APPENDIX E
METEOROLOGY AND HYDROLOGY

THE STUDY
ON
GROUNDWATER DEVELOPMENT
IN
WANGDUEPHODRANG DISTRICT OF BHUTAN

FINAL REPORT

VOLUME III: SUPPORTING REPORT

APPENDIX-E METEOROLOGY AND HYDROLOGY

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E.1 Introduction

E.1.1 Objective of the Study

The main objective of the meteo-hydrological study is to clarify the meteo-hydrological conditions in the Chang Chhu basin and the study area for the Study on the Groundwater Development in Wangduephodrang District (hereinafter referred to as "the Study").

In the Phase 1 and 2 Field Work, the existing meteo-hydrological data and information were collected, and the field survey and investigation were carried out. Some preliminary studies and analyses were also carried out based on the data and information collected and the field survey conducted to the extent that the principal meteorological and hydrological features of the respective basins and areas were clarified.

In the Home Office Work, further detailed study and analyses were carried out based on the information and study results of Field Work. These results were checked and improved during the Field Work in Phase 3.

The results of the Study are presented below.

E.1.2 Summary of Study

(1) Field Work

The works carried out during the Field Work are summarized below.

- Data collection	Rainfall data	(21	stations)
	Meteorological data	(17	stations)
	Hydrological data	(8	stations)
- Installation and observation of automatic rain gauge recorders		(4	stations)
- Installation and observation of automatic water level recorder		(1	station)
- Installation and observation of water level staff gauge		(9	stations)
- Discharge measurement		(11	sites)

- Data analysis and preparation of simple database
- Other field investigations

(2) Home Office Woke

The study carried out during Home Office Work are summarized below.

- Further data analysis and improvement of simple database
- Estimate of rainfall pattern in the Chang Chhu basin
- Probability analysis of rainfall parameters
- Improvement of Tank Model
- Probability analysis of river discharge at the Chang Chhu
- Estimation of sediment runoff at the Chang Chhu

- Analysis of the date observed through the Study

(3) Summary of Meteorology

The climate of the Chang Chhu basin is classified into the following three (3) categories based on its altitude widely varying from 300 m to above 6,000 m as follows:

- Himalayan zone (altitude of above 3,000 m a.s.l)
- Temperate Himalayan zone (altitude of 1,500 to 3,000 m a.s.l)
- Semi-tropical monsoon zone (altitude of 300 to 1,500 m a.s.l)

The climate of the study area (altitude of 1,200 to 2,800 m) has both characteristics of the temperate Himalayan and the semi-tropical monsoon. The mean monthly rainfall is higher from April to September than that from October to March, and these two (2) periods are generally referred to as the rainy and the dry seasons, respectively.

The meteorological parameters observed in the meteorological station at CARD (13640046, altitude 1,200 m) in Wangduephodrang which is located at the center of the study area are summarized below.

- Annual rainfall	710 mm
- Mean Temperature	19 °C
- Average Maximum Temperature	24 °C
- Average Minimum Temperature	13 °C
- Relative humidity	75 %
- Wind velocity	1.8 m/s
- Sunshine	5.5 hr/day
- Evaporation	1,790 mm/year

(4) Summary of Hydrology

Although there are 26 meteorological stations in and around the Chang Chhu basin, the rainfall data of 21 stations were collected. Only a few stations are located in the high mountain area with on altitude of over 3,000 m a.s.l. Since all the rainfall data do not include snow fall, it is considered impossible to estimate annual precipitation of high mountain area based on these rainfall data.

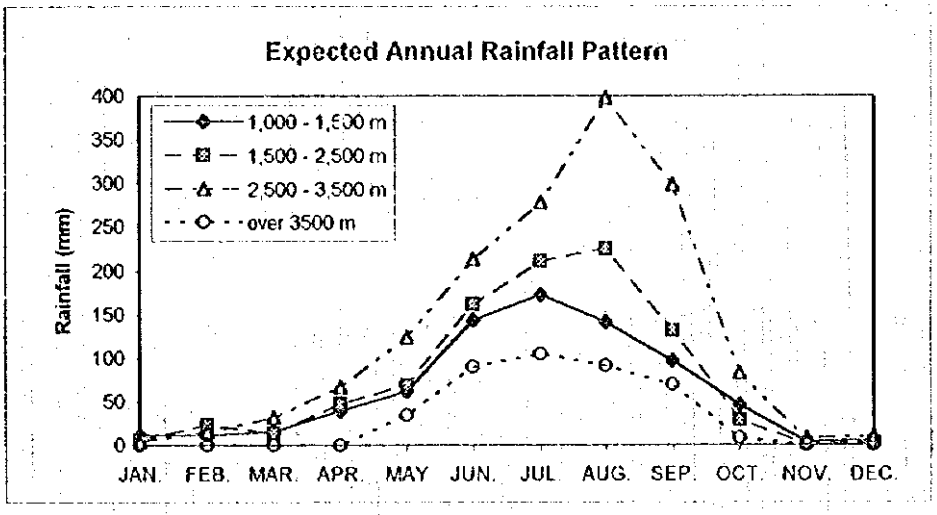
The correlation coefficients of monthly rainfall between every two (2) stations were calculated. Each station has a correlation coefficient of more than 75% with its neighboring stations. Especially a correlation coefficient of more than 80 % was found among the stations located in the same sub-basin of same river system.

The annual rainfall in the basin vary from place to place depending on its altitude as shown below.

Estimated Rainfall in the Study Area

Altitude	Annual Rainfall (mm)
1,000- 1,500 m	700
1,500 - 2,500 m	1,200
2,500 - 3,500 m	1,800
over 3,500 m	500

Using the rainfall data at the stations in the Wangdue Valley, annual rainfall pattern in the Chang Chhu basin was roughly estimated as shown below;



Based on the estimated rainfall and altitude, the rainfall pattern in the study area and at intake site was estimated as shown below;

Estimated Rainfall Pattern in the Study Area and at Intake Site

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Study Area	8	26	17	56	83	193	249	256	153	39	2	4	1,086
Bajo Intake Site	6	22	28	68	120	228	297	384	271	71	6	8	1,509
Lobeysa Intake Site	7	25	26	68	113	226	295	363	245	63	5	7	1,442
Thangyul Intake Site	6	21	33	75	135	243	316	433	315	86	7	10	1,680

Approximately 1,500 mm and 1,600 mm of annual runoff were estimated at Wangdue Rapids on the Chang Chhu and at Yebesa on the Mo Chhu, respectively. These values are considered approximately twice of rainfall at Wangduephodrang. Taking into account of the present basin conditions, the runoff of the basin may be affected by those from glaciers in high mountains.

From the result of Tank Model analysis, the annual water balance at Wangdue Rapids at the Chang Chhu is roughly expected as shown below.

Summary of Water Balance of Chang Chhu

(mm/year)

Rainfall and Snowfall	2,400
Evaporation and Others	1,100
Runoff from Precipitation	1,300
Runoff from Glaciers	200
Total Runoff	1,500

Based on the result of Tank Model analysis, the monthly mean and minimum flow for 10 years were estimated and were summarized as shown below;

Estimated Monthly Mean Discharge at Wangdue Rapids (m3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1985	95.7	108.4	86.6	85.0	99.1	279.3	626.8	524.7	493.1	537.6	244.0	231.0	284.2
1986	107.8	74.6	62.8	61.9	92.6	770.7	672.5	535.0	428.1	342.7	139.9	107.6	283.6
1987	80.7	75.8	152.9	376.9	232.1	381.9	447.0	359.5	495.1	490.0	168.6	92.8	289.0
1988	67.9	66.7	80.6	140.9	195.1	335.7	557.9	535.7	302.9	135.4	99.6	76.2	216.2
1989	84.4	73.9	141.1	70.1	582.0	1109.0	910.4	503.3	567.8	265.3	186.4	87.5	381.8
1990	65.7	100.8	106.1	267.6	191.7	419.9	701.3	504.4	576.8	388.7	153.6	120.9	299.5
1991	132.1	128.3	88.3	77.9	321.7	535.2	498.0	687.7	680.0	251.1	130.0	89.5	301.7
1992	69.2	60.0	88.5	120.6	164.7	318.7	590.5	711.3	439.0	224.5	123.3	84.0	249.6
1993	69.7	66.6	61.8	102.3	225.9	232.7	532.6	811.6	532.2	289.5	146.5	101.1	264.9
1994	76.6	65.3	75.9	133.2	200.5	406.4	431.8	609.2	461.1	293.3	121.9	86.7	247.9
Mean	85.0	82.0	91.4	143.6	231.2	479.1	596.9	598.3	497.6	313.0	151.3	108.3	281.7
Max	132.1	128.3	152.9	376.9	582.0	1109.0	910.4	811.6	680.0	537.6	244.0	231.0	1109.0
Min	65.7	60.0	61.8	61.9	99.1	232.7	431.8	503.3	302.9	135.4	99.6	76.2	60.0

Estimated Monthly Minimum Discharge at Wangdue Rapids (m3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1985	88.9	97.6	67.8	57.9	71.3	172.8	399.6	363.7	338.0	302.5	197.4	194.6	57.9
1986	100.1	67.2	49.5	42.2	71.7	477.0	428.8	371.3	293.5	231.1	112.4	90.7	42.2
1987	75.0	68.3	120.5	256.8	167.0	236.4	285.0	387.8	339.4	269.7	136.4	82.4	68.3
1988	63.0	60.1	63.5	96.0	140.4	207.8	355.7	371.3	207.7	91.3	80.6	64.2	60.1
1989	78.4	66.6	111.2	47.8	418.7	686.4	580.4	348.9	389.3	178.9	150.8	73.7	47.8
1990	61.0	90.8	83.6	182.3	137.9	259.9	447.2	349.7	395.4	262.1	124.3	101.8	61.0
1991	122.7	115.6	69.6	53.1	150.3	211.2	317.5	476.7	379.1	169.9	107.5	78.0	53.1
1992	64.5	55.0	54.7	84.5	125.0	184.2	350.5	441.9	270.5	155.5	98.9	71.8	54.7
1993	64.5	58.9	50.3	67.7	153.6	153.6	383.0	620.9	401.8	186.1	119.5	84.5	58.9
1994	70.9	60.6	69.2	81.9	124.3	208.8	232.6	428.1	296.3	155.6	99.1	76.6	60.2
Mean	78.9	74.1	74.9	97.0	156.9	279.8	376.9	416.9	330.2	205.9	123.7	91.9	74.9
Max	122.7	115.6	120.5	256.8	418.7	686.4	580.4	620.9	401.8	362.5	197.4	194.6	686.4
Min	61.0	55.0	49.5	42.2	71.3	153.6	232.6	348.9	207.7	91.3	80.6	64.2	42.2

Based on the existing hydrological data, the specific discharge in the Study area was estimated as shown below;

Estimated Specific Discharge in the Study Area

(unit : $m^3/s/km^2$)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specific Q	0.022	0.021	0.019	0.027	0.034	0.067	0.104	0.140	0.114	0.051	0.036	0.025

Using this specific discharge, the river discharge at intake site was estimated as shown below;

Estimated Monthly River Discharge at Intake Site

(unit : m^3/s)

River	C.Area(km^2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tabeong Chhu	119.40	2.602	2.509	2.327	3.231	4.034	8.028	12.483	16.755	13.577	6.067	4.286	3.029
Pe Chhu	145.70	3.175	3.051	2.840	3.943	4.922	9.797	15.190	20.446	16.568	7.403	5.230	3.698
Lachhu	2.23	0.048	0.047	0.043	0.060	0.075	0.150	0.232	0.312	0.253	0.113	0.080	0.056
Uship	4.18	0.091	0.087	0.081	0.113	0.141	0.281	0.435	0.585	0.475	0.212	0.150	0.106
Mochuna	8.78	0.191	0.184	0.171	0.237	0.296	0.590	0.915	1.231	0.998	0.446	0.315	0.223
Takarong Chhu	6.80	0.148	0.142	0.133	0.183	0.230	0.457	0.709	0.954	0.773	0.346	0.244	0.172

Using the result of Tank Model Analysis and the runoff characteristics at Wangdue Rapids, the monthly high flow was expected as follows;

Estimated Monthly Maximum Flow at Wangdue Rapids

(unit : m^3/s)

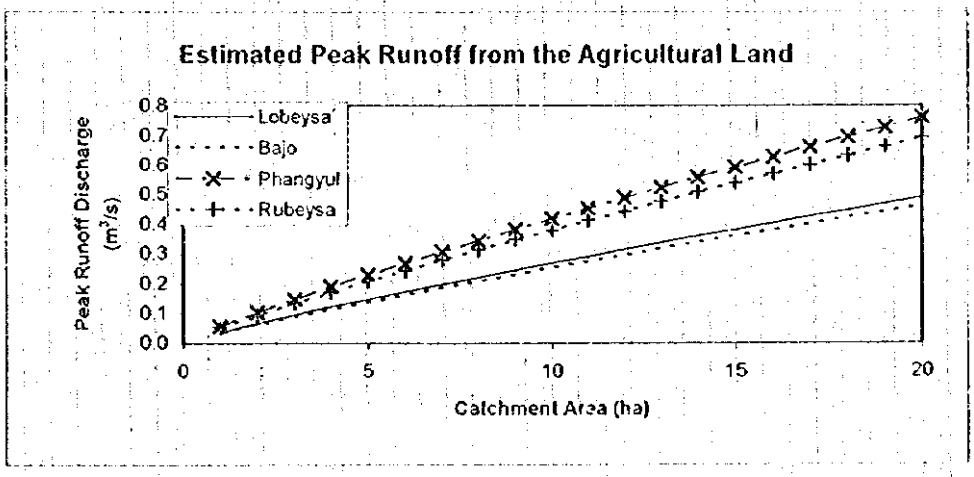
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	107.6	121.8	116.7	128.8	143.3	391.0	1010.7	779.8	680.3	738.8	305.3	270.9	1010.7
1986	121.2	83.8	85.2	93.8	144.2	1079.0	1084.4	796.1	590.8	471.0	173.9	126.2	1084.4
1987	90.8	85.2	207.5	571.0	335.7	534.6	720.8	831.7	683.1	549.7	210.9	114.7	831.7
1988	76.3	75.0	109.4	213.5	282.3	470.0	899.7	796.2	418.0	186.1	124.6	89.3	899.7
1989	94.9	83.1	191.5	105.2	841.9	1552.6	1468.0	748.1	783.4	364.6	233.2	102.6	1552.6
1990	73.9	113.4	144.0	405.4	277.3	587.9	1130.9	749.8	795.9	534.2	192.2	141.7	1130.9
1991	148.5	144.2	119.8	118.0	302.3	477.8	803.0	1022.2	964.0	365.2	158.8	106.3	1022.2
1992	78.3	67.2	138.7	170.9	236.6	612.7	867.5	1094.7	590.5	289.0	155.6	98.3	1094.7
1993	77.9	75.1	71.0	164.9	329.0	425.7	935.2	1163.6	752.8	423.1	181.7	119.6	1163.6
1994	83.5	70.4	110.2	1114.8	292.9	790.6	738.5	833.0	711.3	352.1	168.0	98.1	1114.8
Mean	95.3	91.9	129.4	308.7	318.5	692.2	965.9	881.5	697.0	427.4	190.4	126.8	965.9
Max.	148.5	144.2	207.5	571.0	841.9	1552.6	1468.0	1163.6	964.0	738.8	305.3	270.9	1552.6
Min.	73.9	67.2	71.0	93.8	143.3	391.0	720.8	748.1	418.0	186.1	124.6	89.3	748.1

Using Rational formula, the peak runoff discharge of the main rivers for average year was estimated as shown below;

Estimated Peak Discharge at Main Rivers

Max. 24 hr Rainfall (mm)			58.8		
River	Catchment Area (km^2)	Duration Time (hr)	Rainfall Intensity	Peak Runoff (m^3/s)	Specific Q ($m^3/s\,km^2$)
Pe Chhu	158	40.69	1.88	41.292	0.261
Limti Chhu	34	27.01	2.31	10.905	0.321
Tabe Rongchhu	121	37.89	1.95	32.767	0.271

There are several tributaries in the study area and the direct runoff from the rainfall is drained through these tributaries. The direct runoff come from the agricultural land and the amount of the peak runoff varies depending on the scale of catchment area. Using the Rational Formula mentioned above, the relationship between the catchment area and the peak runoff discharge was analyzed as shown below;



Using the result of the low and high flow analyses at Wangdue Rapids, the probability analysis was carried out for the Chang Chhu and other rivers. The results are summarized as shown below;

Result of Runoff Probability Analysis at Chang Chhu and Dang Chhu

(m^3/s)

Site	Wangdue Rapids			Upper Part of Chang Chhu			Dang Chhu		
Catchment Area (km^2)	5640			4956			684		
Return Period	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
1/500	191.7	2017.3	36.8	168.4	1772.6	32.3	23.2	244.7	4.5
1/200	198.1	1858.8	38.4	174.1	1633.4	33.7	24.0	225.4	4.7
1/100	203.7	1741.2	39.8	179.0	1530.1	35.0	24.7	211.2	4.8
1/50	210.4	1625.0	41.4	184.8	1428.0	36.4	25.5	197.1	5.0
1/20	221.2	1472.6	43.9	194.3	1294.0	38.6	26.8	178.6	5.3
1/10	231.7	1356.1	46.2	203.6	1191.7	40.6	28.1	164.5	5.6
1/5	245.9	1235.4	49.2	216.1	1085.6	43.2	29.8	149.8	6.0
1/2	277.9	1054.9	55.5	244.2	927.0	48.8	33.7	127.9	6.7

Result of Runoff Probability Analysis for Other Rivers

($m3/s$)

Site	Pe Chhu			Linti Chhu			Tabe Rongchhu		
Catchment Area (km2)	158			34			121		
Return Period	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
1/100	5.708	176.26	1.115	1.228	46.55	0.240	4.371	139.87	0.854
1/50	5.893	148.26	1.159	1.268	39.16	0.249	4.513	117.65	0.888
1/20	6.195	114.50	1.229	1.333	30.24	0.264	4.745	90.87	0.941
1/10	6.492	91.15	1.295	1.397	24.07	0.279	4.972	72.33	0.991
1/5	6.889	69.27	1.379	1.483	18.29	0.297	5.276	54.97	1.056
1/2	7.785	41.29	1.555	1.675	10.91	0.335	5.962	32.77	1.191

Using the river section and the result of probability analysis, the river flow at the Chang Chhu was analyzed applying the non-uniform flow calculation. Based on this result, the flow conditions at the river pump station in CARD are summarized below;

Estimated Water Level at CARD River Pump Station (TP.m)

Return Period	River Bed	1/500	1/200	1/100	1/50	1/20	1/10	1/5	1/2
Mean flow	1193.4	1195.9	1195.9	1196.0	1196.0	1196.1	1196.2	1196.3	1196.5
Maximum flow	1193.4	1200.5	1200.2	1199.9	1199.6	1199.3	1199.0	1198.7	1198.2
Minimum flow	1193.4	1194.9	1194.9	1194.9	1194.9	1194.9	1194.9	1194.9	1195.0

Using the suspended sediment and the river discharge data at Wangdue Rapids and Yebesa, the relationship between river discharge and suspended sediment was analyzed. The results are summarized below.

