152	S9036164	0.52	0.86	0.56	1.19
2	S9036164	S8936259	0.47	0.87	0.80	1.71
3	S9036259	S9036233	0.66	0.96	0.97	0.84
4	S9036259	S9036286	0.63	0.90	0.90	0.75
5	S9036286	S9036283	0.89	0.99	0.99	0.97
6	S9036286	S9036052	0.50	0.80	0.86	1.04
7	S9036286	S9036308	0.54	0.89	0.97	0.76
8	S9036308	S9136029	0.53	0.86	0.85	0.67
9	S9136029	S9037047	0.66	0.94	0.93	1.00
10	S9037010	S9037047	0.67	0.96	0.97	0.96
11	S9036308	S9136063	0.51	0.91	0.89	0.80
12	S9036188	S9036303	0.58	0.88	0.80	0.95
13	S9036283	S9036248	0.44	0.84	0.85	1.14
14	S9037047	S9137048	0.43	0.81	0.75	1.49
15	S9036191	S9036286	0.46	0.86	0.92	1.49
16	S9136029	S9137002	0.51	0.87	0.81	0.83
17	S9137002	S9137053	0.60	0.93	0.92	1.10
18	S9037047	S9137072	0.53	0.92	0.98	0.88
19	S9137072	S9137048	0.65	0.95	0.95	1.06
20	S9137002	S9137053	0.60	0.93	0.92	1.10
21	S9137006	S9137053	0.52	0.95	0.95	0.99
22	S9137053	S9137074	0.38	0.82	0.76	0.89
23	S9137054	S9137090	0.47	0.85	0.89	0.96
24	S9137074	S9137058	0.45	0.91	0.81	0.95

Table B3.1 (4) Results of Regression Analysis for Rainfall Records

No.	Combination of Rainfall Stations Station No. (a)	(b)	Estimated Correlation Coefficient for Rainfall Records Daily	Monthly	Yearly	Regression Formula R(a) = A•R(b) Coefficient A
(For Rainfall Stations Located in and around Mutonga River Basins)						
1	S9037085	S9037124				1.23
2	S9037085	S8937185	0.56	0.92	0.90	1.22
3	S9037185	S9037086	0.54	0.94	0.92	1.20
4	S9037185	S9037150	0.60	0.86	0.86	0.90
5	S9037150	S9037186	0.53	0.87	0.97	0.94
6	S9037074	S9037185	0.66	0.95	1.00	1.05
7	S9037011	S9037185	0.56	0.93	0.97	1.16
8	S9037186	S9037195	0.66	0.92	0.90	1.22
9	S9037195	S9037123	0.65	0.93	0.94	1.15
10	S9037195	S9037153	0.65	0.93	0.91	0.87
11	S9037195	S9037034	0.68	0.93	0.93	0.93
12	S9037034	S9037199	0.70	0.94	0.95	0.97
13	S9037102	S9037086	0.58	0.93	0.91	0.98
14	S9037027	S9037195	0.55	0.82	0.95	1.16
15	S9037065	S9037186	0.43	0.86	0.89	1.06
16	S9037193	S9037034	0.49	0.87	0.91	1.13
17	S9037199	S9037133	0.46	0.88	0.90	0.72
18	S9037161	S9037133	0.58	0.92	0.95	1.31
(For Rainfall Stations Located in and around Ena River Basins)						
1	S9037077	S9037134	0.48	0.86	0.87	0.91
2	S9037053	S9037199	0.47	0.87	0.95	1.09
3	S9037172	S9037199	0.45	0.78	0.80	1.48
4	S9037164	S9037072	0.48	0.87	0.95	0.99
5	S9037142	S9037166	0.44	0.88	0.92	0.92
6	S9037163	S9037135	0.24	0.71	0.49	1.37
7	S9037170	S9038023	0.33	0.69	0.72	1.12
8	S9038023	S9038002	0.41	0.82	0.81	0.58
9	S9037146	S9037226	0.40	0.92	0.95	1.25
10	S9037226	S9037227	0.28	0.92	0.91	0.99
11	S9037224	S9138005	0.25	0.85	0.85	1.08
12	S9038008	S9038001	0.46	0.94	0.94	0.98
13	S9038008	S9138008	0.43	0.85	0.83	1.20

Table B3.2 (1) Weightness of Thiessen's Polygon for Each Subbasin

(i) Subbasin 4BE2

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9036273	1,319.2	2.643
2	S9036247	1,443.4	0.620
3	S9036246	1,489.7	1.004
4	S9036157	1,731.4	1.459
5	S9036271	2,119.8	8.621
6	S9036025	1,168.1	1.369
7	S9036164	1,544.3	0.103
8	S9036259	2,644.1	1.479
9	S9036315	2,646.7	2.173
10	S9036292	2,274.3	0.902
11	S9036212	2,407.4	0.920
12	S9036052	2,065.6	0.132
13	S9036104	1,787.6	1.450
14	S9036302	1,825.0	1.616
15	S9036106	2,118.2	0.808
16	S9036293	2,247.5	0.965
17	S9036314	2,575.8	2.855
18	S9036291	1,798.9	1.859
19	S9036128	1,459.9	1.961
20	S9036217	1,478.1	2.063
21	S9036282	1,110.1	1.122
22	S9036297	1,029.9	1.106
23	S9036268	904.5	0.659
24	S9036274	981.4	0.533
25	S9036275	891.2	0.925
26	S9036072	910.6	0.314
27	S9036251	845.7	0.596
28	S9036017	973.1	0.706
29	S9036288	1,002.3	1.231
30	S9036144	835.6	4.227
31	S9037064	897.6	4.023
32	S9037120	1,015.2	5.325
33	S9037015	1,642.5	1.765
34	S9037099	1,249.1	0.847
35	S9037069	1,042.4	2.792
36	S9037203	877.7	2.369
37	S9036043	1,008.9	1.843
38	S9036127	1,445.0	1.420
39	S9037157	1,443.6	2.439
40	S9037002	1,163.8	1.396
41	S9037100	1,323.8	0.957
42	S9037131	1,398.2	3.004
43	S9037181	1,497.1	3.569
44	S9037042	1,645.8	2.298
45	S9037109	1,309.6	2.933
46	S9037063	1,629.8	2.340
47	S9037207	1,108.9	1.427
48	S9037001	1,061.0	0.213
49	S9037044	1,137.1	0.066
50	S9037037	1,022.4	1.192
51	S9037096	1,202.0	4.878
52	S9037137	902.9	1.310
53	S9037112	974.6	0.184
54	S9037179	955.0	0.500
55	S9037031	1,526.2	0.758
56	S9037075	1,757.6	2.448
57	S9037115	2,205.1	0.316
58	S9037127	2,389.4	0.949
Basin Average Rainfall (mm)		1,477.3	

(ii) Subbasin 4CB4

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9036164	1,544.3	1.830
2	S9036286	1,993.8	2.592
3	S9036233	2,219.2	5.947
4	S9036259	2,644.1	9.034
5	S9036212	2,407.4	11.664
6	S9036283	1,926.7	6.404
7	S9036220	1,531.4	16.543
8	S9037010	1,053.7	10.063
9	S9037047	1,015.0	10.490
10	S9036052	2,065.6	24.442
11	S9137048	942.4	0.534
12	S9037072	1,120.9	0.457
Basin Average Rainfall (mm)		1,835.8	

(iii) Subbasin 4CA2

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9036025	1,168.1	0.228
2	S9036164	1,544.3	10.482
3	S9036152	1,296.6	10.728
4	S9036188	1,671.4	5.453
5	S9036303	1,591.4	20.507
6	S9036191	1,337.4	1.719
7	S9036286	1,993.8	9.570
8	S9036233	2,219.2	6.038
9	S9036259	2,644.1	0.598
10	S9036283	1,926.7	11.963
11	S9036220	1,531.4	13.672
12	S9136063	1,209.0	0.297
13	S9136029	1,013.5	2.252
14	S9037010	1,053.7	5.924
15	S9037047	1,015.0	0.114
16	S9037072	1,120.9	0.456
Basin Average Rainfall (mm)		1,619.8	

(iv) Subbasin MASI-RL

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9036220	1,531.4	0.030
2	S9037047	1,015.0	3.836
3	S9036052	2,065.6	1.538
4	S9037044	1,137.1	1.953
5	S9137048	942.4	2.388
6	S9037072	1,120.9	1.036
7	S9137002	843.8	2.028
8	S9137006	934.9	2.749
9	S9137053	926.9	5.408
10	S9137054	1,019.6	0.601
11	S9137074	824.8	7.616
12	S9137090	981.0	17.920
13	S9037192	1,053.5	7.255
14	S9037223	1,120.9	6.534
15	S9037028	1,122.8	3.440
16	S9037061	1,240.5	6.264
17	S9037037	1,022.4	1.660
18	S9037137	902.9	2.734
19	S9037050	1,304.1	2.554
20	S9037183	745.1	10.890
21	S9037222	716.2	9.358
22	S9137076	613.9	2.208
Basin Average Rainfall (mm)		967.9	

Table B3.2 (2) Weightness of Thiessen's Polygon for Each Subbasin

(v) Subbasin KAM-RL

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037183	745.1	4.606
2	S9037222	716.2	55.876
3	S9137076	613.9	27.292
4	S9037104	832.4	12.225
Basin Average Rainfall (mm)		704.0	

(vi) Subbasin 4DD1

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037137	902.9	0.223
2	S9037112	974.5	3.208
3	S9037147	951.2	2.659
4	S9037110	989.5	2.978
5	S9037179	955.0	5.378
6	S9037031	1,526.2	9.977
7	S9037075	1,757.6	0.890
8	S9037115	2,205.1	5.953
9	S9037127	2,389.4	19.399
10	S9037077	1,913.0	2.800
11	S9037134	1,742.2	3.557
12	S9037129	1,869.9	5.601
13	S9037008	1,137.3	4.006
14	S9037053	1,499.3	0.142
15	S9037171	991.8	3.037
16	S9037103	1,016.4	2.990
17	S9037169	874.7	4.136
18	S9037165	832.4	5.341
19	S9037050	1,304.1	7.097
20	S9037183	745.1	2.698
21	S9037104	832.4	4.599
22	S9037039	906.2	2.422
23	S9037072	1,120.9	0.697
24	S9037164	1,134.7	0.213
Basin Average Rainfall (mm)		1,494.4	

(vii) Subbasin GITA-RL

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037222	716.2	30.172
2	S9137076	613.9	0.690
3	S9037146	683.3	20.862
4	S9037104	832.4	43.621
5	S9037135	1,016.0	4.655
Basin Average Rainfall (mm)		773.4	

(viii) Subbasin KIND-RL

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037222	716.2	5.348
2	S9137076	613.9	1.248
3	S9037224	734.9	20.321
4	S9037146	683.3	69.340
5	S9037135	1,016.0	3.744
Basin Average Rainfall (mm)		707.2	

(ix) Subbasin KIA-RL

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9137076	613.9	17.271
2	S9037224	734.9	15.883
3	S9138005	791.9	18.766
4	S9037227	840.9	13.015
5	S9038008	693.7	5.104
6	S9038009	781.0	5.012
7	S9037167	791.1	11.935
8	S9037226	852.8	5.582
9	S9037146	683.3	1.742
10	S9037135	1,016.0	5.690
Basin Average Rainfall (mm)		767.1	

(x) Subbasin 4EA7

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037127	2,389.4	3.609
2	S9037077	1,913.0	8.537
3	S9037172	1,103.0	1.994
4	S9037133	1,179.0	3.247
5	S9037161	897.2	4.458
6	S9037170	832.1	3.648
7	S9037187	1,071.8	4.021
8	S9037065	1,393.7	8.636
9	S9037193	1,489.8	7.252
10	S9037153	1,614.2	1.582
11	S9037034	1,682.8	1.055
12	S9037199	1,636.0	4.862
13	S9037123	2,081.3	3.626
14	S9037195	1,807.7	2.208
15	S9037186	1,478.5	3.032
16	S9037027	1,559.0	7.861
17	S9037086	2,081.1	7.103
18	S9037102	2,113.4	7.760
19	S8937002	939.0	0.412
20	S9037074	1,661.3	0.791
21	S9037011	1,501.5	0.560
22	S9037185	1,736.2	2.670
23	S9037150	1,564.9	4.532
24	S9037085	1,428.8	6.543
Basin Average Rainfall (mm)		1,605.3	

Table B3.2 (3) Weightness of Thiessen's Polygon for Each Subbasin

(xi) Subbasin MUTO-L

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037077	1,913.0	4.218
2	S9037134	1,742.2	0.805
3	S9037053	1,499.3	9.822
4	S9037171	991.8	1.221
5	S9037167	791.1	0.666
6	S9037039	906.2	7.325
7	S9037135	1,016.0	4.911
8	S9037163	742.6	16.149
9	S9037166	1,065.7	7.686
10	S9037072	1,120.9	6.188
11	S9037142	1,163.3	5.633
12	S9037164	1,134.7	6.854
13	S9037172	1,103.0	5.466
14	S9037133	1,179.0	3.663
15	S9037161	897.2	5.910
16	S9037170	832.1	12.791
17	S9037187	1,071.8	0.222
18	S9037199	1,636.0	0.472
Basin Average Rainfall (mm)		1,063.2	

(xii) Subbasin MUTO-R

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9038009	781.0	6.048
2	S9038013	652.0	33.479
3	S9037167	791.1	9.102
4	S9037163	742.6	2.743
5	S9037170	832.1	9.102
6	S9038023	933.0	39.526
Basin Average Rainfall (mm)		802.5	

(xiii) Subbasin 4F19

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037127	2,389.4	0.247
2	S9038006	756.9	0.654
3	S9037187	1,071.8	8.889
4	S9037086	2,081.0	0.318
5	S9037102	2,113.4	9.062
6	S8937002	939.0	5.920
7	S8937000	1,454.2	6.904
8	S8937065	1,304.6	4.344
9	S8937038	1,412.1	1.431
10	S8937062	1,371.6	3.985
11	S9037124	1,751.7	3.123
12	S9037074	1,661.3	1.838
13	S9037011	1,501.5	3.146
14	S9037085	1,428.8	5.425
15	S9037160	980.4	10.762
16	S9038010	899.4	7.722
17	S9037221	1,209.6	8.995
18	S8937072	1,560.3	6.097
19	S8937099	1,663.0	4.524
20	S8937021	1,467.5	1.643
21	S8937066	1,527.1	1.414
22	S8937019	1,756.3	1.467
23	S8937014	2,127.7	1.343
24	S8937053	2,135.4	0.512
25	S8937060	2,347.9	0.565
Basin Average Rainfall (mm)		1,380.2	

(xiv) Subbasin GRAF RL

No.	Station No.	Mean Annual Rainfall between 1957 and 1990 (mm)	Weightness of Thiessen's Polygon (%)
1	S9037170	832.1	17.024
2	S9038023	933.0	25.704
3	S9038006	756.9	44.307
4	S9037187	1,071.8	12.965
Basin Average Rainfall (mm)		855.8	

Table B3.3 Annual Monthly Rainfall for Subbasin 4BE2

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	98.5	33.0	118.4	308.7	390.2	43.9	29.8	33.2	53.9	179.4	193.0	117.0	1,598.9
1958	85.3	114.7	84.3	190.9	399.4	100.8	121.2	23.8	18.1	52.3	175.8	180.1	1,546.5
1959	83.1	42.2	60.7	300.0	234.6	20.0	75.1	63.9	44.6	65.4	209.9	83.4	1,282.9
1960	65.0	49.8	140.0	259.3	94.2	59.4	18.5	21.8	37.2	161.8	126.4	74.7	1,107.9
1961	17.2	60.2	89.4	255.0	210.2	59.9	88.4	102.9	137.4	641.9	634.1	157.0	2,453.6
1962	115.6	11.6	88.4	205.2	306.0	45.1	45.2	83.9	36.2	136.3	113.9	122.2	1,309.5
1963	104.2	67.7	121.6	563.5	339.3	55.4	13.2	57.9	23.8	68.7	208.3	272.6	1,896.1
1964	42.1	73.1	130.3	576.0	176.5	46.7	60.5	99.5	27.5	169.8	177.4	141.3	1,720.7
1965	69.3	22.0	62.1	218.8	166.8	36.5	47.2	45.6	39.4	166.9	321.4	63.2	1,259.3
1966	60.7	54.6	168.4	438.0	149.4	65.8	24.7	42.6	28.8	177.9	210.1	29.0	1,449.9
1967	16.6	24.2	60.2	327.7	509.8	55.6	63.6	78.0	101.3	343.9	252.7	51.6	1,885.4
1968	19.9	199.3	203.5	406.3	278.9	84.6	62.6	49.6	29.1	182.8	331.4	136.6	1,984.5
1969	80.6	103.9	151.2	112.4	264.5	33.3	56.7	53.8	53.6	88.7	141.4	49.2	1,189.3
1970	180.1	36.4	181.3	339.9	195.7	60.0	45.6	58.9	30.1	98.0	107.1	59.9	1,393.0
1971	42.0	14.8	76.0	248.2	251.5	73.8	61.2	64.1	40.4	89.8	93.3	109.3	1,164.4
1972	63.5	131.3	49.1	131.9	337.5	72.8	35.7	34.8	82.0	302.8	295.8	58.3	1,595.5
1973	81.1	95.6	24.6	276.1	175.0	41.5	44.8	55.2	64.6	130.4	173.2	31.5	1,193.7
1974	27.3	38.1	119.3	297.4	128.2	123.9	155.5	76.9	38.0	73.4	172.3	60.6	1,311.0
1975	16.6	24.0	55.5	226.0	219.0	52.8	89.7	55.3	79.3	154.2	93.1	78.0	1,143.5
1976	26.5	60.8	42.5	188.4	170.0	66.9	64.9	43.4	68.4	82.7	129.2	128.1	1,071.9
1977	80.0	52.9	114.2	462.3	279.3	43.1	50.5	51.9	38.5	185.6	333.5	130.3	1,822.2
1978	84.8	110.2	268.3	420.9	142.1	56.7	57.9	60.4	70.0	181.2	151.2	115.9	1,719.5
1979	145.1	121.5	149.3	263.1	363.7	107.2	42.8	37.9	30.0	129.6	170.8	77.7	1,638.7
1980	49.3	23.9	67.0	167.2	284.1	40.5	15.5	63.8	21.3	106.8	281.6	58.7	1,179.7
1981	28.7	40.8	247.5	301.0	304.9	41.5	49.2	55.0	50.9	176.0	117.2	119.6	1,532.2
1982	39.5	20.7	75.7	327.5	420.3	54.3	47.4	46.0	70.3	314.3	188.9	93.4	1,698.4
1983	21.1	85.5	48.4	293.0	263.0	75.9	39.8	52.9	34.6	131.0	117.5	139.5	1,302.1
1984	26.4	14.0	32.8	151.2	63.6	28.7	45.5	18.2	42.5	277.7	216.4	67.5	984.5
1985	28.0	79.5	174.7	343.2	257.0	56.7	58.9	34.2	42.0	113.5	155.9	59.7	1,403.2
1986	19.3	19.1	85.4	402.5	314.2	84.2	21.3	20.3	31.6	125.8	177.5	129.1	1,430.4
1987	41.9	23.9	54.6	247.2	207.7	108.1	17.6	90.3	19.9	41.5	231.8	26.3	1,110.9
1988	53.0	28.5	105.4	557.8	188.4	76.5	67.1	91.9	98.6	119.1	233.5	135.6	1,755.3
1989	82.9	61.4	92.2	273.7	181.4	41.9	19.1	72.5	84.2	227.6	256.4	208.6	1,601.8
1990	66.8	67.0	282.2	310.8	195.3	30.9	34.0	38.6	31.0	159.2	169.0	108.3	1,493.2
MEAN	60.6	59.0	112.5	305.6	248.9	60.2	52.1	55.3	50.0	166.4	204.7	102.2	1,477.3