Wangdue Rapids $SS = 0.00884 \times Q^{2.009}$ (Correlation Coefficient: 95 %)
Yebesa $SS = 0.01086 \times Q^{2.091}$ (Correlation Coefficient: 86 %)

where; SS : Suspended Sediment (t/day)
Q : Daily Mean Discharge (m^3/s)

The sediment runoff at both stations was estimated, using the actual daily discharge data and above equations. Approximately 414 thousand ton of annual sediment runoff was estimated at Wangdue Rapids and this amount is expected to be around 745 thousand m^3/year (110 m^3/km^2/year). On the other hand, approximately 140 thousand ton of that was estimated at Yebesa and it is also expected to be 252 thousand m^3/year (100 m^3/km^2/year).

E.2 Field Work

E.2.1 Data Collection

(1) Rainfall Data

Although there are 26 meteorological stations in and around the Chang Chhu basin, the rainfall data at 21 stations are available for the Study in the Thimphu, Punakha, Wangduephodrang and Gasa districts as shown in Table E.2.1 and Fig E.2.1. The daily rainfall data of these 21 stations were collected.

(2) Meteorological Data

The meteorological data are available in 17 meteorological stations in and around the Chang Chhu basin as listed in Table E.2.1. The meteorological parameters were collected on daily basis.

(3) Hydrological Data

There were 22 secondary hydrological stations over the territory of Bhutan in 1990, and almost half of them were replaced with primary stations or closed when the study on the Bhutan Power System Master Plan having been conducted under the finance of IBRD since 1990. As a result, 15 principal stations presented in Fig. E.2.2 and Table E.2.2 have been established so far and the data recorded in these stations are processed with the application provided with the said project.

Out of these stations, eight (8) hydrological stations were selected and the hydrological data necessary for the Study are collected, which mainly include the records of daily mean river water level and daily mean river discharge.

(4) Sediment Data

The data for suspended sediment were collected at the following hydrological stations.

Hydrological Station	Catchment Area (km^2)
Wangdue Rapids	5,640
Yebesa	2,320

E.2.2 Establishment of Meteo-hydrological Stations

(1) Stream Gauging Stations

In order to confirm stream condition in the study area, nine (9) stream gauging stations were established at the locations shown in Table E.2.3 and Fig. E.2.3.

(2) Rainfall Gauging Stations

in order to confirm the rainfall condition in the study area, four (4) rainfall gauging stations were established at the locations shown in Table E.2.3 and Fig. E.2.3.

E.2.3 River and Canal Discharge Measurement

For the purpose to confirm the stream condition in the Study area and to estimate the H-Q rating curve for the hydrological stations installed, the river and canal discharge measurements were carried out. The locations of these discharge measurements are shown in Fig. E.2.3 and their results are summarized in Table E.2.4.

E.2.4 Preliminary Design of Simple Database

The meteorological and hydrological data collected during the Field Work were installed in the computer provided by JICA, and a simple database system was designed preliminarily using the software "Excel".

The simple database developed is summarized as shown below.

Summary of Database System

Directory	Sub-Directory	Data	Remark
C:\WPDB	RAIN	Rainfall Data (21 Station)	Collected from DoP
	METE	Other Meteorological Data (17 Stations)	"
	HYDRO	Hydrological Data (8 Stations)	"
	SEDIMENT	Sediment Data (2 Stations)	"
	RAINREC	Rainfall Data (4 Stations)	Observed by Study Team
	WL	River Water Level Data (9 Stations)	"
	HQRATIN	Discharge Measurement Data (9 Stations)	"

E.3 Availability of Meteo-hydrological Data

E.3.1 Meteorological Data

The Power Division is responsible for collecting, processing and distributing the meteorological data recorded at the meteorological stations in the whole country. The meteorological stations in and around the Chang Chhu basin including rainfall stations, are operated by REID, Power Division and other institutions. All data are registered by Power Division from which all data are obtained in daily and monthly forms.

(1) Rainfall Data

There are 21 unevenly distributed rainfall gauging stations in and around the Chang Chhu basin, where the rainfall data have been observed for more than three (3) years. Though the daily rainfall has been continuously observed at most of the stations since 1985, frequent interruptions of the records are found. Most of the rainfall data is considered applicable for the Study except the data at station Shengana (13830046), which indicate unbelievably large amount. The available data periods of rainfall at these stations are shown in Fig. E.3.1.

(2) Other Meteorological Data

There are 17 meteorological stations in and around the Chang Chhu basin, and the parameters other than rainfall are recorded. The continuous data are not available throughout an entire record period since its installation due to interruption of the observation. The temperature data is only available for the Study except the meteorological data at station CARD. (13640046). The continuity of data at these meteorological stations is shown in Fig. E.3.1.

E.3.2 Hydrological Data

The Power Division is responsible for the collection of hydrological data in Bhutan. Daily mean water level and discharge data are available in the said division. The hydrological data of the eight (8) stations were collected, and the availability of such hydrological data that are collected at these stations is shown in Fig. 7.3.1. The sampling period of suspended sediment data at two (2) stations is also shown in Fig E.3.1.

E.4 Meteorology

The climate of the Chang Chhu basin is classified into the three (3) categories based on its altitude widely varying from 300 m above 6,000 m as follows:

- Himalayan zone (altitude of above 3,000 m a.s.l) characterized by severely cold winter and short and cold summer. The area of the altitude over 4,250 m is considered non-cultivable, and the snow area extends on the mountains above approximately 5,500 m. Any crop except cold resistance such as potato and barley can not grow in this zone.

- Temperate Himalayan zone (altitude of 1,500 to 3,000 m a.s.l) characterized by moderately warm summer and cool winter. The annual rainfall thereof is varying from 500 to 1,200 mm. Rice, banana and orange grow in rather low area, and broad-leaved trees are found in the southern slope of hilly area.

- Semi-tropical monsoon zone (altitude of 300 to 1,500 m a.s.l) characterized by high temperature and humidity. The annual rainfall is observed as above 500 mm, and it sometimes reaches 2,000 mm. The tropical jungle covers most of the area, but there are some dry areas like savanna.

The climate of the study area (altitude of 1,200 to 2,800 m) has both characteristics of the temperate Himalayan and the semi-tropical monsoon.

E.4.1 Rainfall

While rainfall occurs throughout a year in the Chang Chhu basin, it is extremely variable and undependable. The monthly rainfall data are summarized in Table E.4.1, and seasonal rainfall pattern at several rainfall stations is shown in Fig. E.4.1.

Based on the rainfall data in and around the Chang Chhu basin, 500 to 800 mm of

average annual rainfall is expected in Thimphu city area (altitude around 2,400 m a.s.l) and Wangdue Valley area (altitude around 1,200 m a.s.l), and 1,200 mm is observed at Dochu-la (altitude around 3,000 m a.s.l). About 1,500 mm of average annual rainfall is expected at the eastern part of the Dang Chhu basin (altitude around 2,600 m a.s.l) which is one of the main tributaries of the Chang Chhu. Approximately 1,800 mm of average annual rainfall is expected at Gasakhatey (altitude around 2,800 m a.s.l) which is located at upper part of the Mo Chhu. In Lingshi (altitude 4,100 m a.s.l) one of the origins of the Mo Chhu, only 400 mm of average annual rainfall is expected.

The mean monthly rainfall is higher from April to September than that from October to March, and these two (2) periods are generally referred to as the rainy and the dry seasons, respectively. More than 80 % of annual rainfall is expected from April to September, and about 60 % of annual rainfall is observed from June to August.

E.4.2 Temperature

The monthly temperature data is summarized in Table E.4.2 and Fig. E.4.2. The relationship between annual mean temperature and altitude is found out clearly as shown in Fig. E.4.3 and summarized below:

Annual Average Temperature (°C)

Altitude (m a.s.l)	Mean	Maximum	Minimum
1,000 - 1,500	19	25	15
1,500 - 2,500	15	20	10

In general, the winter season is considered from December to February and it is coldest in January. The summer season is considered from June to September, and the temperature observed is considered constant throughout these months. It is quite rare to observe the snowfall in the Wangdue Valley.

E.4.3 Other Parameters

The meteorological data other than rainfall and temperature are available for the Study only at station CARD. The data are summarized as shown in Table E.4.3 and Fig. E.4.4.

(1) Relative Humidity

The monthly average relative humidity (%) in the CARD station was estimated as shown below.

Summary of Relative Humidity (%)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
74.8	73.2	71.0	66.7	73.0	78.3	81.0	80.7	81.0	75.3	73.0	74.3	75.2

The mean annual relative humidity was estimated as 75%. The relative humidity at CARD does not vary throughout a year.

(2) Sunshine

The monthly average of sunshine duration (hr/day) at CARD station is shown below.

Summary of Sunshine (hr/day)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
5.0	5.2	5.7	6.1	5.1	4.1	5.1	5.0	5.2	6.6	6.5	6.0	5.5

The mean annual duration of sunshine was estimated as 5.5 h/day. The mean monthly duration of sunshine is generally higher during the period from October to December than other months.

(3) Wind Velocity

The average monthly mean wind velocity (m/sec) in the CARD station is calculated as shown below.

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1.4	1.9	2.2	2.3	2.2	2.2	2.0	1.6	1.5	1.5	1.2	1.2	1.8

The mean annual wind velocity was estimated as 1.8 m/sec. The wind velocity during the period from February to July is higher than that from August to January. According to the field interview, the wind velocity in the afternoon is much higher than that in the morning throughout a year. Especially in some high land areas (altitude more than 1,500 m a.s.l), more than 2 m/sec of wind velocity often occur in the afternoon.

(4) Evaporation

The annual mean monthly evaporation (mm/day) in the CARD station is shown below.

Summary of Evaporation (mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
2.6	4.1	5.2	6.4	6.1	6.4	6.3	5.4	5.1	4.8	3.7	2.9	4.9

The mean annual evaporation is estimated as 4.9 mm/day. The mean monthly evaporation is higher during the period from March to August than that from September to February.

E.5 Hydrology

E.5.1 General

(1) Drainage System in Bhutan

There are the following four (4) major drainage systems in Bhutan.

- Manas Chhu basin
- Chang Chhu Sankosh basin
- Wang Chhu
- Amo Chhu basin

The Chang Chhu basin belongs to the Chang Chhu Sankosh basin, the second largest basin in the country. Most of the rivers originate in high mountain range of Himalayas of over 7,000 m a.s.l., and flow out to Bengal Bay passing the Indian and Bangladesh territories through Brahmaputra and Ganges rivers. The major drainage system in Bhutan are presented in Fig. E.5.1.

(2) General Conditions of Chang Chhu Basin

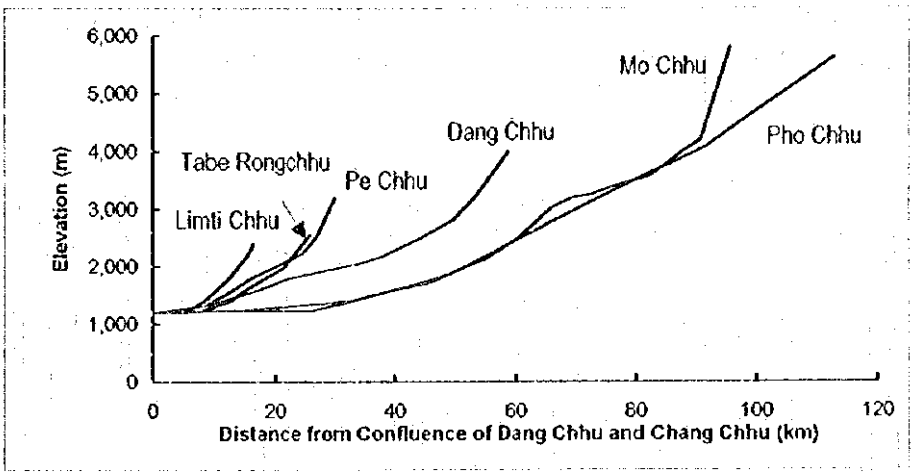
The Upper Chang Chhu basin defined in this Study as those river basins that are located at the upstream of Wangdue Rapids Stream Gauging Station of the Chang Chhu is divided into the following five (5) major sub-basins from north to south as shown in Fig. E.5.2. The catchment area are summarized as shown below;

Chang Chhu System

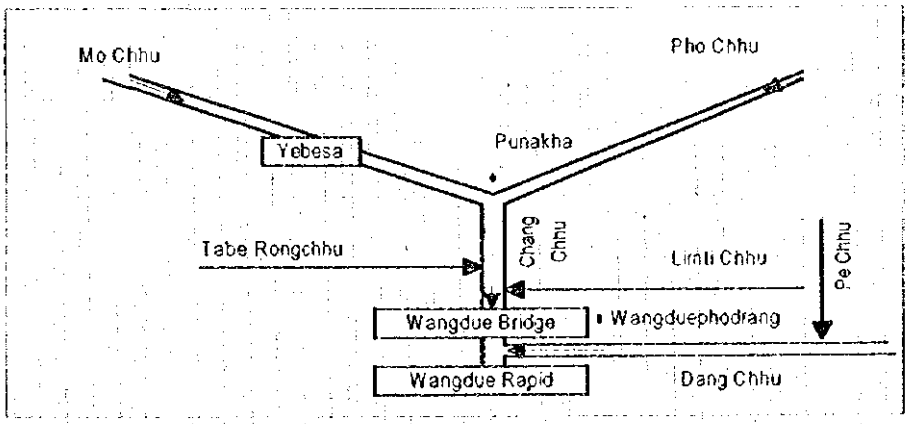
Sub-basin	River and Tributary	Catchment Area (km^2)			River Length (km)
		Unit Basin	Sub-total	Total	
Mo Chhu	Mo Chhu at Yebesa	2,320			
	Mo Chhu at confluence	39	2,359		81.0
Pho Chhu	Pho Chhu at confluence	2,368	2,368		94.5
Pho - Mo Chhu Confluence				4,727	-
Chang Chhu	Tabe Roegchhu	121			17.7
	Limti Chhu	34			11.2
	Chang Chhu (1)	2			
	Chang Chhu (2)	16			
	Chang Chhu (3)	13			
	Chang Chhu (4)	5			
	Chang Chhu (5)	37	228		14.5
Dang Chhu	Pe Chhu	158			21.6
	Dang Chhu (1)	491			
	Dang Chhu (2)	35	684		57.8
Chang - Dang Chhu Confluence				5,639	-
Chang Chhu (6)	-	1			-
Chang Chhu at Wangdue Rapids		-		5,640	-

The total drainage area of the Upper Chang Chhu basin is measured to be 5,640 km^2 at the Wangdue Rapids Stream Gauging Station Site.