Table B3.4 Annual Monthly Rainfall for Subbasin 4CB4

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	117.6	36.9	95.3	448.8	540.9	134.7	32.2	41	46.7	180.4	233.3	64	1971.8
1958	65.8	198.6	283.8	238.5	597.6	179.9	167.1	23.9	16.2	114.8	187.2	130.5	2203.9
1959	47.5	30	101.7	217.3	325.1	20.2	62.4	97.2	54	49.8	255.9	164.9	1426
1960	54.4	83.9	247.7	307.3	138.3	45	28.7	24.5	73.2	120.1	256.5	60	1439.6
1961	26.9	71.4	129.5	267.5	201.2	70.7	73.5	79.7	110.7	479.8	680	269	2460
1962	129.5	3	74.6	433.4	380.6	62.5	48.7	138.7	71.3	160.1	183.6	122.5	1808.6
1963	129	84.4	166.4	616.9	363.7	83.1	9.2	54.5	30.6	117.9	334.2	296.6	2286.5
1964	61.8	147	221.9	539.6	323.5	62.5	119.9	82.1	56.2	153	236.9	164.6	2169
1965	87.4	43.7	88.4	330.2	259.8	52.2	52.1	49.7	59.8	191.4	310.8	140.8	1666.4
1966	104.3	88.2	293.4	553.4	212.5	85.4	27.4	47.8	63.5	169	214.6	20	1879.4
1967	1.6	35.8	58.1	355.1	541.2	91.5	95	77.1	84.1	297	264	52.4	1952.8
1968	3.1	173	312.4	424.7	274.6	117	59.6	45.3	11.8	169.6	471.1	200	2262.1
1969	101.9	141.9	174.7	72.9	359.2	45.3	59.6	60.5	42.3	88.7	164.6	28.9	1340.5
1970	193.6	32.2	231.4	548.2	288.8	96.3	45.5	49.6	21.7	103.3	167.3	49.2	1827
1971	31.4	5.5	99.3	415.1	382.1	64.3	61.6	35.3	31.1	76.9	123.2	131.6	1457.4
1972	85.4	133.9	61.3	139.5	267.6	93.7	30.7	22.5	72.4	379	333.2	95.4	1714.6
1973	139.3	92	13.1	331.7	170.5	53.4	24.7	31	99.7	115.1	187.2	24.7	1282.4
1974	12.3	23.9	177.7	550.9	137.5	179.6	207.5	63.5	34.4	88	137.2	41.8	1654.2
1975	12.9	8.9	82.4	244.7	277.8	59.2	70.2	39.2	140.4	223.6	111.2	71.2	1341.8
1976	36.1	71.1	80.4	207.9	157.1	79	65.5	32	78.8	110.9	348.1	117.9	1384.6
1977	112.2	150.9	170.9	635.9	422	83.1	63	69.7	31.8	168	545.4	180.7	2633.5
1978	113.8	106.6	458.6	737.4	237	108.1	99.5	64	137	396.8	244.8	219.6	2923.4
1979	188.6	162.4	281.3	637.4	434.8	106.3	45.4	55.5	41.5	148.5	197.5	85	2384.1
1980	119.6	27.1	99.4	198.6	423.3	96	21.7	73.2	60.5	116.5	666.8	93	1995.7
1981	34	23.9	285.9	404.1	406.2	42.5	56.8	39.9	39.3	160.6	153.3	195.6	1842.2
1982	40.3	14.1	108.8	338.8	372.8	64.1	54.3	69	81.5	387.9	287	117.5	1936
1983	9.6	85.2	61.2	372.6	246.1	102.6	48.9	57.1	25.6	181.1	117.4	212.2	1519.5
1984	12.1	5.6	38.8	170.5	43.9	22.1	66.4	31.1	47.4	299.7	283.5	82.8	1104
1985	7.2	157	211.7	530.2	226.9	68	50.8	27.9	28.2	169	162.8	53.5	1693.4
1986	36.1	18	120.7	407.8	397.8	71	22.1	12.7	23.6	137.3	269.3	140.4	1656.8
1987	29	32.6	28.9	334.5	233.3	111.4	24.2	50.8	15.8	24.1	252.5	45.9	1183
1988	122.6	56.2	215.5	705.4	261.5	132.4	78	95.3	94.1	85.2	284.6	181.6	2312.3
1989	166.5	85.2	145.6	378.4	231.6	52.9	49.7	49.7	100	168.1	262.4	223.1	1913.2
1990	68	67	414.7	334.9	265.1	46.8	40.5	48.7	21.5	195.9	145.3	143.8	1792.3
MEAN	73.6	73.4	165.7	395	305.9	81.8	60.7	54.1	57.3	177.3	266.8	124.1	1835.8

Table B3.5 Annual Monthly Rainfall for Subbasin 4CA2

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	104.8	42.0	89.1	391.0	399.9	129.9	42.3	33.3	41.3	147.3	176.6	64.3	1,661.9
1958	41.1	203.6	332.0	135.5	348.8	123.4	117.7	26.8	8.3	110.6	145.7	121.5	1,715.0
1959	68.2	47.0	138.6	222.5	266.9	20.9	45.3	69.7	57.3	55.1	196.7	68.0	1,256.4
1960	89.5	112.2	243.5	319.7	121.4	46.8	24.7	28.5	87.3	144.4	169.6	42.6	1,430.3
1961	23.3	66.8	94.9	240.0	219.8	90.6	89.4	113.0	126.7	406.3	533.0	242.9	2,246.8
1962	179.5	6.1	101.5	377.2	349.1	77.4	32.9	74.5	73.1	150.0	123.2	94.6	1,639.1
1963	111.8	82.5	177.7	521.6	303.2	66.2	7.3	65.4	24.9	103.8	239.4	245.2	1,949.1
1964	42.5	142.7	198.8	465.4	234.9	51.3	73.3	67.8	52.7	115.3	181.1	92.1	1,717.8
1965	90.0	51.9	81.3	295.8	269.4	71.2	59.5	53.5	58.7	164.9	247.4	98.9	1,542.7
1966	76.0	96.4	245.7	429.6	172.5	70.2	25.8	84.1	54.4	144.4	169.9	21.9	1,590.9
1967	2.5	49.4	71.0	313.4	383.9	76.4	93.3	69.2	73.4	220.1	199.0	58.6	1,610.3
1968	6.0	152.7	297.5	372.2	196.4	96.8	43.8	29.1	16.4	152.2	351.0	149.6	1,863.6
1969	82.4	114.3	132.5	65.8	339.4	36.5	47.5	37.4	41.9	98.7	139.5	20.8	1,156.7
1970	207.2	35.2	207.4	381.9	286.5	91.3	36.3	53.5	36.3	96.3	134.7	39.0	1,605.6
1971	69.9	13.3	73.7	367.6	319.7	80.5	88.1	53.6	38.8	87.4	106.1	131.7	1,430.4
1972	72.8	174.4	60.7	137.8	234.9	123.3	33.0	33.6	86.9	358.9	271.7	78.6	1,666.7
1973	122.8	125.9	10.9	272.8	149.5	92.9	28.1	43.0	98.2	89.4	175.8	23.3	1,232.5
1974	12.8	22.7	163.3	456.6	107.1	140.5	190.0	78.3	41.2	76.2	144.1	45.3	1,478.0
1975	12.8	15.5	104.9	211.5	204.9	47.7	80.9	47.5	78.5	143.3	73.4	63.1	1,084.1
1976	32.4	69.8	86.6	194.0	164.1	113.2	76.8	55.5	94.8	73.1	190.2	79.2	1,229.7
1977	121.9	95.0	148.0	504.0	370.2	82.1	63.2	90.4	28.8	181.5	483.7	112.0	2,280.8
1978	117.2	89.5	348.0	393.7	189.8	70.2	47.3	43.5	82.0	240.3	143.0	179.4	1,943.9
1979	117.0	171.9	180.9	356.7	315.9	146.1	58.4	37.2	41.5	109.4	135.3	69.7	1,740.2
1980	64.8	44.2	143.3	253.1	382.2	99.0	32.2	62.9	33.7	130.3	640.2	99.6	1,985.5
1981	32.5	49.0	240.6	314.7	295.2	55.6	71.6	41.8	71.0	141.4	154.3	146.8	1,614.6
1982	29.9	23.2	53.2	229.8	339.0	66.8	49.1	54.9	82.0	316.7	254.4	118.6	1,617.7
1983	22.7	87.3	57.1	294.8	248.2	105.0	69.0	55.6	33.6	167.5	111.3	157.6	1,409.5
1984	30.8	9.9	27.4	201.3	51.3	19.3	73.8	50.6	69.8	243.5	237.1	74.6	1,089.3
1985	14.0	115.5	201.3	384.4	217.2	75.6	60.6	20.4	28.7	128.2	120.4	38.6	1,405.0
1986	33.7	27.3	131.1	358.5	325.6	75.7	17.9	10.2	22.0	148.1	244.5	143.5	1,538.1
1987	59.7	57.3	58.8	321.0	210.9	138.6	31.7	53.6	40.7	39.3	262.7	37.7	1,311.8
1988	214.4	79.4	320.2	879.0	224.6	73.8	145.3	125.6	87.9	75.2	322.9	137.0	2,685.2
1989	162.5	104.8	151.7	296.6	238.0	55.4	39.8	73.4	100.5	166.8	197.7	210.1	1,797.4
1990	82.0	77.6	310.7	296.5	228.7	55.8	47.7	53.6	39.8	147.5	84.5	121.6	1,546.0
MEAN	75.0	78.1	155.4	331.1	256.2	81.4	60.1	55.6	57.4	152.2	216.5	100.8	1,619.8