The present conditions of each basin of the Chang Chhu basin are briefed below, and their longitudinal profiles and the schematic diagram are shown below;



Longitudinal Profile of Change



Chang Chhu Drainage System

1) Mo Chhu Sub-basin

The Mo Chhu sub-basin area is measured to be 2,359 km^2, and considered to be one of the largest sub-basin in Upper Chang Chhu basin. It originates in the glacier zone located at the north end of the country, the Himalayan Range of over 7,000 m a.s.l. The river flows through narrow and deep gorge southward joining many tributaries, and near Gasakatey meets the Same Chhu flowing from Lingshi. The river runs southward to reach the confluence with the Pho Chhu at Punakha. The river length from the most upstream to the confluence with the Pho Chhu is measured to be about 81 km. A stream gauge station operated by Power Division is located at Yebesa, seven (7) km upstream of the confluence with the Pho Chhu. The drainage basin with on altitude of over 5,000 m is covered by snow throughout a year, while the other remaining parts are covered with well dense forest or little cultivated lands.

2) Pho Chhu Sub-basin

The Pho Chhu, which is also considered as one of the largest sub-basin in the Upper Chang Chhu basin, starts its flow in the glacier zone of Himalayan

Range of over 7,000 m a.s.l, and flows southeastward in the high mountain range collecting drainage of glaciers. It changes its flow direction gradually toward south, and reaches the confluence with the Mo Chhu at Punakha joining the tributaries such as Si Chhu, etc. The drainage area is measured to be about 2,369 km^2 at the confluence. The basin is covered by deep forest consisting mainly of well-grown pine trees except for the snow-covered areas located in the high mountain ranges of over 5,000 m a.s.l. The distance from its uppermost reach to the confluence is measured to be about 95 km.

3) Tabe Rongchhu Sub-basin

The Tabe Rongchhu originates in the mountain range located east to Thimphu, and runs eastward along the narrow valley, and flows into the Chang Chhu near Lobeysa. Many villages are scattered along the river and its small tributaries, and the cultivated land is developed. The vegetation of the basin is fairly good in upstream portion, but in lower reach near Lobeysa it becomes poor due to dry climate in Wangdue Valley. The distance to the confluence is measured to be about 18 km, and the drainage area of 121 km^2. There are many small intakes constructed by local farmers to divert river water for irrigating their cultivated lands along the river. Two (2) intakes; Lobeysa Upper and Lower canals are also located on the middle reach of this river.

4) Limti Chhu Sub-basin

The Limti Chhu originate in the hilly area of about 2,400 m a.s.l. near the Limbukha village which is located north to Bajo area. The river flows southward, and flows into the Chang Chhu in the Bajo area. The vegetation of its catchment area is not so dense, and the cultivated lands are expanded in the flat and sloped areas along the river. The river length is measured to be about 11 km, and the drainage area is 34 km^2.

5) Dang Chhu Sub-basin

At the Wangduephodrang town, the Dang Chhu which has an estimated drainage area of 684 km^2, flows into the Chang Chhu from the left bank. The Dang Chhu originates in the mountain area of about 5,000 m that is located at around 27°45'N and 90°15'. The river flows southward, changes its direction to west gradually, and flows into the Chang Chhu near Wangduephodrang town. At the point 7.5 km upstream of the confluence with the Chang Chhu, the Pe Chhu, which has a length and drainage area of 22 km and 158 km^2, respectively, flows into this river. The total drainage area of the Dang Chhu at this confluence is measured to be 649 km^2. The Pe Chhu is the important source of domestic water for Wangduephodrang town as well as the irrigation water for the Bajo area. Its intake facility is constructed on the Pe Chhu about one (1) km upstream of the confluence of the Dang Chhu and Pe Chhu, and an open channel and a pipeline of two (2) 10 cm-dia. steel pipes are installed along the foothill of Phangyul hill area to convey the intake water to the water treatment plant in Wangduephodrang town. The vegetation of this basin mainly consist of dense forest in the high mountain area of over 2,000 m, and in the

low lands along the river cultivated lands are developed. At Wangdue Rapids which is located downstream of the Chang Chhu and the Dang Chhu, there is a stream gauging station, and the total drainage area of the Chang Chhu basin at this station point is measured to be 5,640 km^2.

(3) Basin Condition of Study Area

The Study area of 65 km^2 is composed mainly of the Chang Chhu and the Dang Chhu basins. The Chang Chhu and the Dang Chhu flow from north to south and from east to west, respectively, and join each other at the south to the Wangduephodrang town.

The Chang Chhu, which flows through flat lands of the Bajo and the Lobeysa sub-areas, has two (2) perennial tributaries, namely the Limti Chhu on left bank and the Tabe Rongchhu on right bank. The Tabe Rongchhu has a drainage area of about 18 km^2, but most of the area extends out of the study area. The Limuti Chhu originating in the Limbukha village is also considered similar to the Tabe Rongchhu, and most of its drainage area is located out of the study area, though it has a drainage area of about 12 km^2. Since both sub-areas have limited and poorly vegetated areas of watersheds, most of rainfall in such sub-areas is judged to be drained rapidly to the Chang Chhu without any retarding.

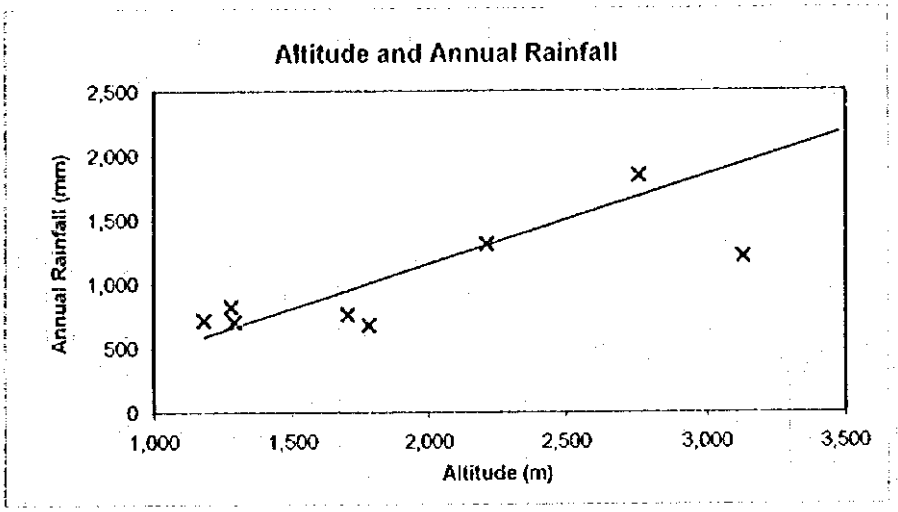
On contrary, the Dang Chhu has a few flat planes along its course in the study area, and both sides of bank are formed of steep and deep valley. The Phangyul and the Rubeysa sub-areas are located on elevated high hilly lands from 1,600 m to 2,000 m. The Phangyul sub-area has a limited area of Watersheds, and rainfall in this area is considered to be drained rapidly to the Dang Chhu similar to the other sub-areas in the Chang Chhu basin. The rainfall in these elevated lands are expected to be larger than those in other two (2) sub-areas in the Chang Chhu basin due to their altitude.

E.5.2 Rainfall Analysis

(1) Characteristics of the Rainfall at the Chang Chhu Basin

The correlation coefficients of monthly rainfall were calculated for every two stations as shown in Table E.5.1. Each station has a correlation coefficient of more than 75% with its neighboring stations. Correlation coefficients of more than 80 % were found especially among the stations located along the Wangdue Valley from North to South.

The relationship between altitude and mean annual rainfall at the stations in Wangdue Valley is shown below;



From this figure, the following tendency is expected.

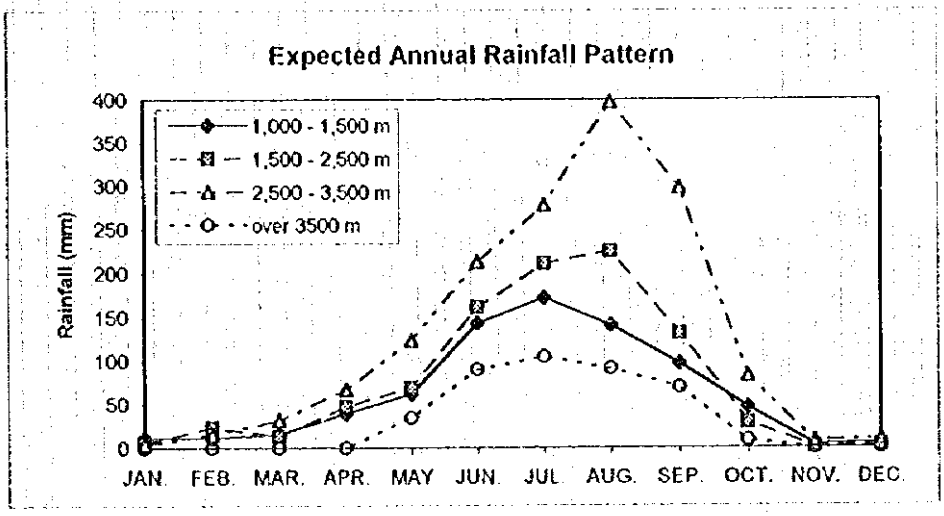
Expected Rainfall in the Study Area

Altitude(m)	Annual Rainfall (mm)	Area(km2)
1,000 - 1,500	700	92
1,500 - 2,500	1,200	791
2,500 - 3,500	1,800	1,085
over 3,500	500	3,672

In the Thimphu city area, similar kind of tendency is not found.

(2) Expected Annual Rainfall Pattern in the Chang Chhu Basin

Using the rainfall data at the stations in the Wangdue Valley, annual rainfall pattern in the Chang Chhu basin was roughly estimated as shown below;



More than 85% of the annual rainfall is expected to occur during the period from April to September, and especially in the area of altitude of over 1,500 m more than 90% of annual rainfall is expected. About 60% of annual rainfall is expected

during the period from June to August in whole areas, and only in the area of altitude from 2,500 to 3,500 m, the amount of rainfall during the period from July to September is larger than that from June to August.

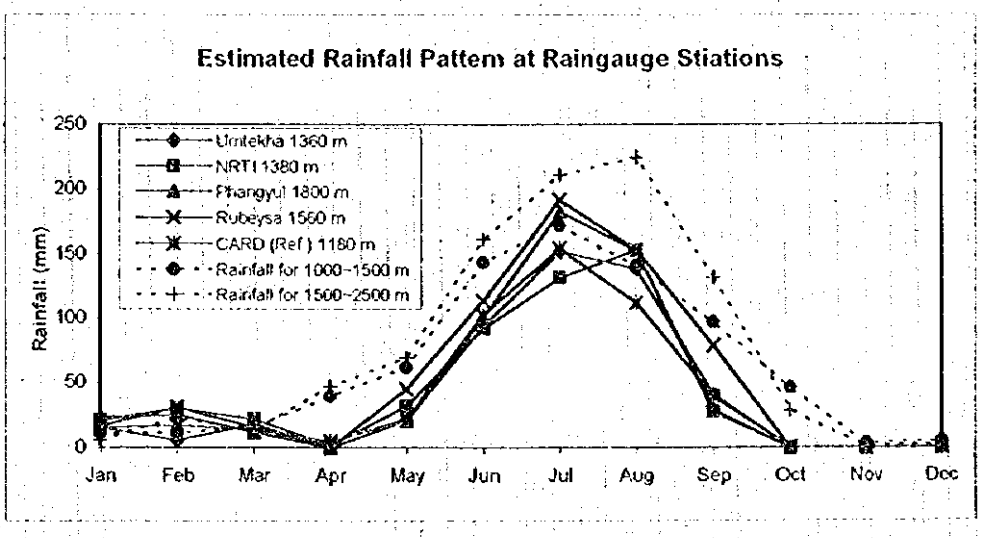
Four (4) automatic rain gauge recorders were installed and the rainfall data has been observed for 15 months. The original data was organized as shown in the Data Book II and summarized as shown below;

Summary of Recorded Rainfall

(Unit: mm)

Station	Elevation (m)	1994 Jun	Jul	Aug	Sep	Oct	Nov	Dec	1995 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Umtekha (RG1)		105	98	152	41	0	0	0	15	6	18	0	21	83	205	125
(1-year Total)	1,360												(456)	(434)	(541)	(514)
NRTI (RG2)		113	81	151	28	0	0	0	21	30	22	2	32	71	182	154
(1-year Total)	1,380												(480)	(438)	(539)	(542)
Phangyul (RG3)		124	135	174	29	0	0	1	23	25	12	0	21	77	230	132
(1-year Total)	1,800												(544)	(497)	(592)	(550)
Rubeysa (RG4)		166	162	194	79	0	0	0	17	31	16	0	45	62	221	113
(1-year Total)	1,560												(710)	(666)	(665)	(584)
CARD (Ref.)		119	134	167	40	1	0	0	15	17	14	5	22	103	155	112
(1-year Total)	1,180												(534)	(518)	(558)	(483)

In 1995, the rainy season was started at end of May and it was about two months delayed than that of average year. The estimated rainfall pattern at the stations based on the recorded data is shown below and these are quite similar with that for 1,000 ~ 2,500 m.



Looking for the total amount of the 12 months rainfall for June 1994 to August 1995, it is assumed this period was one of the drought periods for this area considering the data series at the CARD. As for analyzing in this aspect, it is necessary to observe at least more than five (5) years and to analyze in more detail.

In the Study, more rainfall analysis was carried out based on this result.

The area at each elevation is shown in Fig. E.5.3 and is summarized below;

Distribution of Area by Altitude

(unit km²)

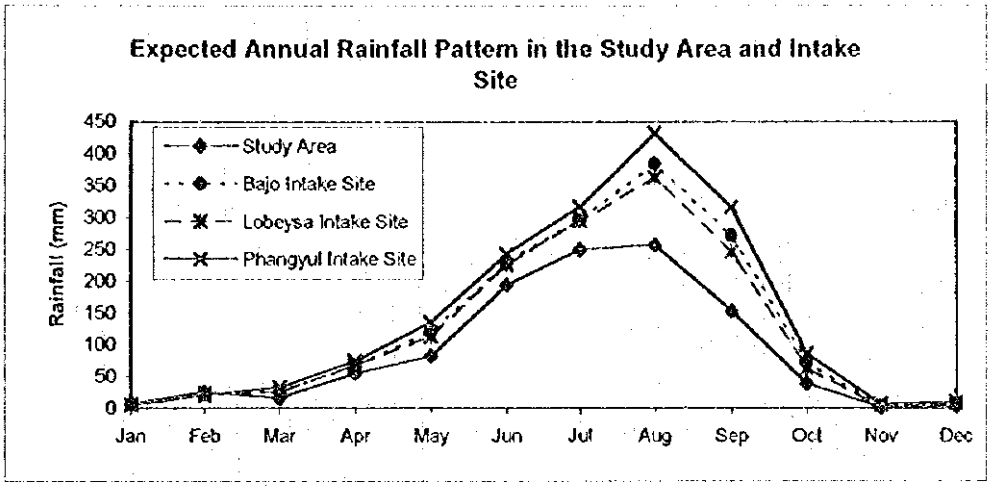
Area in the Sub-basin								
Sub-basin	River & Tributary	Altitude (m) 1000-1500	1500-2000	2000-2500	2500-3000	3000-3500	Over 3500	Total
Mo Chhu	Mo Chhu at Yebesa	1.5	67.1	138.4	142.5	245.2	1711.8	2320.0
	Mo Chhu at Confluence	16.5	104.6	138.4	142.5	245.2	1711.8	2359.0
Pho Chhu	Pho Chhu at Confluence	26.9	109.6	121.2	125.6	199.6	1785.1	2368.0
Pho - Mo Chhu Confluence		43.4	214.2	259.6	268.1	444.8	3496.9	4727.0
Chang Chhu	Tabe Rongchhu	3.3	23.7	44.4	31.6	18.0	-	121.0
	Limti Chhu	2.9	11.1	15.1	4.9	-	-	34.0
	Chang - 1	0.7	1.3	-	-	-	-	2.0
	Chang - 2	9.1	6.9	-	-	-	-	16.0
	Chang - 3	6.1	6.9	-	-	-	-	13.0
	Chang - 4	3.6	1.4	-	-	-	-	5.0
	Chang - 5	10.1	17.6	6.2	3.1	-	-	37.0
Sub-total at Chang Chhu		79.2	283.1	325.3	307.7	462.8	3496.9	4955
Dang Chhu	Pechhu	2.1	14.3	48.4	56.6	28.5	8.1	158.0
	Dang - 1	3.2	26.9	64.8	106.5	122.9	166.7	491.0
	Dang - 2	6.5	16.1	12.4	-	-	-	35.0
Sub-total at Dang Chhu		11.8	57.3	125.6	163.1	151.4	174.8	684.0
Chang - Dang Chhu Confluence		91.0	340.4	450.9	470.8	614.2	3671.7	5639.0
	Chang - 6	1.0	-	-	-	-	-	1.0
Chang Chhu at Wangdue Rapids		92.0	340.4	450.9	470.8	614.2	3671.7	5640.0

New Stream Gauge Station							
Stations	Altitude (m) 1000-1500	1500-2000	2000-2500	2500-3000	3000-3500	Over 3500	Total
SR1	0.7	9.4	42.4	56.6	28.5	8.1	145.7
SR2	2.2	26.9	64.8	106.5	122.9	166.5	489.8
SR3	8.3	43.0	77.2	106.5	122.9	166.7	524.6
SR4	0.9	11.1	15.1	4.9	-	-	32.0
SR5	3.3	23.7	44.4	31.6	18.0	-	121.0
SR6	1.7	23.7	44.4	31.6	18.0	-	119.4

Using those areas and the expected rainfall patterns in the Study Area, the total average rainfall was estimated as low as only 800 mm/year.

(3) Estimated Annual Rainfall Pattern in the Study Area and at Intake Site

The altitude of the study area varies from 1,200 m to 2,500 m approximately, and its annual rainfall pattern was roughly expected as shown below using the expected annual rainfall pattern and the distribution area by altitude. For the catchment area of the Bajo, Lobeysa and Phangyul canal, the annual rainfall pattern was also estimated.



The expected rainfall pattern is tabulated as shown below;

Expected Rainfall Pattern in the Study Area and at Intake Site

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Study Area	8	26	17	56	83	193	249	256	153	39	2	1	1,086
Bajo Intake Site	6	22	28	68	120	228	297	384	271	71	6	8	1,509
Lobeysa Intake Site	7	25	26	68	113	226	295	363	245	63	5	7	1,442
Phangyul Intake Site	6	21	33	75	135	243	316	433	315	86	7	10	1,680

Comparing with rainfall pattern at CARD, the annual rainfall in the study area is expected to be around 50% more than that at CARD. However, during November and December, however, it is expected to be less than 50% of the monthly rainfall at CARD.

(4) Probability Analysis

The probability analysis was carried out on the following items and the results are shown in Table E.5.2.

- Annual Rainfall
- Maximum 24 hr Rainfall
- Maximum 3 days Rainfall
- Continuous Days without Rainfall (less than < 0.1 mm)
- Continuous Days without Rainfall (less than < 5.0 mm)

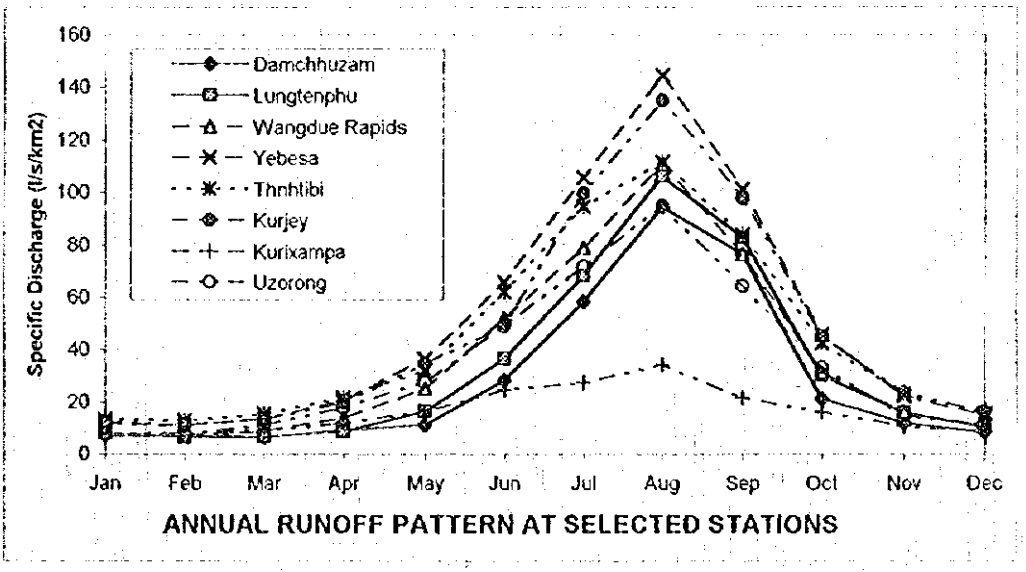
The analyses were conducted for the 12 stations which is considered to have acceptable data continuity.

E.5.3 Runoff Analysis

(1) Characteristics of Runoff

1) River Discharge at Selected Stations in Bhutan

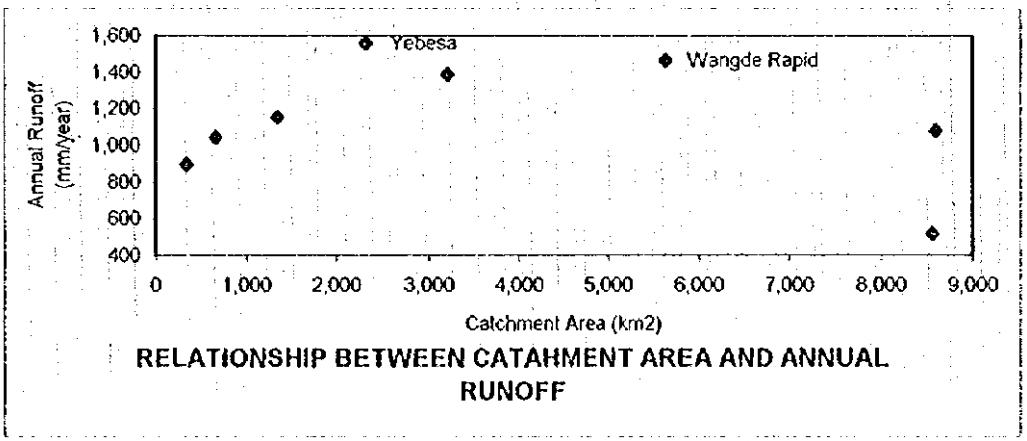
River discharges at eight (8) stations listed in Table E.2.2 are summarized in Table E.5.3, and their specific discharges are summarized as shown below;



ANNUAL RUNOFF PATTERN AT SELECTED STATIONS

In general, the amount of river discharge is rising up from April and the maximum discharge is observed in August. The low flow season starts from November and lasts until April. Comparing with rainfall pattern, the high and the low flow seasons occur with one (1) month delay from the rainy and the dry seasons, respectively. About 70% of annual runoff occurs during the period from May to October, and 40% to 70% during the period from June to August. Discharge during February and March are considered to be the lowest.

The relationship between catchment area and annual runoff is shown below;



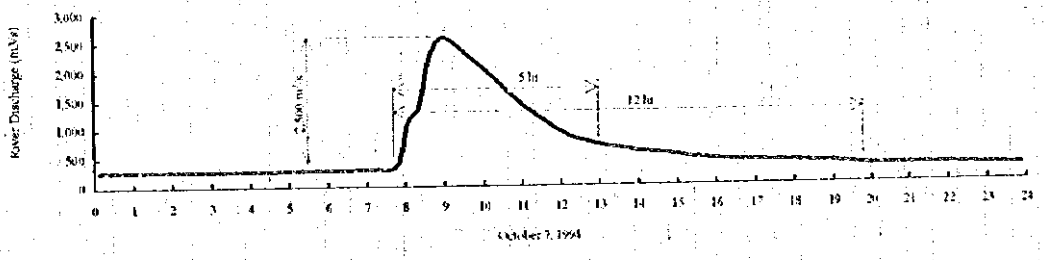
RELATIONSHIP BETWEEN CATAHMENT AREA AND ANNUAL RUNOFF

About 1,500 mm/year of annual runoff is expected for the Yebesa and the Wangdue Rapids stations, and this value is considered to be the highest among the eight (8) stations. Though comparatively low amount of annual rainfall is observed at the stations with catchment area of less than 2,000 km^2, those stations are located in the area with an altitude of more than 2,000 m a.s.l.

2) Chang Chhu Basin

According to the runoff discharge data at Wangdue Rapid and Yebesa, the Chang Chhu basin is considered to be one of the highest runoff area in Bhutan. The daily discharge at both stations are shown in Fig. E.5.4.

As shown in this Figure an extraordinary flood occured, on the October 7th, 1994, because of the outburst of glacial lake named Lugge which is attached to the glacier and is located on the eastern tributary of the Pho Chhu and the maximum flood discharge was estimated as more than 2,500 m^3/s. This amount of discharge might be more or less 3 ~ 4 times larger than that of usual flood in the rainy season. According to the discharge data of DOP, the hydro pattern on that day are shown as below;



Hydrograph of the Flood in October 7, 1994 by the Outburst of Glacial Lake

The flooding period was around only 5 hours and this amount did not have much influence to the mean monthly discharge. Therefore, it was not necessary to consider this phenomenon for hydrological analyses except for high flow and sediment runoff analysis.

The monthly discharges at both stations are shown in Table E.5.4. In the lowest flow season, the difference between monthly maximum and minimum discharges is found to be within the range less than +/-10 % of monthly mean discharge, while in the high flow season it reaches to a range from +/-40 to 50%.

3) Study Area

There are a few perennial tributaries in the study area. The rainfall in the study area seems to flow down to the Chang Chhu within a few hours. Some water flows from adjacent areas through artificial canals.

The daily water revel has been observed at the stations as shown in Fig. E.2.3 for June 1994 to August 1995 and the recorded data are tabulated as shown in

the Data Book II. The discharge measurement has been carried out at these stations as shown in Table E.2.4 and, based on this result and site conditions such as flow section, longitudinal slope, etc., H-Q rating curve at each stations was estimated as shown in Fig. H.5.5. The coefficients of rating curve are tabulated as shown below;

Coefficients of H-Q Rating Curve

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

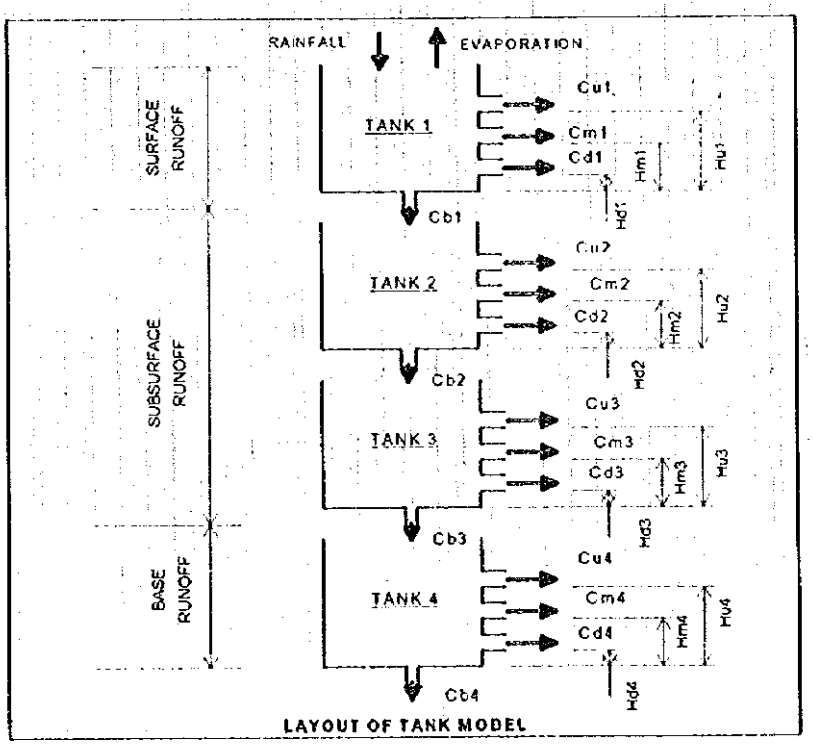
	a	b	c
SR1	2.640	2.399	0.770
SR2	6.640	2.426	1.200
SR3	11.354	2.755	0.810
SR4	2.581	2.470	0.100
SR5	20.456	2.657	0.200
SR6	10.782	2.605	0.350
SC1	5.466	1.438	0.000
SC2	7.819	2.198	0.000
SC3	3.149	1.980	0.000

Using the water level record and these coefficients, the daily discharge were estimated and the results are shown in the Data Book II and are summarized as shown in Table E.5.5.

(2) Low Flow Analysis

1) Low Flow Analysis for Chang Chhu

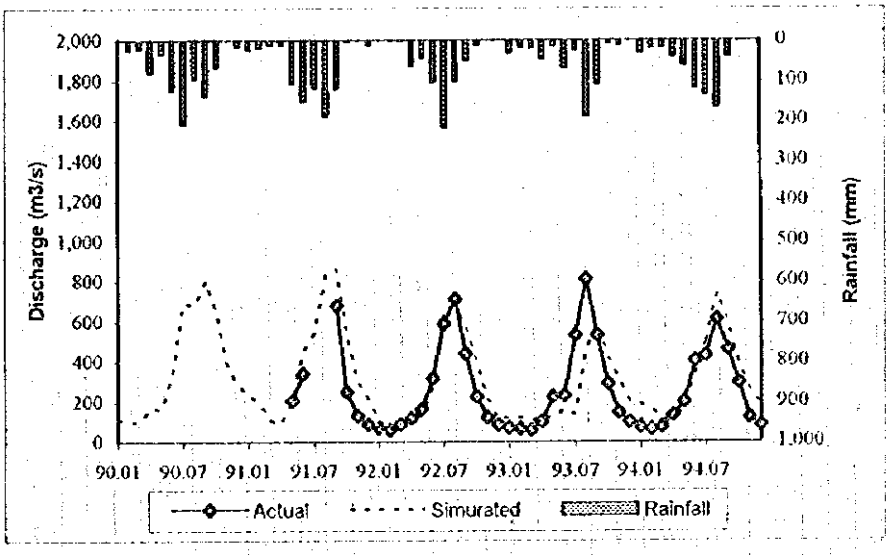
Using the monthly rainfall data at the CARD station and the river discharge data at Wangdue Rapids, a monthly Tank Model was designed for the low flow analysis of the Chang Chhu as shown below;



The following coefficients were found out through the simulation and the comparison between the actual and simulated data is shown below;

Estimated Coefficients of TANK Model

Catchment Area					5640 km2			
Coefficient of Tank Hole					Height of Tank Hole			
	Cu	Cm	Cd	Cb		Ha	Hm	Hd
Tank 1	0.060	0.030	0.120	0.250	Tank 1	1000	800	0
Tank 2	0.300	0.200	0.000	0.150	Tank 2	20	0	0
Tank 3	0.300	0.200	0.000	0.050	Tank 3	10	0	0
Tank 4	0.100	0.000	0.000	0.001	Tank 4	0	0	0
Period of Rainfall Data from 1985 to 1991					Period of Hydrological Data 1991 to 1994			
Rainfall Coefficient			4		Evaporation Coefficient			0.6
Correlation Coefficient between Simulated and Actual Data					96.1%			



Comparison between Actual and Simulated Discharge

From the result of this analysis, the water balance at Wangdue Rapid is expected as summarized below:

Summary of Water Balance of Chang Chhu

(mm/year)

Rainfall and Snowfall	2,400
Evaporation and Others	1,100
Runoff from Precipitation	1,300
Runoff from Glaciers	200
Total Runoff	1,500

Based on this model and rainfall data at CARD, the monthly river discharge at Wangdue Rapids was estimated as shown below;

Expected Monthly Discharge at Wangdue Rapids (m3/s)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1985	95.2	108.4	85.6	85.6	99.1	279.3	626.8	524.7	493.1	537.6	244.0	231.6	284.2
1986	197.8	74.6	62.8	61.9	99.6	170.7	622.5	535.6	428.3	342.7	139.0	107.6	283.0
1987	80.7	75.8	152.9	376.9	232.1	381.9	447.6	559.5	425.1	400.0	168.6	97.8	289.0
1988	67.9	66.7	80.6	149.9	195.1	335.7	557.9	535.7	302.9	135.4	99.6	76.2	216.2
1989	84.4	73.9	141.1	201.1	582.0	1109.0	910.4	503.3	567.8	265.3	186.4	87.5	381.8
1990	65.7	109.8	106.1	267.6	191.7	419.9	701.3	504.4	576.8	388.7	153.6	120.9	299.8
1991	132.1	128.3	88.3	77.9	321.7	536.2	498.6	687.7	689.0	251.1	139.0	89.5	301.2
1992	69.2	60.0	88.5	120.6	164.7	318.7	590.5	711.3	439.0	224.5	123.3	84.6	249.6
1993	69.7	66.6	61.8	102.3	225.9	232.7	532.6	811.6	533.2	289.5	146.5	101.1	264.5
1994	76.6	65.3	75.9	133.2	209.5	406.4	431.8	699.2	461.1	295.3	121.9	86.7	247.0
Mean	85.0	82.0	94.4	143.6	231.2	479.1	596.9	598.3	497.6	313.0	151.3	108.3	281.7
Max.	132.1	128.3	152.9	376.9	582.0	1109.0	910.4	811.6	689.0	537.6	244.0	231.6	1109.0
Min.	65.7	60.0	61.8	61.9	99.1	232.7	431.8	503.3	302.9	135.4	99.6	76.2	60.0

Using this result and the runoff characteristics at Wangdue Rapids, the monthly low flow was estimated as shown below;