Table B3.6 Annual Monthly Rainfall for Subbasin MASI-RL

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	128.0	13.8	69.5	201.1	228.0	16.3	7.4	7.8	18.7	73.4	199.0	65.8	1,028.9
1958	28.5	90.7	99.0	242.5	301.6	37.2	38.5	1.4	4.9	41.1	131.9	84.9	1,102.1
1959	54.4	18.4	73.1	139.6	178.8	2.7	17.0	20.9	5.6	10.7	226.2	62.2	809.5
1960	11.4	11.3	166.6	125.1	36.3	6.6	6.2	4.1	6.6	112.7	86.2	42.4	615.4
1961	8.0	23.8	84.5	199.1	77.6	18.0	9.2	8.8	25.2	346.7	511.5	124.6	1,437.1
1962	65.4	2.6	53.3	238.7	147.3	16.1	11.6	34.3	11.4	121.4	88.8	86.1	877.0
1963	57.9	71.5	113.7	294.9	214.0	21.7	6.3	22.3	15.4	66.4	260.7	283.1	1,428.0
1964	55.0	31.2	158.2	328.2	38.5	15.2	9.7	38.9	7.2	64.1	136.4	121.4	1,004.0
1965	73.3	1.2	46.3	216.5	45.7	5.7	6.1	7.9	3.7	82.0	201.8	39.6	729.8
1966	57.7	18.7	186.8	192.8	41.8	9.5	7.7	7.9	19.1	63.8	186.9	29.2	821.8
1967	3.7	13.4	65.5	186.7	360.1	13.6	16.8	20.9	23.2	163.1	148.8	16.1	1,032.0
1968	0.1	130.6	242.8	283.0	101.7	37.0	13.9	10.9	2.9	70.8	413.5	148.1	1,455.3
1969	37.0	95.7	117.5	44.4	149.4	7.6	38.1	18.9	12.2	51.4	158.0	30.1	760.4
1970	71.5	1.3	187.3	249.8	125.2	9.7	26.6	12.8	39.7	24.4	104.7	40.9	893.8
1971	25.7	2.8	46.7	300.2	179.0	14.3	20.2	5.9	2.3	32.0	107.8	123.0	859.8
1972	39.0	57.2	57.1	47.8	156.0	33.1	6.1	3.3	24.9	229.8	164.0	38.5	856.8
1973	95.4	18.9	14.2	188.2	43.4	3.5	6.9	4.3	47.2	51.7	150.8	19.6	644.0
1974	0.4	16.5	116.3	287.0	44.9	39.7	64.1	20.8	1.8	39.8	153.6	38.2	823.1
1975	12.8	2.8	96.5	230.8	65.1	6.0	30.2	3.3	53.7	80.9	125.7	32.0	739.8
1976	2.3	21.4	18.3	221.9	37.9	65.8	4.9	1.1	17.0	37.0	179.9	83.9	691.3
1977	43.2	38.9	82.9	414.5	127.6	14.9	5.8	11.6	15.3	31.3	342.8	106.9	1,235.5
1978	71.7	102.9	220.5	244.6	30.6	6.1	8.0	3.9	33.8	168.7	174.4	95.7	1,161.0
1979	117.2	73.2	168.3	274.9	128.6	22.8	5.9	5.0	1.2	33.0	226.2	33.2	1,089.4
1980	35.8	5.0	52.4	144.1	210.5	1.7	1.3	10.1	3.2	33.1	312.7	19.2	829.1
1981	10.1	4.0	291.7	232.7	173.6	6.3	2.9	1.6	12.4	74.9	130.7	63.9	1,004.7
1982	10.4	7.1	100.1	240.8	60.2	12.9	6.9	2.9	16.8	265.5	196.8	79.4	1,000.0
1983	3.4	57.5	33.7	260.1	28.8	14.2	3.1	7.7	1.8	72.9	64.7	123.1	671.0
1984	12.7	0.7	41.7	116.1	4.7	1.3	9.6	2.8	25.7	169.8	197.5	91.0	673.5
1985	8.8	94.7	145.3	327.5	56.6	8.0	4.6	1.7	1.1	49.0	156.1	42.6	895.8
1986	20.3	7.4	98.1	266.2	116.2	19.6	5.3	7.0	7.7	117.7	260.5	136.1	1,061.9
1987	53.9	46.8	67.7	243.2	135.2	94.6	26.8	45.2	55.3	31.3	279.8	28.0	1,107.7
1988	45.3	15.6	154.8	413.2	74.5	40.9	4.8	7.4	19.4	36.6	191.3	177.4	1,181.1
1989	98.6	11.4	136.5	298.2	106.1	12.2	10.6	8.3	13.5	117.1	229.1	93.9	1,135.5
1990	47.2	57.0	304.5	339.5	68.3	2.4	6.4	1.8	13.2	102.0	168.4	140.4	1,251.1
MEAN	41.4	34.3	115.0	236.3	114.5	18.7	13.2	11.0	16.6	90.2	196.1	80.6	967.9

Table B3.7 Annual Monthly Rainfall for Subbasin KAMB-RL

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	21.9	5.6	78.2	130.6	174.2	6.3	12.7	12.9	26.2	66.3	152.4	41.1	728.4
1958	13.8	33.6	35.4	160.3	204.9	20.5	30.8	1.9	3.3	27.1	82.4	62.2	676.4
1959	46.1	3.5	68.1	102.0	121.9	2.3	29.6	15.0	6.9	7.5	173.5	56.1	632.6
1960	9.2	5.4	71.9	65.4	19.7	5.7	2.8	4.9	1.3	105.2	35.0	37.6	364.0
1961	2.8	12.2	42.4	150.2	93.3	15.0	10.7	9.7	50.1	292.0	434.3	33.7	1,146.4
1962	40.3	0.4	42.1	148.7	119.1	1.0	15.2	43.9	5.9	76.6	64.0	75.3	632.5
1963	31.6	58.6	71.3	238.2	102.6	15.8	8.6	16.0	9.5	51.3	141.3	114.6	859.4
1964	23.8	17.6	85.2	225.9	40.5	7.5	12.7	25.9	7.1	84.1	97.5	104.1	731.9
1965	14.3	0.0	20.1	148.4	47.9	7.1	10.7	11.9	3.3	60.2	168.2	10.2	502.3
1966	17.0	15.5	123.0	170.9	45.1	6.7	15.5	5.2	12.0	79.7	176.5	26.3	693.3
1967	4.5	3.8	69.2	188.7	294.9	10.6	15.5	27.6	23.7	119.8	159.9	0.0	918.1
1968	0.0	61.3	136.5	211.9	96.9	30.3	20.3	18.4	6.1	68.5	276.3	113.7	1,040.3
1969	6.8	72.4	105.4	68.9	86.4	2.9	80.8	36.9	25.1	55.9	177.3	12.3	731.2
1970	80.0	0.0	126.5	145.5	64.5	4.5	15.0	21.6	88.4	28.7	80.1	26.8	681.7
1971	0.6	5.7	34.0	172.2	110.0	10.3	42.0	8.1	2.3	23.2	104.8	28.4	541.7
1972	33.1	12.6	5.3	36.1	123.4	12.5	10.4	4.1	31.9	176.2	179.4	32.6	657.5
1973	37.5	17.1	14.2	105.5	24.4	3.3	10.9	10.3	33.1	29.3	137.2	5.3	428.0
1974	2.3	15.4	63.4	191.7	45.5	33.6	59.8	11.0	0.1	11.6	123.5	47.8	605.6
1975	3.8	1.7	42.1	198.3	36.5	1.8	20.9	0.0	43.4	64.1	76.3	19.4	508.4
1976	0.0	29.7	0.6	189.8	19.0	28.8	0.3	0.0	7.2	11.6	116.3	95.5	498.9
1977	19.2	23.0	17.5	333.5	38.9	8.1	0.0	5.2	35.7	0.0	278.3	110.9	870.2
1978	41.7	84.4	150.8	123.2	17.8	0.4	0.0	0.0	23.4	111.5	180.6	79.2	813.1
1979	115.5	37.4	107.1	191.4	94.6	28.0	2.9	4.5	0.0	27.9	191.0	26.4	826.7
1980	6.4	0.1	42.5	101.3	111.0	0.0	0.4	8.9	0.9	32.3	177.4	12.5	493.7
1981	3.4	0.5	290.5	151.7	81.5	0.8	0.7	0.7	12.6	43.2	79.8	33.5	698.9
1982	1.6	0.3	76.4	175.8	57.8	4.3	3.8	0.3	14.7	182.1	129.1	42.1	688.1
1983	4.6	15.9	24.4	232.7	21.5	0.3	8.7	1.2	1.8	40.4	38.5	64.5	454.6
1984	22.4	4.4	68.2	131.7	0.3	0.0	1.4	0.2	8.9	135.6	161.5	94.9	629.5
1985	6.3	75.9	86.7	263.8	34.2	1.0	3.4	2.2	1.5	39.9	86.3	39.1	640.3
1986	8.6	3.5	31.0	269.7	74.1	9.3	4.4	3.2	3.0	62.9	234.9	62.4	766.9
1987	51.5	24.1	40.7	140.3	108.4	66.3	16.1	20.5	24.6	15.6	151.8	12.8	672.6
1988	40.6	3.3	120.0	301.5	41.2	10.2	6.0	10.0	32.2	56.1	149.4	147.2	917.8
1989	54.9	3.1	119.5	203.4	51.7	2.0	6.5	0.0	4.4	148.8	188.0	104.9	887.2
1990	57.4	34.0	207.3	293.1	73.5	2.5	5.1	0.0	11.9	97.1	120.8	94.3	997.0
MEAN	24.2	20.1	77.0	175.4	78.7	10.6	14.2	10.1	16.6	71.5	150.7	54.9	704.0