Estimated Monthly Minimum Discharge at Wangdue Rapids (m3/s)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1985	88.9	97.6	67.8	57.9	71.3	172.8	329.6	363.7	338.0	362.5	197.4	194.6	57.9
1986	100.1	67.2	49.5	42.2	71.7	147.0	428.8	371.3	293.5	231.1	112.4	90.7	42.2
1987	75.0	68.3	120.5	256.8	167.0	236.4	285.0	387.8	339.4	269.7	136.4	82.4	68.3
1988	63.0	60.1	63.5	96.9	140.4	207.8	355.7	371.3	207.7	91.3	80.6	64.2	60.1
1989	78.4	66.6	111.2	97.8	418.7	686.4	580.4	348.9	389.3	178.9	150.8	73.7	97.8
1990	61.0	90.8	83.6	182.3	137.9	259.9	447.2	349.7	395.4	262.1	124.3	101.8	61.0
1991	122.7	115.6	69.6	53.1	150.3	211.2	317.5	476.7	370.1	159.9	102.5	78.6	53.1
1992	64.5	55.6	54.7	84.5	125.0	184.2	350.5	441.9	279.5	158.5	98.9	71.8	54.7
1993	64.5	58.9	59.3	67.7	153.6	163.0	620.9	491.8	186.1	110.5	84.5	58.9	
1994	70.9	60.6	69.2	81.9	124.3	208.8	232.6	428.1	296.3	158.6	99.1	76.6	60.6
Mean	78.9	74.1	74.0	97.0	156.9	279.8	376.0	416.6	339.2	265.9	122.7	91.9	74.0
Max.	122.7	115.6	120.5	256.8	418.7	686.4	580.4	620.9	491.8	362.5	197.4	194.6	686.4
Min.	61.0	55.6	49.5	42.2	71.3	153.6	232.6	348.9	207.7	91.3	80.6	64.2	42.2

2) Low Flow Analysis for the Study Area

In order to estimation of runoff discharge in the Study Area, the relationship between catchment area and monthly runoff was analyzed as shown in Fig. E.5.6 based on the discharge data of DOP. The influence of glacial runoff was considered for the estimation. The coefficients are tabulated as shown below;

Coefficients of Monthly Runoff

$Q = a^{*}A^{b}$ (Q:m^3/s km^2, A:km^2)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
a	1,077	1.173	373	281	212	389	714	961	1,061	421	612	601
b	-0.616	-0.643	-0.418	-0.290	-0.185	-0.168	-0.203	-0.203	-0.268	-0.243	-0.394	-0.463

Based on this coefficients; the specific discharge in the Study area was estimated as shown below;

Estimated Specific Discharge in the Study Area

(unit : m^3/s km^2)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specific Q	0.022	0.021	0.019	0.027	0.034	0.067	0.104	0.140	0.114	0.051	0.036	0.025

Using this specific discharge, the river discharge at intake site was estimated as shown below;

Estimated Monthly River Discharge at Intake Site

(unit : m^3/s)

River	C.Area(km²)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Taberong Chhu	119.40	2.602	2.500	2.327	3.231	4.034	8.028	12.453	16.755	13.577	6.067	4.286	3.029
Pe Chhu	145.70	3.175	3.051	2.840	3.943	4.923	9.797	15.196	20.448	16.568	7.403	5.233	3.698
Lachhu	2.23	0.048	0.047	0.043	0.060	0.075	0.150	0.232	0.312	0.253	0.113	0.080	0.056
Uship	4.18	0.091	0.087	0.081	0.113	0.141	0.281	0.435	0.586	0.475	0.212	0.150	0.106
Mochuna	8.78	0.191	0.184	0.171	0.237	0.296	0.590	0.915	1.231	0.998	0.446	0.315	0.223
Takarong Chhu	6.80	0.148	0.142	0.133	0.184	0.230	0.457	0.709	0.954	0.773	0.346	0.244	0.172

Comparing with the recorded discharge as shown in Table E.5.5, this result shows similar value as the recorded discharge.

(3) High Flow Analysis

1) High Flow Analysis for Chang Chhu

It is necessary to use the daily rainfall and the discharge data for high flow analysis while applying any kind of runoff model. However, the daily rainfall data in the Chang Chhu basin is considered as insufficient for the high flow analysis in view of their uneven locational distribution in the basin. Using the existing rainfall data, the daily Tank Model had been tried to be established on preliminary level, but it was eventually found that this kind of trial and approach are logically impossible.

Therefore, using the result of Tank Model Analysis and the runoff characteristics at Wangdue Rapids, the monthly high flow was expected as follows;

Estimated Monthly Maximum Flow at Wangdue Rapids

(unit : m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	107.6	121.8	116.7	128.8	143.3	391.0	1010.7	779.8	680.3	738.8	305.3	270.9	1010.7
1986	121.2	83.8	85.2	93.8	141.2	1079.0	1084.4	796.1	590.8	471.0	173.9	126.2	1084.4
1987	90.8	85.2	207.5	571.0	335.7	534.6	720.8	831.7	683.1	549.7	210.9	114.7	831.7
1988	76.3	75.0	109.4	213.5	282.3	470.0	899.7	796.2	418.0	186.1	124.6	89.3	899.7
1989	94.9	83.1	191.5	106.2	841.9	1552.6	1468.0	748.1	783.4	364.6	233.2	102.6	1552.6
1990	73.9	113.4	144.0	405.4	277.3	587.9	1130.9	749.8	795.9	534.2	192.2	141.7	1130.9
1991	148.5	144.2	119.8	118.0	302.3	477.8	803.0	1022.2	964.0	365.2	158.8	106.3	1022.2
1992	78.3	67.2	138.7	170.9	236.6	612.7	867.5	1094.7	590.5	289.0	155.6	98.3	1094.7
1993	77.9	75.1	71.0	164.9	329.0	425.7	935.2	1163.6	752.8	423.1	181.7	119.6	1163.6
1994	83.5	70.4	110.2	1114.8	292.9	790.6	738.5	833.0	711.3	352.1	168.0	98.1	1114.8
Mean	95.3	91.9	129.4	308.7	318.5	692.2	965.9	881.5	697.0	427.4	190.4	126.8	965.9
Max.	148.5	144.2	207.5	571.0	841.9	1552.6	1468.0	1163.6	964.0	738.8	305.3	270.9	1552.6
Min	73.9	67.2	71.0	93.8	143.3	391.0	720.8	748.1	418.0	186.1	124.6	89.3	748.1

In this analysis, the flood caused by the outburst of glacial lake should be neglected and this result was confirmed based on interview, flood mark survey and the river section data by applying non-uniform flow calculations.

The high flow analyses were carried out for the Pe Chhu, the Limti Chhu and the Tabe Rongchhu by applying the Rational Formula as described below;

$$Qf = f\,I\,A/3.6$$

Where Qf : Peak flood discharge (m^3/s)
f : Flood runoff coefficient (considering the condition of the Study area, a coefficient of o.7 was applied)
I : Rainfall intensity on the duration time (mm/hr)
A : Catchment area (km^2)

Due to a lack of hourly rainfall data, rainfall intensity was estimated using the following formula:

$$I = R_{24}/24\ (24/T)^{n}$$

Where R_{24} : Maximum 24 hr rainfall (mm)
T : Duration time (hr)
n : Coefficient (considering the condition of the Study area, a coefficient of 1/2 was applied)

The time duration should be varied depending on the condition of catchment area. Therefore, time duration was estimated using the following formula:

$$Tp = C\ A^{(0.22)}\ I^{(-0.35)}$$

Where Tp : Time duration in minutes (min)
C : Coefficient (considering topographic and land use condition in the Study area, a coefficient of 350 was applied)

Using those formula, the peak runoff discharge for average year was estimated as shown below;

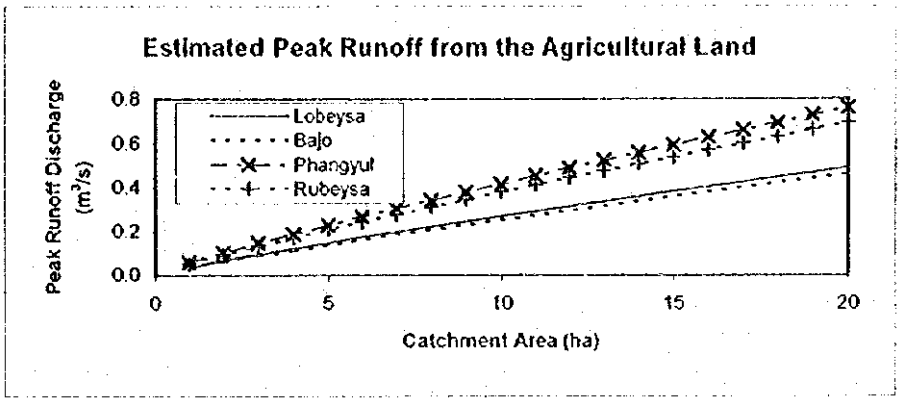
Estimated Peak Discharge at Main Rivers

Max. 24 hr Rainfall (mm)			58.8		
River	Catchment Area (km^2)	Duration Time (hr)	Rainfall Intensity	Peak Runoff (m^3/s)	Specific Q ($m^3/s\ km^2$)
Pe Chhu	158	40.69	1.88	41.292	0.261
Limti Chhu	34	27.01	2.31	10.905	0.321
Tabe Rongchhu	121	37.89	1.95	32.767	0.271

For the Dang Chhu Basin, the peak runoff discharge was analyzed as shown in Paragraph (4) of this section.

2) High Flow Analysis for the Study Area

There are several tributaries in the study area and the direct runoff from the rainfall is drained through these tributaries. The direct runoff comes from the agricultural land and the amount of the peak runoff should be varied depending on the scale of catchment area. Using the Rational Formula above mentioned, the relationship between the catchment area and the peak runoff discharge was analyzed as shown below;



(4) Probability Analysis

1) Probability Analysis for Chang Chhu

Using the results of the low and high flow analyses at Wangdue Rapids, the probability analysis was carried out for the Chang Chhu on the following items.

- Annual Mean Flow
- Annual Low Flow
- Annual High Flow

Using the specific discharge at Wangdue Rapids, the probability discharges of the Chang Chhu at the upper part from the Wangdue Bridge and the Dang Chhu were expected as shown below;

Result of Runoff Probability Analysis at Chang Chhu and Dang Chhu

(m^3/s)

Site	Wangdue Rapids			Upper Part of Chang Chhu			Dang Chhu		
Catchment Area (km^2)	5640			4956			684		
Return Period	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
1/500	191.7	2017.3	36.8	168.4	1772.6	32.3	23.2	244.7	4.5
1/200	198.1	1858.8	38.4	174.1	1633.4	33.7	24.0	225.4	4.7
1/100	203.7	1741.2	39.8	179.0	1530.1	35.0	24.7	211.2	4.8
1/50	210.4	1625.0	41.4	184.8	1428.0	36.4	25.5	197.1	5.0
1/20	221.2	1472.6	43.9	194.3	1294.0	38.6	26.8	178.6	5.3
1/10	231.7	1356.1	46.2	203.6	1191.7	40.6	28.1	164.5	5.6
1/5	245.9	1235.4	49.2	216.1	1085.6	43.2	29.8	149.8	6.0
1/2	277.9	1054.9	55.5	244.2	927.0	48.8	33.7	127.9	6.7

2) Probability Analysis for the Other Rivers

The probability analysis for mean and minimum flow was carried out for the Pe Chhu, the Limti Chhu and the Tabe Rongchhu, based on the specific discharge of the Dang Chhu. The probability for the maximum flow was estimated by applying the Rational Formula as described below and based on the result of rainfall analysis. Results of the possibility analysis are summarized below;

Result of Runoff Probability Analysis for Other Rivers

(m3/s)

Site	Pe Chhu			Limti Chhu			Tabe Rongchhu		
Catchment Area (km2)	158			34			121		
Return Period	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
1/100	5.708	176.26	1.115	1.228	46.55	0.240	4.371	139.87	0.854
1/50	5.893	148.26	1.159	1.268	39.16	0.249	4.513	117.65	0.888
1/20	6.195	114.50	1.229	1.333	30.24	0.264	4.745	90.87	0.941
1/10	6.492	91.15	1.295	1.397	24.07	0.279	4.972	72.33	0.991
1/5	6.889	69.27	1.379	1.483	18.29	0.297	5.276	54.97	1.056
1/2	7.785	41.29	1.555	1.675	10.91	0.335	5.962	32.77	1.191

(5) River Water Flow Analysis

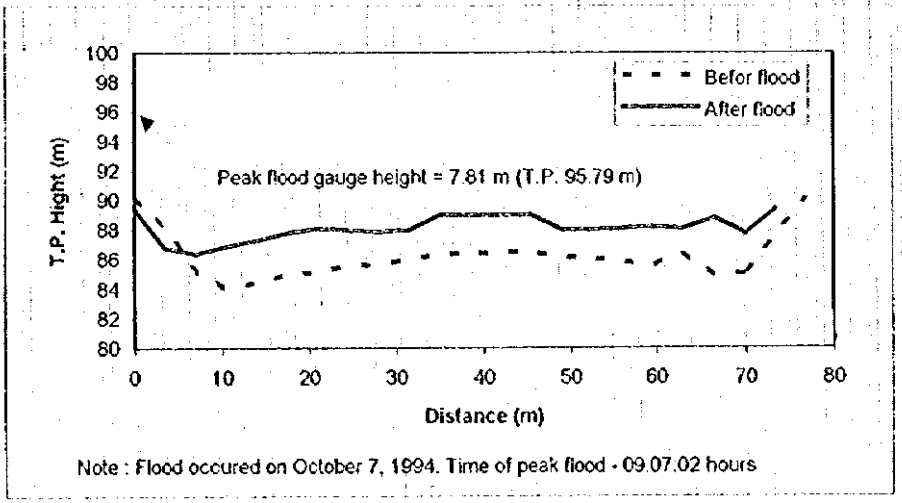
Using the river section as shown in Fig. E.5.7 and the result of probability analysis, the river flow at the Chang Chhu was analyzed by applying the non-uniform flow calculation. The result is shown in Fig. E.5.8 and it has been confirmed throughout the Field Work. From this result, the flow condition at the river pump station in CARD are summarized below;

Estimated Water Level at CARD River Pump Station (TP.m)

Return Period	River Bed	1/500	1/200	1/100	1/50	1/20	1/10	1/5	1/2
Mean flow	1193.4	1195.9	1195.9	1196.0	1196.0	1196.1	1196.2	1196.3	1196.5
Maximum flow	1193.4	1200.5	1200.2	1199.9	1199.6	1199.3	1199.0	1198.7	1198.2
Minimum flow	1193.4	1194.9	1194.9	1194.9	1194.9	1194.9	1194.9	1194.9	1195.0

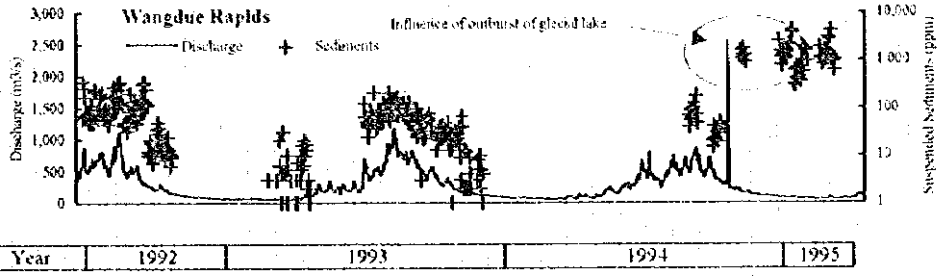
E.5.4 Sediment Runoff Analysis

As mentioned before, the extraordinary flood occured on the October 7th, 1994, caused by outburst of glacial lake and this phenomenon has affected so much for the sedimentation as more than 1 m rising up the river bed of Chang Chhu. The comparison between the cross-section of the river before the flood and after the flood at Wangdue Rapid is shown below;



CROSS SECTION PROFILE OF WANGDUE RAPIDS BEFORE AND AFTER FLOOD

Same comparison at different section is shown in Fig. E.5.7 and it can be said the river condition was changed exactly after this flood. Furthermore, the suspended sedimentation load (SS) has rising up 100 ~ 1000 times more than that of before the flood and this phenomenon has been continued even at 6 month later as shown below;



Therefore, it is necessary to neglect the SS data series after the flood for sediment runoff analysis in the Chang Chhu basin.

Using the suspended sediment and the river discharge data at Wangdue Rapids and Yebesa, the relationship between river discharge and suspended sediment was analyzed as shown Fig. E.5.9 The results are summarized below.

Wangdue Rapids $SS = 0.00884 \times Q^{2.009}$ (Correlation Coefficient: 95 %)
Yebesa $SS = 0.01086 \times Q^{2.091}$ (Correlation Coefficient: 86 %)

where; SS : Suspended Sediment (t/day)
Q : Daily Mean Discharge (m^3/s)

The sediment runoff at both stations was estimated as shown in Table E.5.6, using the actual daily discharge data and above equations. Approximately 414 thousand ton of annual sediment runoff was estimated at Wangdue Rapids and this amount is expected to be around 745 thousand m^3/year (110 m^3/km^2/year). On the other hand, approximately 140 thousand ton of that was estimated at Yebesa and this also is expected to be 252 thousand m^3/year (100 m^3/km^2/year). The specific suspended sediment runoff at Yebesa is less than that at Wangdue Rapids by 10 m^3/km^2/year, but, considering the longitudinal slope at the Chang Chhu system, this value is expected to be within a calculation difference.

The sampling of suspended sediment was carried out at new stream gauging stations as shown in Table E.5.7. The relationship between river discharge and suspended sediment runoff was analyzed as shown in Fig. E.5.9 and coefficients are summarized as shown below;

Estimated Coefficients

$SS=A*Q^B$ (SS:t/d, Q:m^3/s)

River	A	B	Correlation C
SR1	0.715	1.867	71%
SR2	0.183	1.511	59%
SR3	0.008	2.560	68%
SR4	-	-	-
SR5	0.460	1.950	81%
SR6	0.840	1.700	77%

For the Limti Chhu (SR4), there was no flow in almost observation date since most of all the river discharge was used for irrigation purpose at the upper basin of this river. Therefore, it was impossible to analyze the sediment runoff based on the recorded data.

Applying those coefficients, the sediment runoff at each stations was roughly estimated as shown below. However, it is necessary to collect the hydrological data for this analysis.

Estimated Sediment Runoff

River	Sediment Runoff (t/year)	Specific Sediment Runoff (m^3/year/km^2)
SR1	12,120	133
SR2	33,772	110
SR3	50,856	120
SR4	-	-
SR5	7,460	98
SR6	6,255	86

APPENDIX E
TABLES

Table E.2.1 List of Meteorological Stations in and around the Chang Chhu Basin

No.	Agency	District	Name of Station	Locaton			Station No.	Year of Established	Period of Data Collected		Remark
				Elevation	Longitude	Latitude					
1	DoA	Thimphu	Gidakom	2210	E89-35'	N27-27'	12620046	Apr.85	Apr.85	Dec. 94	
2	DoF	Thimphu	Chumithangka	2560	E89-32'	N27-27'	12680052	Sep.89			
3	DoAH	Thimphu	Serbithang	2560	E89-40'	N27-26'	12690054	Jul.78			
4	DoA	Thimphu	Simthoka	2310	E89-40'	N27-26'	12700046	Oct.85			
5	DoA	Thimphu	Yusipang	2680	E89-43'	N27-28'	12720046	Jun.85	Jun.85	Dec. 93	
6	DoP	Thimphu	Dochu-la	3130	E89-45'	N27-29'	12740044	Jun.91	Jun.91	Dec. 93	*
7	DoP	Thimphu	Thimphu	2300	E89-38'	N27-28'	12810044	Mar.87			
8	DoA	Thimphu	Thimphu	2365	E89-38'	N27-29'	12820046	Jun.85	Jun.85	Dec. 94	
9	DoCW	Thimphu	Thimphu	2380	E89-38'	N27-29'	12830048	May.83			
10	DoCW	Thimphu	Indian Embassy	2320	E89-39'	N27-30'	12860048	Jan.65	Jan.90	Jan. 94	*
11	DoA	Thimphu	Taba	2455	E89-39'	N27-31'	12880046	Jan.85	Jan.85	May. 93	
12	DoA	Daga	Tashitangu	1270	E90-03'	N27-02'	13340046	Mar.85	May.85	Dec. 94	
13	DoA	W/Phodrang	Phobjikha	2860	E90-11'	N27-28'	13390046	Mar.85	Mar.85	Dec. 94	
14	DoA	W/Phodrang	Uma(Daga)	1700	E89-55'	N27-18'	13410046	Jan.85	Jan.85	Jul. 92	
15	DoP	W/Phodrang	Baso/Ruru Chhu	980	E89-55'	N27-21'	13440044	Nov.89	Nov.89	Dec. 94	
16	DoA	W/Phodrang	Gaselo	1780	E89-54'	N27-25'	13470046	Jan.85	Jan.85	Mar. 92	
17	DoA	W/Phodrang	Samtengang	1960	E90-00'	N27-33'	13530046	Mar.85	Mar.85	Dec. 94	
18	DoA	W/Phodrang	Nobding	2600	E90-11'	N27-33'	13550046	Jan.85	Jan.85	Dec. 94	
19	DoP	W/Phodrang	Pele-la	3480	E90-12'	N27-32'	13560044	Dec.91	Jun.92	Jun. 93	*
20	DoCW	W/Phodrang	W/Phodrang	1290	E89-54'	N27-29'	13620048	Jul.83	Jul.83	Feb. 94	*
21	DoA	W/Phodrang	Wangdue (CARD)	1180	E89-54'	N27-29'	13640046	Jan.85	Jan.85	Nov. 94	
22	DoP	Thimphu	Lumichawa	2210	E89-47'	N27-31'	13660044	Jun.91	Jun.91	Jan. 94	
23	DoA	Punakha	Punakha	1280	E89-52'	N27-34'	13670046	Mar.85	May.85	Sep. 94	
24	DoA	Punakha	Gasakhatey	2760	E89-43'	N27-54'	13760046	May.85	May.85	Nov. 94	
25	DoA	Thimphu	Lingishi	4100	E89-26'	N27-52'	13780046	May.85	May.85	Nov. 90	
26	DoA	Punakha	Shengana	1680	E89-56'	N27-36'	13830046	Jan.85	Jan.85	Dec. 94	

Note * : Rainfall Data only

Table E.2.2 List of Principal Hydrological Stations in Bhutan

No.	Code	Name of Station	Location		Altitude (m)	Catchment Area(km2)
			Latitude	Longitude		
1	12370045	Lobnakha on Wang Chhu				
2	12440045	Damchuzam on Haa Chhu (*)	27-21'41N	89-18'14E	2690	336
3	12800045	Lungtenphu on Thimphu Chhu (*)	27-26'48N	89-39'40E	2260	663
4	13200045	Tashiding on Daga Chhu				
5	13310045	Dubani on Sankosho Chhu				
6	13450045	Maza Falls on Baso Chhu				
7	13490045	Wangdi Rapids on Pho-Mo Chhu (*)	27-27'45N	89-54'11E	1190	5640
8	13700045	Yebesa on Mo Chhu (*)	27-37'59N	89-49'03E	1230	2320
9	14190045	Tinhtibi on Mangde Chhu (*)	27-08'44N	90-41'36E	565	3200
10	15350045	Chhumey on Khargang Chhu				
11	15490045	Kurjey on Chamkher Chhu (*)	27-35'13N	90-44'13E	2600	1350
12	16200045	Kurizampa on Kuri Chhu (*)	27-16'27N	91-11'47E	540	8600
13	17400045	Uzorong on Gongri Chhu (*)	27-15'40N	91-25'03E	570	8560
14	17720045	Lungtenzampa on Gamri Chhu				
15	17650045	Tashiyangtshi on Kholong Chhu				

Note (*) : Hydrological Data Collected

Table E.2.3 List of Meteo-hydrological Stations newly Installed in the Study Area

(1) Rain Gauge Station

No.	CODE	Name of Station	Date of Established	Location		Altitude (m)	Remark
				Latitude	Longitude		
1	RG1	Umtekha	May/94	89-54'N	27-32'E	1360	
2	RG2	NRTI	May/94	89-53'N	27-28'E	1380	
3	RG3	Phangyul	May/94	89-56'N	27-32'E	1800	
4	RG4	Rubes	May/94	89-54'N	27-27'E	1560	

(2) Stream Gauge Station

No.	CODE	Name of Station	Date of Established	Location		Altitude (m)	Catchment Area(km2)
				Latitude	Longitude		
1	SR1	Pe-Bajo Canal Intake	May/94	89-58'N	27-31'E	1400	145.80
2	SR2	Dangchhu Upstream	May/94	89-57'N	27-31'E	1320	489.78
3	SR3	Dangchhu Downstream	May/94	89-54'N	27-28'E	1200	678.95
4	SR4	Limtichhu	May/94	89-54'N	27-31'E	1200	32.04
5	SR5	Tabe Rongchhu Downstream	May/94	89-54'N	27-32'E	1200	121.35
6	SR6	Tabe Rongchhu Upstream	May/94	89-54'N	27-33'E	1320	116.25

(3) Canal Gauge Station

No.	CODE	Name of Station	Date of Established	Location		Altitude (m)	Remark
				Latitude	Longitude		
1	SC1	Upper Lobeysa Canal	May/94	89-50'N	27-32'E	1340	
2	SC2	Lower Lobeysa Canal	Jun./94	89-50'N	27-32'E	1310	
3	SC3	Bajo Canal Intake	May/94	89-54'N	27-33'E	1320	

Table E.2.4 Result of Discharge Measurement

Site	Date	Gauge H(m)	A(m2)	V(m/s)	Q(m3/s)
SR1	31/Mar./94	0.45	2.170	3.805	8.257
	18/Apr./94	0.28	2.379	2.745	6.530
	21/May/94	0.42	2.132	3.295	7.026
	5/Jun./94	0.45	2.283	3.455	7.888
	29/Jun./94	1.10	7.839	1.947	15.264
	8/Jul./94	0.74	3.725	4.676	17.416
	23/Aug./94	1.20	6.988	1.373	9.598
	20/Sep./94	1.18	6.874	1.804	12.400
	7/Dec./94	0.67	4.243	1.385	5.878
	4/Jan./95	0.64	4.105	1.632	6.699
	21/Feb./95	0.50	3.482	0.901	3.139
	13/Mar./95	0.74	2.169	3.840	8.329
	4/Apr./95	0.48	2.190	2.797	6.126
	23/May./95	0.44	2.007	3.072	6.165
	3/Jul./95	0.58	3.833	1.050	4.023
	30/Jul./95	0.91	5.416	1.600	8.668
	23/Aug./96	1.14	6.649	1.684	11.198
SR2	9/Apr./94	0.45	12.053	1.347	16.235
	19/Apr./94	0.08	11.081	1.119	12.398
	21/May/94	0.20	13.061	1.647	21.510
	5/Jun./94	0.37	14.497	1.652	23.951
	29/Jun./94	1.10	27.802	2.053	57.084
	8/Jul./94	0.45	15.889	2.686	42.678
	23/Aug./94	0.84	20.528	1.991	40.876
	20/Sep./94	0.70	18.421	1.898	34.956
	28/Oct/94	0.21	11.676	1.447	16.894
	7/Dec./94	0.52	15.828	1.231	19.489
	4/Jan./95	0.45	14.856	1.138	16.912
	21/Feb./95	0.40	14.173	1.185	16.792
	13/Mar./95	0.10	10.307	1.009	10.399
	23/May./95	0.26	12.317	1.682	20.723
	3/Jul./95	0.60	16.964	2.424	41.126
	30/Jul./95	0.10	10.307	3.215	33.136
	23/Aug./96	1.26	27.431	3.200	87.780
SR3	12/Apr./94	0.15	11.064	1.313	14.530
	19/Apr./94	0.09	9.644	1.277	12.314
	21/May/94	0.29	14.636	1.648	24.117
	5/Jun./94	0.34	15.999	1.746	27.939
	29/Jun./94	1.12	39.316	2.159	84.864
	8/Jul./94	0.63	20.620	1.659	34.206
	23/Aug./94	1.10	32.541	2.321	75.511
	20/Sep./94	0.96	27.982	1.756	49.148
	28/Oct./94	0.46	15.740	1.645	25.895
	7/Dec./94	0.34	11.800	1.397	17.341
	4/Jan./95	0.93	27.103	1.186	39.830
	21/Feb./95	0.22	10.954	1.057	11.583
	13/Mar./95	0.12	9.111	1.113	10.141
	23/May/95	0.35	13.488	1.703	22.973
	3/Jul./95	0.98	28.586	2.058	58.827
	30/Jul./95	1.00	29.207	1.867	54.536
	23/Aug./96	0.96	27.982	1.969	55.102
SR4	1/Apr./94	0.10	0.107	0.316	0.034
	19/Apr./94	0.07	0.043	0.581	0.025
	21/May/94	0.05	-	-	Nil
	5/Jun./94	0.05	-	-	Nil
	29/Jun./94	0.58	1.618	0.975	1.578
	8/Jul./94	0.05	-	-	Nil
	8/Sep./94	0.21	0.165	1.000	0.165
	28/Oct./94	0.15	0.203	1.320	0.268
	7/Dec./94	0.10	0.243	1.317	0.319
	21/Feb./95	-	0.124	0.958	0.119
SR5	30/Mar./94	0.50	2.352	1.794	4.219
	18/Apr./94	0.42	2.105	1.831	3.857
	21/May./94	0.24	1.640	0.163	0.267
	5/Jun./94	0.08	1.761	0.467	0.822
	28/Jun/94	0.51	9.206	0.710	6.537
	29/Jun./94	0.92	15.039	1.470	22.100
	8/Jul./94	0.47	3.786	3.237	12.256
	23/Aug./94	0.70	8.051	1.341	10.798
	20/Sep./94	0.66	7.450	1.523	11.346
	28/Oct./94	0.47	3.538	2.377	8.410
	7/Dec./94	0.39	3.154	2.001	6.311
	4/Jan./95	0.33	2.808	1.879	5.276
	21/Feb./95	-	2.752	1.415	3.894
	13/Mar./95	0.47	1.590	1.596	2.538
	4/Apr./95	0.47	1.725	1.998	3.445
	23/May./95	0.20	1.122	1.400	1.571
	3/Jul./95	0.58	6.315	0.642	4.053
	30/Jul./95	0.71	8.204	1.089	8.931
	23/Aug./96	0.76	8.994	0.725	6.516
SR6	30/Mar./94	0.52	2.064	1.758	3.628
	18/Apr./94	0.56	2.086	1.093	2.280
	21/May/94	0.18	1.029	0.117	0.120
	5/Jun./94	0.18	0.948	0.823	0.780
	28/Jun/94	0.77	2.930	2.998	8.784
	8/Jul./94	-	2.508	3.189	7.998
	20/Aug./94	0.62	4.938	1.145	4.966
	20/Sep./94	-	-	1.976	-
	28/Oct./94	0.47	2.780	2.984	8.296
	7/Dec./94	0.33	2.210	2.543	5.621
	4/Jan./95	0.56	2.198	2.308	5.074
	21/Feb./95	-	1.699	1.471	2.499
	13/Mar./95	0.47	2.780	2.974	8.269
	5/Apr./95	0.19	0.788	1.585	1.249
	23/May./95	0.19	0.155	2.245	0.348
	3/Jul./95	0.45	2.828	1.179	4.156
	30/Jul./95	0.50	3.239	1.075	4.760
	23/Aug./96	0.44	2.749	1.105	4.040
SC1	30/Mar./94	0.22	0.165	3.518	0.580
	5/Jun./94	0.08	0.070	3.014	0.211
	28/Jun./94	0.12	0.188	3.086	0.580
	8/Jul./94	0.21	0.196	2.868	0.562
	28/Oct/94	0.10	0.189	3.677	0.695
	7/Dec./94	0.10	0.177	2.418	0.428
	4/Jan./95	0.23	0.187	1.508	0.282
	21/Feb./95	0.19	0.249	3.942	0.980
	23/May/95	-	0.167	2.044	0.341
	30/Jul./96	0.30	0.323	4.634	1.495
	3/Jul./96	0.18	0.172	4.402	0.756
SC2	30/Mar./94	0.35	0.554	1.298	0.719
	18/Apr./94	0.41	0.662	2.325	1.539
	28/Jun./94	0.25	0.997	1.831	1.826
	8/Jul./94	0.21	0.711	1.740	1.237
	20/Sep./94	0.21	0.947	3.124	2.958
	28/Oct./94	0.15	0.445	1.928	0.858
	7/Dec./94	0.19	0.349	1.275	0.445
	5/Jan./95	0.22	0.327	1.150	0.376
	21/Feb./95	-	0.364	3.713	1.352
	13/Mar./95	-	0.577	1.957	1.129
	3/Jul./95	-	0.767	1.849	1.418
	30/Jul./95	-	1.072	3.996	4.283
SC3	31/Mar./94	0.40	0.147	1.644	0.242
	29/Jun./94	0.53	0.354	0.819	0.290