Table B3.8 Annual Monthly Rainfall for Subbasin 4DD1

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	63.2	25.0	78.3	262.9	295.0	10.0	24.3	33.4	50.5	166.1	266.8	138.1	1,413.5
1958	23.6	62.4	75.7	257.4	436.3	80.2	98.8	15.2	7.5	39.5	281.8	175.0	1,553.3
1959	52.8	24.5	83.0	268.7	298.0	11.0	86.6	49.0	26.7	36.5	252.0	80.3	1,269.1
1960	24.1	13.2	118.6	171.3	61.3	28.1	15.8	13.6	8.9	147.3	82.2	52.3	736.8
1961	10.8	9.6	72.8	242.1	173.2	66.2	94.9	77.7	163.9	616.9	594.4	121.7	2,244.1
1962	91.6	6.7	73.8	239.2	313.0	26.3	77.1	121.4	61.2	162.2	87.8	77.6	1,338.0
1963	63.3	79.2	132.7	501.3	345.5	78.4	31.6	67.4	27.2	80.6	240.0	175.0	1,822.2
1964	41.0	48.0	185.4	388.7	165.5	48.6	50.7	117.8	41.6	189.0	141.3	126.1	1,543.8
1965	56.6	20.8	58.3	263.5	145.8	32.9	55.3	67.5	38.4	114.0	328.5	78.1	1,259.7
1966	44.1	25.3	200.2	386.8	161.4	85.9	58.9	31.7	38.1	240.7	235.4	14.1	1,522.6
1967	14.9	10.9	70.1	253.7	532.4	54.5	87.2	90.2	96.9	299.3	267.4	27.6	1,805.2
1968	10.9	174.8	203.3	353.1	304.2	101.3	113.8	76.9	19.3	176.1	360.5	178.5	2,072.9
1969	60.8	91.3	138.6	71.2	314.6	37.1	112.9	132.3	52.0	124.9	187.2	27.6	1,350.6
1970	128.8	57.1	202.3	370.2	252.3	74.0	63.0	105.0	58.7	104.9	138.2	40.7	1,595.3
1971	21.2	14.0	48.3	321.0	274.8	89.9	101.8	52.7	34.6	110.1	81.0	75.7	1,225.2
1972	58.7	68.7	32.0	126.1	349.1	59.0	66.4	34.1	123.7	393.7	261.4	63.0	1,636.0
1973	69.4	57.2	24.9	252.8	226.7	41.6	51.3	56.5	56.5	118.3	196.8	30.9	1,182.8
1974	13.3	26.9	54.5	247.6	117.2	146.1	200.1	64.1	37.9	61.0	141.1	40.9	1,150.7
1975	5.2	3.8	51.9	319.3	216.8	57.6	113.2	80.3	64.6	113.3	100.8	53.1	1,179.8
1976	12.8	35.2	24.2	330.3	236.4	93.0	46.2	36.1	84.0	86.1	188.8	89.3	1,262.4
1977	60.1	67.2	97.9	471.1	281.1	56.8	69.8	59.3	46.1	180.2	388.3	95.0	1,872.9
1978	48.2	91.4	213.3	393.0	109.0	59.8	77.1	62.5	70.9	258.6	120.7	109.2	1,613.6
1979	137.9	78.5	116.4	316.8	386.2	119.0	72.5	52.4	29.3	92.4	204.4	58.8	1,664.6
1980	48.0	4.5	72.0	198.1	247.2	16.4	40.7	104.8	17.2	126.9	423.9	51.8	1,351.4
1981	11.5	37.7	265.2	382.5	329.0	33.2	51.3	74.3	59.8	145.1	144.1	72.1	1,605.7
1982	34.6	30.4	85.0	306.6	414.3	56.9	75.8	61.3	93.5	301.2	145.8	74.3	1,679.7
1983	11.5	32.3	14.7	373.4	305.6	78.2	54.7	43.2	39.4	176.4	113.7	108.2	1,351.4
1984	28.4	5.6	34.9	201.7	64.9	40.2	53.9	25.9	36.5	288.8	209.9	86.7	1,077.4
1985	27.7	70.1	179.7	330.6	255.3	58.1	50.4	59.0	43.0	126.8	139.9	36.6	1,377.2
1986	12.6	8.0	71.8	354.4	360.1	68.8	19.8	22.1	51.2	96.8	281.0	90.8	1,437.5
1987	39.5	8.1	42.2	293.9	275.3	94.6	42.2	167.9	29.1	36.1	227.6	27.4	1,283.8
1988	58.2	26.6	115.2	666.1	142.4	51.6	21.6	70.0	63.0	214.9	352.3	231.0	2,012.9
1989	88.2	23.8	117.1	318.5	201.3	70.0	18.1	59.6	75.1	292.3	242.7	107.0	1,613.9
1990	84.6	46.9	269.6	322.8	213.0	87.7	30.4	53.3	49.8	218.3	196.5	129.0	1,702.0
MEAN	45.8	40.8	106.6	310.5	259.0	62.1	65.5	65.8	52.8	174.6	224.2	86.6	1,494.4

Table B3.9 Annual Monthly Rainfall for Subbasin GITA-RL

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	20.9	9.9	63.9	119.8	126.3	3.1	9.5	6.4	24.8	43.8	139.5	76.1	644.1
1958	25.6	24.6	34.9	109.6	182.6	18.0	20.0	1.0	1.7	19.6	87.5	88.9	613.9
1959	50.7	1.7	79.9	109.6	126.5	1.1	24.4	11.6	3.4	3.7	231.4	63.0	707.1
1960	0.4	12.7	79.3	58.5	22.2	3.0	1.4	2.4	0.7	82.8	30.4	62.9	356.6
1961	6.2	22.3	76.5	165.1	67.0	6.7	5.5	6.6	155.6	379.2	462.2	41.1	1,394.1
1962	50.6	2.1	31.3	257.9	93.3	0.6	9.6	22.9	6.2	43.9	59.8	65.7	643.8
1963	35.7	52.0	106.0	195.3	114.7	13.6	4.3	9.5	19.9	34.0	157.8	157.0	899.7
1964	51.5	39.0	88.4	276.8	27.1	2.6	7.0	17.1	4.2	66.5	125.5	201.6	907.3
1965	13.8	0.0	30.5	123.4	19.2	3.8	4.7	5.7	1.9	41.0	142.9	19.8	406.5
1966	18.9	8.6	115.1	128.2	59.8	6.3	7.7	2.6	6.0	91.4	163.4	29.8	637.7
1967	8.8	8.2	96.4	176.4	199.6	6.9	6.8	19.0	25.9	134.8	209.6	0.5	892.7
1968	0.0	62.8	186.7	251.4	156.4	30.0	10.1	9.2	3.0	47.2	391.7	126.0	1,274.6
1969	9.1	65.0	119.0	31.7	114.4	1.6	41.8	24.2	12.5	46.4	284.0	19.0	768.7
1970	93.0	0.0	140.4	146.9	64.8	3.2	7.6	13.2	47.8	12.9	82.7	35.6	648.1
1971	1.2	2.3	25.5	244.7	121.5	8.9	21.5	3.2	1.2	19.5	124.8	54.8	629.2
1972	64.3	46.4	20.3	21.9	111.5	15.2	5.6	2.0	23.7	179.0	155.0	67.5	712.6
1973	50.0	7.3	25.2	149.4	23.0	1.5	5.0	5.1	10.0	20.3	163.8	7.7	468.3
1974	10.3	28.4	80.3	179.5	24.8	21.6	30.6	4.1	0.0	27.0	111.6	72.2	590.5
1975	1.0	0.0	51.8	177.2	61.4	0.9	12.8	0.0	31.5	58.4	84.0	21.2	500.2
1976	0.4	26.3	3.5	142.8	10.6	30.9	0.0	0.0	14.1	12.4	113.9	100.1	455.0
1977	31.4	50.1	21.7	411.4	30.6	4.6	0.0	5.9	38.2	1.6	420.5	153.1	1,169.1
1978	37.1	93.2	125.3	132.0	8.8	1.6	0.0	0.0	12.9	146.5	176.3	105.0	838.8
1979	134.4	28.8	77.7	208.8	71.0	16.3	3.9	3.1	0.0	42.1	186.4	44.4	816.8
1980	11.2	0.0	10.1	49.8	70.2	0.0	0.0	6.4	1.6	35.9	207.9	13.7	406.9
1981	1.1	0.9	213.9	147.7	104.0	0.2	1.1	2.9	6.6	58.1	104.2	29.4	670.1
1982	6.0	0.1	62.8	181.7	62.0	2.0	12.1	0.2	9.1	203.1	148.0	45.4	732.3
1983	13.4	20.0	48.1	171.6	24.4	0.0	46.3	0.0	0.8	25.6	65.4	67.2	482.9
1984	18.7	6.8	39.3	156.1	0.1	0.0	0.0	0.0	7.4	160.0	200.3	50.3	638.9
1985	3.2	44.0	92.5	240.1	43.6	4.9	7.0	8.3	6.1	60.0	105.3	40.2	655.3
1986	1.3	0.1	20.4	297.6	73.7	8.2	9.3	0.1	0.2	65.3	234.5	78.5	789.0
1987	38.6	8.6	24.0	99.3	157.7	33.5	20.5	8.2	0.6	6.4	136.3	11.1	544.9
1988	101.6	13.0	108.5	331.2	83.4	8.4	5.7	54.0	144.0	120.3	196.4	115.5	1,281.9
1989	68.2	9.0	87.9	229.4	100.2	3.5	9.3	0.0	5.4	492.3	212.3	254.7	1,472.4
1990	80.9	32.6	439.5	287.7	224.6	13.6	11.3	0.0	31.5	230.2	152.5	139.7	1,644.2
MEAN	31.2	21.4	83.1	176.8	81.8	8.1	10.7	7.5	19.4	88.6	172.6	72.3	773.4

Table B3.10 Annual Monthly Rainfall for Subbasin KIND-RL

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	18.5	11.7	59.2	96.2	89.0	0.6	5.2	1.1	17.1	18.6	124.4	80.0	521.6
1958	29.0	18.8	32.0	90.7	127.8	12.3	8.9	0.2	0.3	10.5	65.6	94.3	490.4
1959	48.9	0.3	79.7	91.7	105.6	0.2	15.4	6.4	0.6	0.7	241.4	64.3	655.2
1960	0.5	14.4	68.9	42.1	17.4	0.6	0.2	0.4	0.1	56.0	24.6	68.0	293.5
1961	6.1	22.9	77.0	148.9	39.4	2.3	1.1	3.2	180.7	352.2	438.9	40.0	1,312.7
1962	53.8	2.7	21.9	275.7	60.7	0.2	4.1	5.8	4.9	28.2	62.1	70.9	591.0
1963	32.4	47.7	109.7	131.0	96.2	9.1	0.8	3.5	21.0	12.8	145.6	167.6	777.3
1964	61.9	42.8	74.0	257.9	12.7	0.9	2.1	7.6	1.6	45.4	120.3	223.3	850.3
1965	9.7	0.0	30.2	93.8	3.8	1.8	0.9	1.6	0.6	28.7	119.4	23.8	314.4
1966	18.3	4.2	104.9	99.4	59.2	6.5	1.4	0.5	1.1	75.4	160.0	30.3	561.2
1967	12.8	1.4	75.3	170.5	68.6	3.2	1.3	13.9	32.1	100.8	300.2	1.3	781.6
1968	0.0	8.0	187.5	249.1	154.4	22.1	1.8	1.6	0.5	22.8	408.0	121.8	1,177.4
1969	6.2	83.8	159.1	31.2	94.6	1.0	7.3	21.0	2.2	31.1	314.6	23.4	775.5
1970	88.2	0.0	163.0	142.1	46.2	2.0	1.8	4.4	14.1	2.6	72.4	63.9	600.6
1971	2.6	0.5	12.9	229.3	160.1	3.2	3.7	0.6	0.2	7.9	192.5	76.3	689.7
1972	65.1	41.3	10.4	4.2	83.4	4.3	1.8	0.4	16.2	140.6	164.5	84.4	616.8
1973	85.5	14.2	8.5	175.9	10.5	0.3	0.9	0.9	14.6	3.0	200.0	24.3	538.7
1974	5.2	45.4	83.3	155.4	9.7	7.8	14.0	0.8	0.0	4.5	123.7	48.2	498.3
1975	3.9	0.1	6.2	225.0	79.9	0.2	6.8	0.0	21.7	24.7	66.5	33.4	468.3
1976	1.5	5.9	4.2	125.0	5.9	40.4	0.0	0.0	17.1	8.2	155.7	84.6	448.5
1977	41.9	88.0	17.2	284.5	59.3	3.2	0.0	3.2	14.7	7.1	394.1	146.7	1,059.9
1978	35.1	110.1	93.8	129.2	1.6	0.1	0.0	0.0	7.5	136.6	153.3	120.0	787.4
1979	161.7	16.0	65.7	165.2	65.4	3.4	0.5	0.5	0.0	9.4	170.7	42.7	701.1
1980	1.1	1.0	26.9	77.6	85.4	0.0	0.0	8.4	0.2	9.8	208.9	10.4	429.7
1981	0.2	0.1	136.8	138.0	49.9	0.0	0.1	0.3	1.2	14.8	101.5	23.8	466.8
1982	3.5	0.0	19.7	144.3	24.9	0.4	1.1	0.0	1.3	119.0	201.7	100.7	616.5
1983	7.0	32.4	7.5	108.7	29.1	0.1	42.8	0.1	0.1	5.0	39.1	105.2	377.1
1984	24.9	4.9	15.6	148.9	0.5	0.0	0.1	0.0	3.8	156.7	210.9	45.9	612.2
1985	0.6	34.1	35.8	206.8	41.8	4.6	0.9	0.8	0.6	29.1	111.4	45.6	512.0
1986	0.5	0.2	21.7	323.7	84.1	7.2	0.9	0.5	0.1	38.7	322.2	89.9	889.7
1987	25.9	1.8	7.3	120.2	54.0	40.3	2.4	1.5	1.1	1.2	148.2	12.8	416.6
1988	86.3	12.0	106.1	273.0	65.7	10.6	3.4	64.5	133.2	100.0	204.8	120.4	1,180.1
1989	57.8	7.7	81.0	201.5	95.8	2.7	8.5	0.0	4.0	449.4	237.7	282.5	1,428.6
1990	125.0	4.2	363.2	278.3	256.5	16.3	11.8	0.0	36.2	66.3	159.6	285.3	1,602.6
MEAN	33.0	20.0	69.6	159.8	65.9	6.1	4.5	4.5	16.2	62.3	181.3	84.0	707.2