Table E.4.1 Summary of Rainfall Data

No.	Code	Name of Station	Elevation (m)	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1	12620046	Gidakom	2,210	8	12	27	28	40	91	130	102	79	30	5	5	556
2	12720046	Yusipang	2,680	1	8	19	42	56	129	149	142	113	34	3	2	697
3	12740044	Dochu-la	3,150	0	0	0	58	80	197	135	401	290	53	0	0	1,214
4	12820046	Thimphu	2,365	15	21	23	38	60	114	203	171	106	43	2	3	800
5	12860048	Indian Embassy	2,320	0	11	16	23	55	91	147	157	151	27	2	1	661
6	12880046	Taba	2,455	2	3	10	29	59	169	188	158	108	57	1	6	787
7	13340046	Tashitangu	1,270	14	26	26	64	99	329	381	239	184	76	2	6	1,447
8	13390046	Phobjikha	2,860	9	3	19	59	72	201	305	204	142	30	3	1	1,048
9	13410046	Uma(Daga)	1,700	6	32	13	45	70	134	236	98	122	6	1	2	764
10	13440044	Baso/Ruru Chhu	980	30	22	67	43	107	147	179	260	141	47	0	5	1,048
11	13470046	Gaselo	1,780	3	16	14	41	74	140	149	105	78	54	3	6	685
12	13530046	Samtengang	1,960	12	14	17	51	99	199	296	289	173	36	10	4	1,199
13	13550046	Nobding	2,600	10	14	26	65	139	292	389	416	226	52	10	3	1,643
14	13560044	Pele-la	3,480	31	32	31	81	188	210	379	321	199	69	4	21	1,565
15	13620048	W/Phodrang	1,290	12	13	15	32	68	148	149	135	85	40	3	4	704
16	13640046	Wangdi(CARD)	1,180	10	12	16	40	61	144	153	130	91	39	5	10	710
17	13660044	Lumichawa	2,210	8	22	13	55	63	211	248	472	194	26	0	0	1,311
18	13670046	Punakha	1,280	18	7	14	42	61	125	186	151	101	56	3	2	766
19	13760046	Gasakhatey	2,760	8	27	55	79	179	238	409	362	310	104	15	18	1,800
20	13780046	Lingishi	4,100	0	0	0	0	34	90	105	92	70	8	0	0	398
21	13830046	Shengana	1,680	48	88	50	186	337	506	591	596	506	90	16	8	3,001

Table E.4.2 Summary of Temperature Data (°C) (1/3)

Station	Item		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
12620046	Mean	Mean	6.7	7.9	11.1	13.9	18.1	20.8	21.2	20.5	19.5	16.0	11.0	7.6	14.5
Gidakom		Max.	12.8	13.3	17.5	18.5	26.5	26.0	26.5	24.0	22.3	20.5	15.5	12.0	26.5
2210 (m)		Min.	0.5	1.5	5.8	8.5	10.5	15.3	16.3	15.0	13.3	11.0	4.3	3.3	0.5
85 - 94	Max.	Mean	14.2	15.1	18.4	21.0	24.1	26.1	26.2	25.2	24.5	23.4	19.6	16.8	21.2
		Max.	21.5	23.0	27.0	27.0	32.0	32.0	34.0	30.0	29.5	27.0	24.0	22.5	34.0
		Min.	4.0	4.0	8.0	11.5	12.0	18.0	18.0	16.0	15.0	18.5	10.0	6.0	4.0
	Min.	Mean	-0.7	0.7	3.9	6.9	12.0	15.4	16.2	15.9	14.5	8.7	2.3	-1.6	7.9
		Max.	8.5	7.5	11.0	12.0	21.0	20.0	19.0	20.0	17.0	15.0	12.0	5.0	21.0
		Min.	-6.5	-5.0	-2.5	1.0	5.0	8.5	12.5	13.0	9.0	1.0	-4.0	-8.0	-8.0
12720046	Mean	Mean	4.7	6.2	8.3	12.0	14.1	16.7	17.7	17.2	16.4	12.7	8.3	5.3	11.6
Yusipang		Max.	9.0	10.5	15.0	20.0	17.5	19.5	19.5	24.5	19.0	19.0	14.0	10.0	24.5
2680 (m)		Min.	0.0	3.5	4.0	8.0	8.5	13.5	15.5	12.5	9.5	7.5	5.0	-5.0	-5.0
85 - 93	Max.	Mean	8.5	11.8	13.0	16.8	17.8	20.2	20.9	20.5	20.1	17.9	15.7	12.1	16.3
		Max.	15.0	20.0	20.0	24.0	23.0	23.0	24.0	28.0	24.0	26.0	26.0	19.0	28.0
		Min.	4.0	7.0	8.0	11.0	11.0	14.0	17.0	14.0	10.0	10.0	12.0	-1.0	-1.0
	Min.	Mean	0.9	0.7	3.7	7.2	10.4	13.2	14.6	13.8	12.6	7.6	0.9	-1.4	7.0
		Max.	5.0	4.0	13.0	19.0	15.0	18.0	18.0	21.0	16.0	14.0	6.0	4.0	21.0
		Min.	-5.0	-4.0	0.0	1.0	5.0	7.0	11.0	11.0	8.0	2.0	-2.0	-10.0	-10.0
12820046	Mean	Mean	6.1	8.0	10.6	13.8	17.1	20.3	20.9	20.8	19.1	15.5	10.5	7.6	14.2
Thimphu		Max.	15.2	13.8	17.4	19.5	24.5	24.6	25.4	26.5	27.0	22.5	16.0	12.5	27.0
2365 (m)		Min.	-1.1	0.3	5.2	6.9	11.0	14.5	15.7	15.0	11.5	9.2	3.7	2.2	-1.1
85 - 94	Max.	Mean	14.3	15.7	17.9	20.5	23.3	25.8	25.7	25.6	23.7	22.4	18.9	16.1	20.8
		Max.	27.3	24.0	26.0	26.1	30.5	32.0	32.2	32.0	31.0	32.0	24.4	25.0	32.2
		Min.	2.5	6.0	6.0	11.1	14.6	16.5	17.0	17.0	14.0	14.0	11.1	8.5	2.5
	Min.	Mean	-2.1	0.3	3.4	7.2	10.9	14.8	16.1	15.9	14.6	8.6	2.1	-0.9	7.6
		Max.	7.3	9.5	11.5	17.0	21.4	21.5	20.0	26.0	24.0	19.0	11.0	7.0	26.0
		Min.	-10.5	-5.6	-7.0	0.0	4.3	9.4	12.3	11.0	6.9	-1.7	-4.6	-7.6	-10.5
12880046	Mean	Mean	6.3	7.2	9.9	12.7	15.2	18.9	19.6	18.9	17.8	14.0	10.5	6.6	13.1
Taba		Max.	11.5	12.5	16.3	19.5	21.5	23.0	23.8	23.8	22.5	18.8	14.0	10.5	23.8
2455 (m)		Min.	0.0	-0.5	4.8	5.5	7.5	13.8	15.0	13.5	7.5	7.5	6.5	3.0	-0.5
85 - 93	Max.	Mean	17.0	16.0	18.7	21.0	22.9	25.7	25.0	24.8	24.1	21.9	20.1	17.0	21.2
		Max.	27.0	28.0	29.0	29.0	30.0	32.0	32.0	32.0	33.0	30.0	25.0	24.0	33.0
		Min.	8.0	7.0	11.0	10.0	12.5	17.0	16.0	16.0	11.0	11.0	15.0	10.0	7.0
	Min.	Mean	-4.4	-1.6	1.1	4.3	7.6	12.0	14.1	12.9	11.5	6.1	0.8	-3.8	5.0
		Max.	0.0	4.0	10.0	11.0	19.0	18.0	19.0	19.0	15.5	12.0	6.0	-1.0	19.0
		Min.	-9.5	-9.0	-8.0	-1.0	1.0	5.1	10.0	9.0	4.0	-2.0	-5.0	-6.0	-9.5
13340046	Mean	Mean	11.7	12.0	14.4	17.8	19.3	21.2	21.8	22.0	21.4	18.6	15.5	12.8	17.4
Tashitangu		Max.	17.0	15.5	20.5	21.5	23.5	25.0	26.5	25.0	25.5	24.5	19.5	17.5	26.5
1270 (m)		Min.	6.0	7.0	9.5	11.5	13.5	17.0	18.0	18.0	16.0	14.5	11.5	7.5	6.0
85 - 94	Max.	Mean	16.1	16.0	18.4	22.0	23.2	24.4	24.6	25.2	24.5	23.1	21.0	17.9	21.4
		Max.	22.0	21.0	24.0	27.0	28.0	29.0	37.0	30.0	29.0	28.0	26.0	24.0	37.0
		Min.	9.0	10.0	10.0	12.0	16.0	18.0	20.0	19.0	17.0	18.0	17.0	12.0	9.0
	Min.	Mean	7.2	8.0	10.5	13.5	15.4	17.9	19.0	18.7	18.2	14.1	9.9	7.7	13.4
		Max.	12.0	12.0	19.0	18.0	21.0	21.0	22.0	21.0	23.0	23.0	14.0	12.0	23.0
		Min.	2.0	3.0	3.0	7.0	11.0	11.0	12.0	15.0	12.0	8.0	5.0	3.0	2.0
13390046	Mean	Mean	0.8	3.8	6.6	9.6	12.4	14.8	15.4	14.9	14.5	10.6	5.3	2.6	9.3
Phobjikha		Max.	8.0	9.0	13.0	15.0	18.5	20.0	18.0	18.5	18.0	18.5	10.0	8.5	20.0
2860 (m)		Min.	-6.5	-0.5	1.0	3.0	7.0	10.0	10.5	12.0	8.5	5.5	0.5	-2.0	-6.5
85 - 94	Max.	Mean	7.8	10.1	12.5	15.9	17.1	19.1	19.8	18.7	18.5	16.5	13.1	10.1	14.9
		Max.	15.0	15.0	21.0	24.0	22.0	23.0	28.0	25.0	22.0	25.0	19.0	19.0	28.0
		Min.	0.5	2.0	4.0	8.0	11.0	14.0	14.0	14.5	12.0	10.0	6.0	2.0	0.5
	Min.	Mean	-6.2	-2.5	0.7	3.2	7.6	10.5	11.1	11.1	10.4	4.7	-2.5	-4.8	3.6
		Max.	3.0	5.0	9.0	11.0	17.0	19.0	14.0	13.5	15.0	16.0	7.0	2.0	19.0
		Min.	-14.0	-10.0	-7.0	-6.0	0.0	1.0	1.0	8.0	3.0	-3.0	-8.0	-10.0	-14.0

Table E.4.2 Summary of Temperature Data (°C) (2/3)

Station	Item		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
13410046	Mean	Mean	10.9	11.5	14.4	17.5	18.8	21.7	21.2	20.3	20.2	20.0	15.3	12.1	17.0
Uma(Daga)		Max.	12.5	14.0	19.8	20.8	22.0	24.0	24.0	21.5	22.0	22.0	19.0	18.0	24.0
1700 (m)		Min.	9.0	9.5	9.5	13.8	14.0	12.8	19.0	19.5	17.5	17.5	11.5	8.3	8.3
85 - 92	Max.	Mean	14.9	15.7	19.3	22.1	22.8	24.8	23.7	22.6	22.3	22.8	19.3	16.6	20.6
		Max.	18.0	19.0	25.0	26.5	28.0	30.0	27.5	24.0	25.0	24.0	23.0	21.0	30.0
		Min.	13.0	12.0	13.0	17.5	17.0	14.0	20.0	21.0	19.0	20.0	15.0	12.0	12.0
	Min.	Mean	6.9	7.2	9.5	12.9	14.7	18.6	18.7	18.1	18.0	17.1	11.4	7.7	13.4
		Max.	9.0	9.0	16.0	17.0	19.0	20.0	22.0	19.0	21.0	20.0	16.0	15.0	22.0
		Min.	5.0	5.0	5.0	9.0	10.0	11.5	17.0	17.0	15.0	12.0	6.0	-4.0	-4.0
13410044	Mean	Mean	13.7	15.3	17.5	20.9	22.8	24.5	24.2	23.7	23.2	22.2	17.5	14.3	20.0
Baso/Rutu Chhu		Max.	18.5	19.3	22.0	25.0	25.5	27.8	26.8	26.5	25.8	27.5	23.8	17.5	27.8
980 (m)		Min.	9.0	11.5	13.0	15.0	16.8	21.0	20.0	20.3	18.8	17.0	13.0	9.0	9.0
89 - 94	Max.	Mean	17.6	19.7	21.9	25.8	26.9	28.3	27.6	27.1	26.5	25.2	22.3	18.6	23.9
		Max.	25.0	22.5	28.0	30.0	31.0	33.5	31.5	31.5	31.0	31.0	26.5	22.0	33.5
		Min.	10.0	15.0	14.0	16.0	19.5	22.5	21.0	22.0	20.0	18.5	15.0	10.0	10.0
	Min.	Mean	9.8	10.8	13.0	16.0	18.6	20.7	20.8	20.4	19.9	19.2	12.7	10.1	16.0
		Max.	15.0	18.0	17.5	20.5	21.5	29.5	23.0	23.0	22.0	25.5	21.0	13.5	29.5
		Min.	5.5	7.0	9.5	11.0	14.0	18.0	18.0	18.0	17.5	12.5	9.0	6.0	5.5
13470046	Mean	Mean	8.7	10.7	13.1	16.3	18.8	20.8	19.8	21.2	20.2	17.2	13.1	9.8	15.8
Gaselo		Max.	13.0	13.5	17.5	19.5	25.5	23.5	23.5	23.5	22.5	21.0	16.0	13.5	25.5
1780 (m)		Min.	4.5	4.5	8.5	12.0	13.0	16.5	15.0	18.0	16.5	12.5	8.0	6.5	4.5
85 - 92	Max.	Mean	13.8	15.4	18.4	22.0	24.0	24.7	22.5	25.5	24.4	22.0	18.3	14.8	20.5
		Max.	18.0	21.0	23.0	26.0	33.0	29.0	28.0	29.0	29.0	26.0	21.5	19.5	33.0
		Min.	9.0	9.0	12.0	16.0	16.0	16.5	15.0	20.0	18.0	14.0	10.0	10.0	9.0
	Min.	Mean	3.7	5.9	7.8	10.7	13.5	16.9	17.1	17.0	16.0	12.4	7.9	4.8	11.1
		Max.	9.0	11.0	14.0	16.0	24.0	22.0	20.0	22.0	19.0	17.0	12.0	9.0	24.0
		Min.	-1.0	0.0	4.0	6.0	6.0	14.0	15.0	15.0	11.0	7.5	4.0	1.0	-1.0
13530046	Mean	Mean	8.6	10.1	13.2	16.4	18.9	21.8	21.7	21.9	21.0	17.8	13.5	9.9	16.2
Santengang		Max.	15.0	14.0	18.8	21.0	24.5	25.5	25.0	25.0	24.0	22.0	17.0	14.5	25.5
1960 (m)		Min.	2.5	3.0	7.0	9.5	10.5	16.5	17.0	16.5	16.5	12.5	9.0	4.0	2.5
86 - 94	Max.	Mean	14.0	15.4	18.5	22.1	24.5	26.4	26.1	26.6	25.6	23.8	20.3	15.9	21.6
		Max.	21.0	21.0	26.0	29.0	33.0	32.0	33.0	32.0	30.0	28.0	25.0	22.0	33.0
		Min.	4.0	6.0	8.0	12.0	15.0	18.0	20.0	18.5	18.0	15.0	12.0	6.0	4.0
	Min.	Mean	3.2	4.8	7.8	10.6	13.4	17.1	17.2	17.2	16.5	11.7	6.7	3.9	10.8
		Max.	10.0	9.0	14.0	18.0	23.0	24.0	22.0	19.0	20.0	18.0	11.0	11.0	24.0
		Min.	0.0	-1.0	3.0	3.0	3.0	9.0	10.0	13.0	11.0	4.0	2.0	0.0	-1.0
13550046	Mean	Mean	5.3	5.2	8.9	12.6	14.9	17.2	17.4	17.2	15.8	13.0	8.9	5.8	11.9
Nobding		Max.	9.5	11.5	15.0	16.5	19.5	20.3	20.8	20.5	19.0	17.3	15.5	13.0	20.8
2600 (m)		Min.	-0.5	1.5	2.5	7.3	8.8	12.8	13.5	13.0	11.5	9.0	3.8	-0.5	-0.5
85 - 94	Max.	Mean	10.8	9.8	14.8	18.2	19.7	21.1	20.9	20.5	19.0	17.1	13.8	10.6	16.4
		Max.	16.0	19.0	22.0	23.5	26.5	26.0	26.5	25.5	25.5	21.5	19.0	17.0	26.5
		Min.	5.0	4.0	9.0	8.5	11.0	13.5	14.5	15.5	13.0	11.0	7.0	2.0	2.0
	Min.	Mean	-0.3	0.6	3.1	7.0	10.1	13.4	14.0	14.0	12.5	8.9	4.1	1.0	7.4
		Max.	4.0	4.0	10.0	12.5	14.0	18.0	18.0	19.0	14.5	15.0	14.0	15.0	19.0
		Min.	-6.0	-4.0	-6.0	1.0	5.0	9.5	8.0	8.0	9.0	3.5	0.5	-5.0	-6.0
13640046	Mean	Mean	11.5	13.1	16.3	18.9	21.8	24.1	24.0	24.2	23.2	20.4	15.8	12.3	18.8
Wangdi(CARD)		Max.	16.7	19.5	21.5	25.0	28.0	32.5	28.1	30.5	27.0	24.5	23.5	17.8	32.5
1180 (m)		Min.	6.5	6.5	12.0	13.0	14.5	15.0	18.5	18.5	16.0	13.5	8.8	8.5	6.5
85 - 94	Max.	Mean	17.6	18.8	21.9	25.1	27.3	29.1	27.9	28.5	27.7	26.0	22.6	19.7	24.3
		Max.	24.0	24.0	27.0	30.3	32.0	35.0	33.3	35.0	33.1	30.0	28.0	24.1	35.0
		Min.	8.4	11.0	15.0	17.0	17.0	20.0	19.0	19.0	20.0	18.0	14.3	12.5	8.4
	Min.	Mean	5.4	7.4	10.7	12.6	16.3	19.1	20.0	19.9	18.8	14.8	8.9	4.8	13.2
		Max.	15.0	19.0	19.0	21.0	26.0	32.0	25.3	29.6	24.0	20.0	19.0	13.0	32.0
		Min.	-0.9	0.5	4.0	6.0	9.0	10.0	14.0	16.0	1.8	6.0	2.0	-1.6	-1.6