Table B3.11 Annual Monthly Rainfall for Subbasin MUTO-L

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	69.9	22.7	76.1	264.8	185.4	2.7	7.9	14.6	32.0	90.4	227.6	115.6	1,109.8
1958	20.5	42.7	87.2	242.4	215.8	21.9	38.0	4.5	1.3	49.7	260.5	119.1	1,103.7
1959	72.6	19.9	55.7	137.2	158.1	8.8	29.6	31.1	10.7	21.8	214.2	70.8	830.7
1960	3.8	8.6	180.4	155.2	36.0	10.6	9.7	10.7	9.4	143.8	110.5	88.2	767.0
1961	15.1	5.9	102.8	220.5	140.0	18.3	13.1	17.8	41.6	548.7	544.9	48.3	1,717.1
1962	20.9	0.2	85.9	249.0	135.1	2.7	95.9	44.3	18.6	163.6	75.4	56.2	947.8
1963	27.6	49.8	126.8	394.5	165.5	31.7	10.1	24.4	17.8	99.9	313.2	182.1	1,443.3
1964	22.4	8.4	184.0	365.2	45.3	22.7	13.6	39.3	11.7	102.0	135.9	149.4	1,099.9
1965	30.9	0.2	48.9	257.4	70.9	5.2	15.3	30.7	12.7	61.4	309.9	42.1	885.6
1966	26.3	48.4	190.1	311.0	42.6	7.7	22.6	4.4	5.6	159.7	191.9	35.8	1,046.0
1967	12.1	8.1	57.9	285.2	325.5	8.6	15.1	18.0	25.3	256.6	359.1	2.4	1,374.0
1968	0.0	147.6	186.9	356.4	93.1	22.5	28.5	28.8	1.1	145.8	417.3	148.4	1,576.6
1969	24.6	91.2	162.6	48.9	173.2	3.0	15.9	47.4	26.6	97.8	245.2	39.0	975.3
1970	124.8	0.4	209.7	309.6	59.5	16.1	15.2	31.1	2.6	35.3	129.5	40.5	974.4
1971	2.1	0.0	40.1	300.2	136.0	18.7	16.4	9.4	7.3	74.7	153.3	52.5	810.7
1972	53.2	27.9	31.7	65.2	167.3	25.1	10.0	3.4	36.4	241.6	203.2	55.9	920.8
1973	55.1	21.4	20.7	173.4	34.4	5.9	15.8	12.9	19.5	44.4	179.1	4.2	586.8
1974	3.4	34.5	102.7	255.3	32.7	20.2	35.7	9.3	7.5	59.2	148.6	50.2	759.0
1975	1.1	3.1	63.8	325.7	85.3	6.0	22.2	5.3	34.9	97.9	145.2	29.4	819.9
1976	0.2	32.7	10.6	195.5	30.3	43.8	8.8	2.6	19.6	70.6	154.4	114.8	683.7
1977	21.0	34.9	101.3	359.9	128.9	10.3	14.2	14.4	35.1	41.7	562.0	148.5	1,472.1
1978	84.7	114.8	222.4	389.4	35.4	8.7	22.5	13.6	9.4	291.3	256.8	130.3	1,579.3
1979	169.1	67.4	110.6	266.9	92.5	10.3	16.1	7.6	2.7	76.0	264.1	61.7	1,145.0
1980	18.2	0.7	41.8	106.5	79.4	1.2	2.2	14.6	5.0	69.6	319.5	17.8	676.3
1981	1.8	6.4	226.1	263.0	173.7	5.6	6.8	12.4	9.8	82.0	145.6	32.9	966.3
1982	1.7	3.2	78.2	311.4	97.2	8.6	6.1	7.7	22.2	352.9	178.0	114.9	1,182.1
1983	10.6	17.4	28.5	320.0	51.6	7.7	20.0	5.4	14.6	85.5	98.4	106.3	765.9
1984	7.9	4.2	38.6	167.4	12.0	2.9	13.1	4.3	14.8	276.6	177.6	76.7	796.1
1985	3.7	40.6	163.1	279.2	75.6	10.1	16.4	24.4	14.7	100.8	150.3	57.9	937.0
1986	0.5	4.4	58.2	254.0	108.5	19.7	7.4	4.0	10.5	75.1	338.2	107.3	987.8
1987	26.6	3.4	14.2	198.0	131.4	23.2	3.8	29.3	0.9	7.6	210.0	32.5	681.0
1988	52.0	13.8	93.3	470.9	62.2	26.8	10.7	44.2	63.9	139.8	304.2	175.6	1,457.3
1989	67.5	26.6	121.0	296.6	117.9	9.5	12.9	15.9	22.6	318.8	311.1	154.3	1,474.6
1990	61.0	43.4	338.4	312.8	146.3	10.0	15.9	11.4	22.0	234.9	230.0	168.3	1,594.6
MEAN	32.7	28.1	107.7	262.0	107.2	13.4	17.9	17.6	17.4	138.8	237.2	83.2	1,063.2

Table B3.12 Annual Monthly Rainfall for Subbasin MUTO-R

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	45.6	5.0	81.6	137.6	134.2	0.6	1.5	2.0	5.1	26.9	232.0	111.9	784.0
1958	20.5	28.6	17.6	221.6	39.4	1.6	3.5	0.1	0.0	10.9	128.7	180.3	652.9
1959	52.6	6.4	59.6	94.8	153.3	1.6	4.2	16.3	1.1	3.7	165.1	100.2	658.8
1960	6.7	21.0	174.2	90.7	19.8	0.6	0.9	1.2	12.4	105.0	65.5	84.0	582.0
1961	2.3	7.5	18.9	197.6	34.3	2.7	1.3	1.6	5.8	285.7	632.2	101.8	1,291.6
1962	13.1	36.0	137.6	187.1	68.0	0.0	25.2	119.9	3.4	55.5	108.4	125.8	880.2
1963	10.0	18.3	132.2	226.2	24.7	6.6	0.2	4.0	4.3	20.7	269.3	242.6	959.1
1964	102.0	36.8	107.9	212.1	6.7	4.8	0.6	3.6	4.9	37.7	109.3	157.5	783.8
1965	20.7	0.0	21.0	165.1	14.4	12.2	1.4	6.0	2.2	91.5	366.3	12.3	713.1
1966	5.2	29.8	231.5	214.2	20.3	4.6	0.0	3.3	1.3	24.8	291.4	65.3	891.6
1967	1.8	1.0	10.7	220.1	163.1	0.5	0.6	2.1	45.6	144.9	415.8	0.6	1,006.9
1968	0.0	148.7	169.0	333.0	48.5	3.4	3.6	3.2	0.0	49.5	580.8	150.0	1,489.6
1969	42.5	73.9	147.9	52.5	53.8	0.5	1.4	8.3	5.7	94.9	259.6	31.4	772.7
1970	101.8	0.0	166.4	134.7	36.8	3.2	0.1	3.3	0.0	0.6	99.0	31.0	576.9
1971	0.0	0.0	28.0	184.7	46.4	13.0	0.0	0.0	2.4	7.4	132.7	138.6	553.2
1972	92.1	55.1	17.6	3.1	76.0	2.0	0.0	0.0	7.9	123.8	248.9	76.0	702.4
1973	12.3	36.0	10.5	131.3	3.0	0.0	0.2	0.0	2.8	0.6	209.4	34.1	440.2
1974	3.1	23.3	72.5	176.9	18.0	1.0	1.6	0.0	0.7	37.2	135.6	96.9	566.7
1975	6.7	0.5	11.7	215.6	61.5	0.0	18.0	0.0	16.3	21.2	201.1	7.3	560.0
1976	0.0	9.1	1.8	98.8	14.5	11.4	0.3	0.0	0.4	23.2	217.6	123.0	500.0
1977	44.8	20.9	103.1	352.7	37.3	1.8	0.1	4.6	12.9	1.5	443.9	215.0	1,238.8
1978	70.9	173.7	212.8	242.9	2.4	0.0	2.5	0.1	0.0	157.1	242.6	150.8	1,255.5
1979	274.8	43.9	90.1	220.4	32.1	4.5	1.2	1.6	2.6	19.6	235.1	74.0	1,000.0
1980	20.1	4.7	19.9	126.7	17.7	0.0	0.0	3.1	0.8	19.6	241.5	21.0	475.2
1981	4.0	0.2	228.2	165.4	54.5	0.0	8.0	0.1	2.5	65.9	169.5	67.1	765.5
1982	0.2	0.5	13.9	251.6	74.0	0.8	0.0	0.2	17.1	309.6	205.9	198.2	1,072.2
1983	4.8	2.0	5.6	167.1	18.3	0.6	2.1	0.1	1.4	35.2	100.1	106.5	443.9
1984	8.4	0.7	5.6	126.8	3.8	0.1	0.4	0.7	6.8	191.6	208.6	56.9	610.3
1985	15.0	19.7	100.1	160.0	69.9	1.5	1.8	2.9	1.6	59.4	97.6	68.2	597.8
1986	0.0	2.4	63.6	371.6	42.0	7.8	0.9	0.7	1.4	21.8	399.7	126.8	1,038.7
1987	53.4	0.4	26.1	156.7	65.1	30.3	0.0	12.2	0.0	0.0	121.8	31.6	497.7
1988	14.1	0.7	55.2	226.7	4.9	16.4	4.3	2.4	6.6	29.6	89.2	61.9	512.0
1989	56.5	2.4	103.2	272.1	62.3	1.7	9.8	0.1	2.4	205.7	377.0	140.8	1,233.9
1990	57.6	87.6	182.0	284.8	29.1	0.6	13.1	0.0	7.2	144.0	165.6	204.9	1,176.3
MEAN	34.2	26.4	83.2	188.9	45.6	4.0	3.2	6.0	5.5	71.4	234.3	99.8	802.5

Table B3.13 Annual Monthly Rainfall for Subbasin KIAM-RL

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	32.1	11.7	85.3	142.7	109.1	1.4	2.6	1.8	11.7	29.1	215.2	80.6	723.3
1958	22.1	26.3	52.2	172.9	85.9	6.4	9.1	0.1	0.0	15.1	124.9	108.1	623.1
1959	54.6	3.7	64.9	109.6	106.4	1.4	11.8	9.3	1.0	3.2	254.8	77.8	698.7
1960	7.5	11.2	100.7	61.2	14.2	0.6	0.8	1.1	2.7	81.9	66.7	77.6	426.2
1961	8.6	33.9	56.1	160.5	47.8	5.9	1.7	2.3	89.0	333.3	533.4	52.8	1,325.4
1962	41.1	3.5	57.0	250.5	53.1	0.1	17.4	14.1	4.3	58.7	105.0	101.8	706.5
1963	20.8	42.8	116.7	157.1	68.5	9.4	0.1	3.5	11.4	19.1	229.0	211.3	889.8
1964	56.0	29.7	99.0	240.6	9.5	4.9	1.2	5.7	3.0	49.3	114.2	203.2	816.4
1965	12.4	0.0	28.2	140.7	19.1	6.0	2.7	5.6	4.3	58.0	215.7	22.7	515.4
1966	14.6	19.0	163.8	168.8	47.6	8.9	0.0	0.4	1.7	66.5	234.2	35.9	761.4
1967	9.2	3.3	66.4	226.4	98.0	1.8	1.4	12.0	32.6	153.6	340.4	1.4	946.6
1968	0.0	72.4	185.5	308.6	92.2	14.6	4.3	4.2	0.0	39.0	452.3	135.1	1,308.3
1969	16.7	84.8	158.9	53.5	77.0	1.0	1.3	11.4	2.4	39.6	300.2	21.3	768.1
1970	90.3	0.0	181.6	159.0	44.4	5.0	0.4	6.8	6.2	3.1	63.6	45.7	606.0
1971	1.2	0.8	12.1	191.4	103.8	4.9	0.0	1.1	0.5	8.5	161.6	109.7	595.6
1972	50.8	34.1	13.3	2.5	70.7	2.2	0.4	2.7	21.8	133.7	243.4	83.7	659.2
1973	53.1	25.6	8.2	148.5	7.6	0.2	0.6	0.0	21.8	5.6	192.7	20.9	484.9
1974	8.4	37.4	73.6	203.4	14.7	5.0	5.9	1.8	0.3	15.1	113.6	53.7	532.9
1975	4.1	1.1	28.0	269.3	63.9	0.0	5.2	0.0	30.4	39.3	98.0	26.3	565.8
1976	0.7	9.9	2.2	158.9	6.2	43.7	0.2	0.0	10.2	8.8	167.9	71.2	479.9
1977	49.7	56.6	28.2	259.4	63.6	3.4	0.0	4.7	8.7	3.4	402.7	155.5	1,036.0
1978	45.7	115.9	126.9	170.2	1.3	0.2	1.4	0.1	2.5	144.1	164.4	111.8	884.5
1979	185.9	27.9	79.0	170.7	55.6	3.7	2.0	0.4	9.7	22.8	222.5	56.2	836.4
1980	5.2	12.6	59.4	89.5	69.4	0.2	0.0	7.6	0.5	21.8	247.4	3.5	517.1
1981	0.8	0.4	224.3	156.0	53.1	0.0	0.9	0.4	2.3	48.8	110.6	46.0	643.7
1982	1.4	0.7	26.5	152.5	32.4	1.4	2.2	0.0	9.1	171.4	206.9	161.9	766.4
1983	4.5	27.9	12.4	106.7	10.9	0.8	10.3	0.9	0.2	19.7	49.1	96.0	339.6
1984	18.1	2.1	25.0	164.0	2.9	0.0	1.7	0.1	3.8	178.7	242.0	78.1	716.5
1985	3.3	47.9	66.9	204.0	45.7	2.8	1.7	1.6	1.1	61.1	117.9	65.0	619.1
1986	4.0	5.4	27.6	368.1	66.7	9.1	2.6	3.0	1.9	47.1	269.3	127.3	932.1
1987	32.2	15.1	33.1	143.6	56.6	28.3	9.8	16.9	15.5	9.3	144.8	20.3	525.6
1988	51.9	6.3	129.4	256.8	31.1	15.7	2.3	34.7	67.4	86.4	198.8	162.2	1,042.9
1989	50.7	3.9	105.9	232.3	80.6	1.7	6.2	0.1	4.5	274.5	275.5	199.5	1,235.4
1990	56.8	39.7	325.7	301.5	152.9	8.6	7.4	0.0	28.2	96.4	184.3	351.9	1,553.3
MEAN	29.8	23.9	83.1	179.5	54.8	5.9	3.4	4.5	12.1	69.0	207.7	93.4	767.1

Table B3.14 Annual Monthly Rainfall for Subbasin 4EA7

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	91.3	37.4	107.1	348.0	287.9	7.7	11.6	37.6	50.3	195.0	352.6	192.8	1,719.3
1958	40.2	77.6	85.0	325.0	298.1	24.8	79.7	15.4	2.5	81.2	342.9	315.8	1,688.3
1959	73.3	41.7	58.2	201.9	242.6	8.9	31.1	33.9	29.4	34.4	414.0	120.7	1,290.0
1960	17.9	14.2	305.3	250.1	42.4	28.4	12.1	13.4	9.4	212.9	183.2	129.8	1,219.0
1961	18.8	13.6	93.1	352.8	173.0	29.6	30.8	39.7	78.2	880.6	814.3	69.8	2,594.4
1962	78.0	7.3	84.4	374.1	224.5	6.2	77.2	68.8	26.8	232.6	124.6	81.2	1,385.7
1963	53.7	57.0	126.7	519.7	208.8	35.2	23.3	37.7	24.9	137.9	412.7	312.9	1,950.3
1964	63.3	25.4	206.0	470.1	76.0	32.1	23.3	48.0	15.5	161.4	256.2	333.8	1,711.1
1965	44.5	11.5	55.9	305.5	122.4	6.4	24.1	39.8	23.2	165.4	400.9	70.1	1,269.7
1966	39.8	60.2	287.5	420.0	146.0	41.7	34.8	11.0	13.7	332.6	289.6	33.8	1,710.7
1967	14.7	8.8	86.2	416.7	460.5	20.3	40.4	28.7	32.3	435.9	555.6	36.3	2,136.3
1968	2.2	227.2	296.3	493.0	149.8	26.6	43.5	39.1	3.6	324.1	554.0	169.3	2,328.6
1969	49.6	171.1	212.0	64.8	253.5	8.5	42.6	51.2	44.7	192.9	340.7	46.8	1,478.3
1970	141.1	10.2	219.3	381.7	65.0	21.7	27.5	48.0	15.1	123.7	230.9	43.5	1,327.6
1971	12.9	3.3	78.9	422.2	204.0	32.6	40.2	28.5	23.2	163.8	264.2	80.0	1,353.7
1972	50.6	60.7	36.8	140.1	293.0	38.4	100.9	18.0	96.2	427.0	448.6	42.3	1,752.5
1973	78.4	26.4	16.8	195.4	120.5	18.0	23.3	30.6	17.7	126.0	282.2	28.8	964.2
1974	6.0	50.2	210.2	392.3	76.4	46.7	75.7	19.1	15.1	115.6	282.4	74.8	1,364.5
1975	12.0	8.0	47.0	313.3	146.5	29.4	30.6	22.2	41.4	203.5	181.5	40.6	1,075.9
1976	4.6	50.0	13.8	322.2	113.1	84.2	27.4	17.4	29.4	143.9	305.1	169.4	1,280.4
1977	59.0	51.3	183.8	454.5	203.4	21.0	27.8	27.0	23.8	134.0	572.2	161.0	1,918.7
1978	84.0	138.2	351.3	472.7	66.8	24.1	33.7	27.0	56.2	352.3	261.9	194.5	2,062.7
1979	280.1	70.3	151.9	407.8	217.6	32.5	26.9	24.8	8.2	153.1	383.7	91.6	1,848.5
1980	40.4	4.1	64.9	222.3	235.6	5.0	8.3	36.7	34.0	162.5	482.4	46.6	1,342.8
1981	7.7	32.3	305.0	431.6	262.8	15.9	19.7	34.1	29.6	143.5	262.7	91.1	1,635.9
1982	17.8	9.8	68.3	427.0	229.0	20.3	21.2	19.0	52.7	485.7	292.8	156.1	1,799.8
1983	22.9	35.3	12.7	377.5	177.8	24.2	20.5	19.9	42.0	182.8	234.5	205.8	1,356.0
1984	9.8	2.6	38.8	201.6	27.8	11.1	24.0	8.9	14.9	447.9	283.4	103.3	1,174.0
1985	17.5	85.2	225.0	355.6	196.9	17.8	25.3	31.9	21.3	158.6	262.9	79.6	1,477.5
1986	8.6	4.1	72.9	397.2	183.5	32.3	10.3	5.2	25.9	188.1	450.8	144.3	1,523.2
1987	30.5	4.4	25.1	282.3	142.1	40.6	7.0	60.5	3.1	23.9	399.2	53.8	1,072.5
1988	85.8	17.1	125.2	800.5	111.1	26.0	21.3	47.9	68.0	238.0	345.6	263.2	2,149.8
1989	93.0	23.0	108.9	343.9	143.9	17.6	18.9	29.7	55.9	327.4	444.4	156.1	1,762.6
1990	63.0	49.0	353.5	370.5	149.4	20.4	20.1	23.3	10.2	274.3	275.4	246.0	1,855.1
MEAN	50.4	43.8	138.6	360.4	178.0	25.2	31.9	30.7	30.5	234.2	352.6	129.0	1,605.3

Table B3.15 Annual Monthly Rainfall for Subbasin 4F19

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	61.6	31.7	121.3	220.1	260.8	4.3	0.6	40.0	40.9	240.2	367.9	165.6	1,575.0
1958	41.9	111.0	58.3	310.9	162.4	17.6	73.8	17.1	4.9	90.6	258.7	207.2	1,354.4
1959	90.8	22.2	47.0	169.3	195.2	0.1	13.3	19.5	16.7	58.6	378.6	149.3	1,160.5
1960	26.2	30.0	303.3	292.8	30.2	21.3	3.1	6.0	1.7	227.8	145.7	139.5	1,227.7
1961	13.1	28.5	47.0	316.8	152.9	15.1	12.3	23.7	44.8	918.7	640.1	79.0	2,292.1
1962	89.9	11.8	70.8	321.6	205.4	5.6	9.0	36.7	4.8	202.7	127.0	114.0	1,199.4
1963	43.5	52.6	114.1	439.7	147.6	8.1	6.1	22.4	19.4	128.0	432.8	338.2	1,752.5
1964	60.6	34.6	143.3	390.6	65.0	28.4	9.1	19.7	14.1	206.8	272.1	339.8	1,584.0
1965	75.7	52.7	25.3	245.1	53.0	0.3	11.3	15.1	30.2	210.5	315.8	71.1	1,106.0
1966	22.3	40.5	262.7	584.7	60.8	41.4	5.3	5.0	8.2	318.6	340.0	29.5	1,719.2
1967	19.1	10.4	107.1	365.1	413.3	15.2	12.4	10.3	17.5	408.6	525.4	36.5	1,940.9
1968	2.2	206.9	272.2	420.3	114.0	23.5	4.3	3.2	3.0	282.7	569.9	150.7	2,052.9
1969	61.4	167.5	226.7	72.9	184.6	0.6	8.7	13.1	20.6	169.6	326.9	45.3	1,298.1
1970	106.9	2.7	147.4	274.4	45.7	2.6	7.8	14.9	5.0	83.0	241.6	41.8	973.6
1971	12.2	4.2	75.8	401.1	105.8	10.0	4.7	5.8	4.5	114.5	241.6	53.4	1,033.7
1972	54.1	65.4	20.3	83.4	244.0	15.1	25.0	8.7	30.6	388.0	376.3	50.3	1,361.2
1973	91.5	18.5	23.5	205.1	65.4	7.8	10.0	10.7	22.7	77.9	258.0	35.3	826.4
1974	6.6	45.2	245.4	443.0	51.6	22.4	24.2	8.4	5.2	101.4	289.6	98.5	1,341.5
1975	13.3	7.1	51.8	231.3	156.8	19.4	15.1	5.5	32.3	159.6	175.7	63.1	931.0
1976	10.4	46.7	9.9	287.0	77.6	37.7	12.1	7.7	16.2	87.2	230.7	192.1	1,017.3
1977	47.0	29.6	104.6	396.4	144.0	3.1	12.1	10.8	18.8	103.1	463.2	173.3	1,506.0
1978	69.9	108.4	356.9	444.2	26.3	15.4	11.8	5.0	51.5	254.5	219.1	170.7	1,733.7
1979	305.7	42.7	146.8	355.6	144.1	14.8	5.3	10.8	3.8	94.4	394.5	112.5	1,630.9
1980	24.9	5.1	50.9	217.4	157.6	0.2	0.8	10.5	12.0	129.1	410.2	39.8	1,058.7
1981	9.0	18.5	259.7	310.1	208.3	8.8	6.1	10.4	19.3	168.4	229.5	102.0	1,350.0
1982	22.5	7.0	68.7	323.5	162.3	9.6	5.3	2.5	25.7	394.6	291.4	161.3	1,474.4
1983	13.5	28.1	8.0	305.0	138.7	4.6	7.1	11.2	12.9	104.8	163.1	196.4	993.3
1984	5.8	2.7	14.0	157.4	27.2	0.8	7.6	1.6	11.6	419.7	314.5	77.3	1,040.3
1985	33.5	34.0	210.0	339.8	163.1	6.3	7.2	4.1	8.3	147.3	243.2	119.0	1,315.8
1986	7.5	4.7	74.4	403.1	87.1	29.3	3.8	0.7	4.8	146.7	384.0	167.9	1,314.0
1987	40.8	5.2	40.9	235.0	106.1	48.4	0.7	19.8	0.4	9.7	294.2	69.9	871.0
1988	81.5	14.7	127.5	564.2	41.7	33.0	53.3	44.8	49.9	181.2	325.8	304.8	1,822.3
1989	64.6	19.4	94.2	313.3	113.9	3.8	8.7	7.1	42.7	288.0	376.2	198.4	1,530.4
1990	36.0	56.7	289.7	310.9	63.1	3.1	6.0	3.5	9.7	262.7	273.3	222.7	1,537.4
MEAN	49.0	40.2	124.1	316.2	128.7	14.0	11.9	12.8	18.1	211.1	320.5	133.4	1,380.2

Table B3.16 Annual Monthly Rainfall for Subbasin GRAF-RL

(Unit: mm)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1957	59.3	10.0	81.9	177.1	153.2	0.6	0.8	7.6	12.2	36.2	210.3	87.2	836.3
1958	18.8	30.6	32.7	251.5	62.9	2.2	8.8	1.2	0.0	33.0	112.4	185.4	739.6
1959	68.5	9.1	68.8	135.3	121.7	1.5	4.3	11.0	2.0	27.4	154.1	104.1	708.0
1960	8.6	15.0	200.0	158.4	13.4	3.1	0.9	1.8	6.1	113.0	77.9	82.6	680.8
1961	1.8	8.1	23.8	296.6	47.7	3.7	2.1	1.8	7.9	399.2	642.9	57.6	1,493.1
1962	28.1	15.3	125.7	194.8	61.4	0.5	25.4	77.2	3.2	126.5	116.9	98.2	873.4
1963	12.4	22.2	105.3	278.0	60.4	6.2	0.9	5.6	4.9	34.8	260.1	254.2	1,045.0
1964	66.8	24.5	84.8	278.5	12.8	12.5	0.3	3.4	1.8	47.0	98.7	152.0	783.2
1965	19.1	9.1	25.3	134.4	13.3	4.5	1.7	7.5	2.5	154.0	272.0	15.8	659.1
1966	5.7	22.9	205.3	400.9	38.3	10.1	0.4	1.4	0.0	68.0	221.6	33.6	1,008.3
1967	9.0	0.4	36.3	246.9	203.8	20.7	1.5	2.6	18.2	124.7	254.2	0.0	918.4
1968	0.0	81.9	95.9	706.9	22.1	13.2	1.4	0.0	0.0	61.1	787.3	254.2	2,023.9
1969	103.4	128.5	262.1	99.2	134.6	0.6	1.0	3.6	4.8	80.0	262.7	35.1	1,115.5
1970	97.2	0.3	262.2	204.1	30.3	0.0	0.0	6.5	0.0	0.0	161.2	30.6	792.5
1971	0.0	0.0	18.6	223.4	124.0	6.5	0.0	0.0	0.8	12.4	173.6	66.0	625.3
1972	71.4	41.2	33.5	4.0	64.0	11.7	0.8	4.6	6.8	151.8	218.7	57.6	666.0
1973	23.6	32.3	7.7	146.1	8.2	1.1	1.5	0.4	27.7	6.8	152.0	31.1	438.3
1974	0.4	17.1	103.6	214.5	18.1	2.0	3.7	13.8	0.1	53.7	167.3	64.5	659.0
1975	31.7	0.3	11.0	174.4	112.6	0.6	5.3	0.0	13.8	85.0	152.0	17.4	604.1
1976	0.9	15.6	3.8	95.2	18.3	20.5	0.2	0.2	0.3	28.9	142.6	110.8	437.2
1977	37.2	6.0	80.9	296.5	43.0	2.2	0.1	10.6	47.9	1.9	424.5	170.2	1,121.1
1978	105.8	154.4	271.2	372.0	2.6	0.0	0.9	0.0	0.0	239.4	271.2	152.2	1,569.8
1979	239.1	103.7	123.0	215.8	41.7	3.8	0.0	4.7	1.2	18.0	334.2	149.0	1,234.3
1980	10.0	2.7	25.2	174.4	51.2	0.0	0.0	1.2	0.4	32.0	220.1	25.7	542.8
1981	8.9	0.4	168.3	183.6	83.0	0.0	4.6	0.0	1.2	87.8	177.3	81.5	796.6
1982	0.0	0.0	39.3	174.5	145.8	0.0	0.0	0.1	8.5	315.2	129.9	162.3	975.6
1983	2.2	1.5	2.3	188.8	21.7	0.0	0.0	0.0	0.9	31.7	81.5	94.6	425.3
1984	4.9	0.3	5.6	108.9	4.7	0.2	0.0	0.4	3.1	173.4	137.6	41.0	480.1
1985	15.3	16.0	129.3	172.6	29.9	1.3	2.1	3.2	2.1	52.7	201.8	197.3	823.5
1986	0.0	0.0	53.9	299.5	51.8	3.4	0.8	0.9	2.4	21.8	284.8	124.2	843.4
1987	41.8	0.0	27.5	166.2	92.9	23.3	0.0	2.6	0.0	0.0	123.2	19.2	496.7
1988	16.4	0.0	40.9	248.0	1.8	15.5	4.3	0.2	1.2	30.4	71.2	60.2	490.1
1989	71.5	4.6	86.8	229.8	56.0	1.1	8.8	0.0	1.9	84.7	328.5	111.7	985.2
1990	38.0	66.6	152.2	305.9	23.2	0.0	13.0	0.0	1.0	221.3	194.6	189.7	1,205.6
MEAN	35.8	24.7	88.1	222.3	58.0	5.1	2.8	5.1	5.4	86.9	224.1	97.6	855.8