Table E.4.2 Summary of Temperature Data (°C) (3/3)

Station	Item		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
13660044	Mean	Mean	7.6	6.6	7.0	9.5	12.7	17.4	18.0	19.7	18.4	14.3	11.2	8.0	12.5
Lunichawa		Max.	10.0	11.0	10.0	12.5	18.0	22.0	21.0	25.5	23.0	18.0	13.5	11.0	25.5
2210 (m)		Min.	2.5	3.5	5.0	7.0	10.0	11.5	14.0	16.5	13.5	11.5	9.5	4.5	2.5
92 - 94	Max.	Mean	9.8	9.1	8.5	10.7	13.6	20.9	20.8	24.6	23.4	18.0	13.5	9.6	15.2
		Max.	15.0	16.0	11.0	16.0	19.0	29.0	26.0	35.0	33.0	24.0	16.0	13.0	35.0
		Min.	5.0	5.0	7.0	8.0	11.0	11.0	14.0	17.0	15.0	13.0	11.0	6.0	5.0
	Min.	Mean	5.3	4.0	5.5	8.3	11.7	13.9	15.2	14.7	13.3	10.5	9.0	6.4	9.8
		Max.	9.0	11.0	9.0	12.0	17.0	18.0	18.0	18.0	19.0	14.0	11.0	9.0	19.0
		Min.	-0.9	-0.9	3.0	6.0	9.0	3.0	10.0	10.0	8.0	8.0	7.0	3.0	-0.9
13670046	Mean	Mean	12.0	14.6	17.1	20.2	22.0	25.4	25.4	25.5	24.8	21.7	16.7	13.6	19.9
Punakha		Max.	17.5	19.5	22.0	25.5	28.0	30.0	33.0	29.5	30.0	27.5	21.5	18.5	33.0
1280 (m)		Min.	6.0	7.0	10.5	14.5	15.0	20.5	19.0	19.5	20.5	13.5	12.5	6.0	6.0
85 - 94	Max.	Mean	18.7	21.0	24.3	26.9	27.8	30.7	30.2	30.1	29.1	26.4	24.3	21.5	25.9
		Max.	26.0	26.0	30.0	34.0	35.0	37.0	37.0	35.0	35.0	32.0	30.0	29.0	37.0
		Min.	9.0	12.0	12.0	19.0	18.0	21.0	20.0	20.0	20.0	14.0	13.0	10.0	9.0
	Min.	Mean	5.4	8.2	9.9	13.4	16.3	20.2	20.7	20.9	20.6	17.0	9.0	5.7	13.9
		Max.	12.0	14.0	15.0	18.0	21.0	27.0	33.0	28.0	28.0	26.0	16.0	11.0	33.0
		Min.	0.0	2.0	4.0	8.0	9.0	14.0	17.0	18.0	16.0	7.0	2.0	-1.0	-1.0
13760046	Mean	Mean	4.7	6.3	7.8	10.4	14.1	14.9	16.7	16.5	16.2	13.1	9.0	7.6	11.4
Gasakhatey		Max.	10.0	10.5	15.5	16.5	27.5	21.5	21.0	21.0	20.5	19.5	15.0	16.0	27.5
2760 (m)		Min.	0.5	0.5	1.0	3.5	7.0	4.5	12.5	12.0	10.5	7.0	4.0	1.0	0.5
85 - 94	Max.	Mean	8.3	11.0	11.5	14.3	18.6	18.7	20.0	20.4	19.9	17.9	13.8	12.4	15.6
		Max.	15.0	17.0	19.0	21.0	36.0	28.0	25.0	26.0	24.0	26.0	23.0	23.0	36.0
		Min.	1.0	3.0	2.0	4.0	8.0	5.0	13.0	13.0	14.0	8.0	7.0	4.0	1.0
	Min.	Mean	1.1	1.6	4.2	6.4	9.7	11.0	13.4	12.7	12.4	8.3	4.2	2.9	7.3
		Max.	6.3	7.0	12.0	16.0	20.0	19.0	19.0	17.0	19.0	17.0	14.0	14.0	20.0
		Min.	-4.0	-11.0	-3.0	1.0	2.0	4.0	9.0	9.0	7.0	3.0	1.0	-3.0	-11.0
13780046	Mean	Mean	-3.4	-	-	4.0	6.4	9.1	9.6	9.1	8.6	5.9	4.2	1.1	-
Lingishi		Max.	-2.0	-	-	9.5	10.5	11.5	12.0	11.5	11.5	9.5	10.0	4.5	-
4100 (m)		Min.	-5.0	-	-	-4.5	2.0	6.0	7.5	5.5	5.5	3.0	-4.5	-5.5	-
85 - 92	Max.	Mean	6.6	-	-	9.6	11.3	13.4	13.7	12.9	12.1	12.2	11.1	10.0	-
		Max.	9.0	-	-	14.0	18.0	17.0	18.0	16.0	16.0	16.0	17.0	16.0	-
		Min.	5.0	-	-	0.0	5.0	8.0	10.0	8.0	7.0	7.0	0.0	0.0	-
	Min.	Mean	-13.4	-	-	-1.5	1.4	4.7	5.5	5.3	5.1	-0.3	-2.7	-7.8	-
		Max.	-10.0	-	-	8.0	6.0	8.0	10.0	9.0	9.0	8.0	6.0	-1.0	-
		Min.	-16.0	-	-	-9.0	-5.0	0.0	2.0	0.0	0.0	-6.0	-10.0	-13.0	-
13830046	Mean	Mean	12.0	12.7	14.8	17.0	18.0	19.8	20.8	20.9	20.4	18.3	15.7	14.5	17.1
Shengana		Max.	19.2	17.8	20.5	25.0	26.2	30.5	28.0	25.5	26.9	24.5	23.5	28.5	30.5
1680 (m)		Min.	6.0	3.5	10.0	10.5	7.0	9.8	10.0	11.7	14.1	10.5	9.5	4.5	3.5
85 - 94	Max.	Mean	18.4	19.1	21.2	23.6	24.3	25.3	25.3	25.8	25.6	23.8	22.2	20.7	22.9
		Max.	28.0	27.0	29.0	31.4	31.0	38.0	37.0	34.3	35.8	30.0	32.0	33.0	38.0
		Min.	9.0	7.0	11.0	14.6	10.0	13.0	13.0	10.3	19.0	14.0	12.0	6.0	6.0
	Min.	Mean	5.7	6.3	8.4	10.3	11.7	14.3	16.3	15.9	15.3	12.7	9.2	8.3	11.2
		Max.	13.0	13.0	14.0	23.0	23.0	25.0	25.0	22.0	22.0	19.0	19.0	28.0	28.0
		Min.	1.0	-2.0	3.0	3.0	3.0	1.0	4.6	9.0	7.0	5.0	3.0	0.0	-2.0

Table E.4.3 Summary of Other Meteorological Data

13660044 Wangdi (CARD)
1180 m E89-54' N27-29'

Monthly Evaporation Data (mm/day)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1990	3.3	3.7	5.5	5.9	6.9	7.0	6.2	5.8	5.0	4.2	3.7	3.0	5.0
1991	2.5	4.5	5.7	6.5	6.6	5.6	6.0	4.7	4.4	5.1	3.7	2.6	4.8
1992	3.1	3.5	5.2	6.1	6.4	7.3	5.6	5.8	5.5	4.5	3.9	3.0	5.0
1993	1.3		4.6		3.2	5.7	7.1	5.2	5.1	4.7	3.4	2.9	-
1994	2.9	3.9	4.7	7.5	7.1	6.3	7.6	5.5	5.6	5.5	3.8	2.9	5.3
1995	2.7	4.8	5.3	5.9	6.5	6.6	5.1						
MEAN	2.6	4.1	5.2	6.4	6.1	6.4	6.3	5.4	5.1	4.8	3.7	2.9	4.9

Relative Humidity (%)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1990	77.0	77.0	72.0	74.0	74.0	79.0	83.0	80.0	83.0	80.0	75.0	75.0	77.4
1991	76.0	73.0	70.0	64.0	76.0	80.0	84.0	83.0	85.0	76.0	75.0	78.0	76.7
1992	77.0	73.0	72.0										-
1993												75.0	-
1994	75.0	72.0	76.0	62.0	69.0	76.0	76.0	79.0	75.0	70.0	69.0	69.0	72.3
1995	69.0	71.2	65.0										
MEAN	74.8	73.2	71.0	66.7	73.0	78.3	81.0	80.7	81.0	75.3	73.0	74.3	75.2

Wind Velocity (m/s)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1990	1.6	1.8	2.3	2.2	2.2	2.4	1.9	1.5	1.4	1.2	1.0	1.1	1.7
1991	1.2	1.9	2.1	2.2	2.3	2.0	1.8	1.6	1.7	1.6	1.4	1.1	1.7
1992	1.4	2.0	2.0	2.0	2.2	2.3	1.7	1.6	1.6	1.4	1.3	1.3	1.7
1993	1.4	2.0	2.2		2.0	2.1	2.2	1.7	1.3	1.5	1.2	1.1	-
1994	1.3	1.9	2.1	2.4	2.2	2.0	1.9	1.4	1.5	1.7	1.3	1.3	1.8
1995	1.4	1.9	2.3	2.9	2.5	2.3	2.3						
MEAN	1.4	1.9	2.2	2.3	2.2	2.2	2.0	1.6	1.5	1.5	1.2	1.2	1.8

Sunshine (hr)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1990	4.8	4.3	6.2	5.4	5.4	4.3	5.4	5.4	4.8	6.1	7.3	6.1	5.5
1991	5.2	6.2	6.3	6.3	4.0	4.2	4.0	3.9	4.5	7.3	6.2	5.8	5.3
1992	5.6	4.3	4.9	5.5	5.5	4.1	5.5	5.1	6.1	6.0	7.2	6.4	5.5
1993	2.6	6.2	5.9		4.3		4.3		4.7	6.6	5.6	6.0	-
1994	6.3	5.6	4.9	7.0	5.6	5.0	6.6	5.6	5.8	7.0	6.2	5.8	6.0
1995	5.5	4.7	6.0		5.7	2.8	4.6						
MEAN	5.0	5.2	5.7	6.1	5.1	4.1	5.1	5.0	5.2	6.6	6.5	6.0	5.5

Table E.5.1 Correlation Coefficients of Monthly Rainfall

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Code		12620046	12720046	12740044	12820046	12860048	12880045	13340046	13390046	13410046	13440044	13470046	13530046	13550046	13560044	13620048	13640046	13660044	13670046	13760046	13780046
	Name		Gidakom	Yusipang	Dochu-la	Thimphu	Indian E.	Taba	Tashit.	Phobjikha	Uma (D.)	Baso/Ruru C	Gaselo	Samte.	Nobding	Pele-la	W/Phod.	CARD	Lumich.	Punakha	Gasakhatey	Lingishu
	Altitude		2210 (m)	2680(m)	3130(m)	2365(m)	2320(m)	2455(m)	1270(m)	2860(m)	1700(m)	980(m)	1780(m)	1960(m)	2600(m)	3480(m)	1290(m)	1180(m)	2210(m)	1280(m)	2760(m)	4100(m)
1	12620046	C.C.		84.0%	68.3%	85.7%	84.6%	77.8%	87.2%	77.7%	76.1%	84.8%	84.1%	44.1%	75.5%	93.3%	86.2%	84.4%	78.8%	77.3%	68.8%	69.8%
	Gidakom	Nd		100	19	70	43	78	93	76	74	46	91	92	102	12	103	103	27	77	92	56
2	12720046	C.C.			72.3%	81.7%	79.1%	79.4%	78.0%	84.2%	70.2%	87.6%	69.9%	52.1%	79.7%	93.2%	80.8%	80.7%	89.5%	63.9%	69.9%	64.3%
	Yusipang	Nd			31	70	44	88	93	87	71	49	90	95	102	24	104	104	28	77	104	55
3	12740044	C.C.				-	91.5%	77.7%	63.3%	48.2%	33.4%	80.9%	75.0%	33.1%	86.4%	69.2%	80.9%	77.4%	73.9%	71.1%	67.5%	-
	Dochu-la	Nd				0	19	24	16	30	44	21	17	22	20	19	21	21	20	19	23	0
4	12820046	C.C.					80.6%	85.5%	88.9%	83.6%	70.1%	74.2%	82.8%	91.2%	87.7%	-	88.4%	87.0%	-	69.2%	80.5%	76.1%
	Thimphu	Nd					19	57	67	46	53	19	70	62	70	0	71	71	0	49	70	50
5	12860048	C.C.						83.1%	87.9%	68.0%	77.5%	84.6%	80.9%	19.0%	90.5%	91.0%	84.5%	82.2%	66.4%	83.8%	76.2%	69.1%
	Indian Embassy	Nd						31	39	41	26	41	37	43	44	8	44	44	23	35	35	23
6	12880046	C.C.							79.1%	80.2%	62.4%	84.9%	79.2%	58.5%	81.5%	70.5%	82.3%	83.7%	73.5%	70.5%	78.3%	73.4%
	Taba	Nd							70	66	56	35	72	72	82	24	84	84	21	65	87	46
7	13340046	C.C.								73.7%	72.5%	83.5%	80.6%	46.7%	75.3%	87.3%	86.8%	84.4%	58.8%	69.6%	70.8%	78.5%
	Tashitangu	Nd								68	72	39	87	85	94	9	95	95	21	70	85	53
8	13390046	C.C.									59.3%	76.4%	71.6%	41.8%	80.5%	91.3%	76.2%	79.0%	79.9%	57.8%	77.2%	77.0%
	Phobjikha	Nd									56	47	67	78	79	24	80	80	25	57	79	40
9	13410046	C.C.										76.6%	61.0%	48.3%	69.9%	94.5%	66.2%	68.5%	72.4%	70.5%	56.6%	44.4%
	Uma(Daga)	Nd										26	73	65	76	7	77	77	15	51	64	37
10	13440044	C.C.											76.7%	41.3%	91.6%	93.0%	90.1%	88.0%	85.3%	86.1%	76.3%	74.3%
	Baso/Ruru Chhu	Nd											36	60	60	14	61	61	38	37	41	24
11	13470046	C.C.												84.2%	72.4%	97.3%	89.5%	86.1%	60.8%	78.2%	67.1%	68.2%
	Gaselo	Nd												83	95	5	96	96	20	68	82	55
12	13530046	C.C.													47.4%	53.6%	53.7%	57.5%	51.6%	39.4%	41.3%	81.5%
	Samtengang	Nd													106	15	108	108	40	68	86	50
13	13550046	C.C.														98.4%	80.4%	78.0%	89.3%	63.5%	76.7%	69.8%
	Nobding	Nd														13	120	120	40	78	94	56
14	13560044	C.C.															87.0%	86.5%	93.8%	94.5%	86.2%	-
	Pele-la	Nd															14	14	13	12	22	0
15	13620048	C.C.																96.9%	83.2%	76.5%	74.2%	71.4%
	W/Phodrang	Nd																122	40	79	96	57
16	13640046	C.C.																	84.6%	75.8%	73.9%	70.7%
	Wangdue(CARD)	Nd																	40	79	96	57
17	13660044	C.C.																		71.4%	73.0%	-
	Lumichawa	Nd																		27	19	0
18	13670046	C.C.																			65.9%	59.1%
	Punakha	Nd																			70	41
19	13760046	C.C.																				77.6%
	Gasakhatey	Nd																				57
20	13780046	C.C.																				
	Lingishu	Nd																				

Note C.C. Correlation Coefficient Nd ..Number of Data

Table E.5.2 Result of Rainfall Probabilty Analysis (1/4)

12620046 Gidakom								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	393.5	112.5	196.8	87	179	88	151
1/50	2.00	403.8	98.1	171.4	69	168	78	150
1/20	5.00	421.4	80.1	139.6	50	152	67	149
1/10	10.00	439.6	67.1	116.6	37	138	58	148
1/5	20.00	465.4	54.5	94.0	27	122	48	147
1/2	50.00	528.9	37.2	63.1	16	95	35	144
12720046 Yusipang								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	404.2	113.4	194.7	38	102	59	160
1/50	2.00	428.7	100.7	174.7	33	96	54	159
1/20	5.00	468.2	84.2	148.3	26	87	46	157
1/10	10.00	506.2	71.8	127.9	22	80	41	156
1/5	20.00	556.5	59.0	106.6	18	72	35	155
1/2	50.00	667.1	40.3	74.5	13	61	27	152
12740044 Dochu-la				Data not Available				
12820046 Thimphu				Data not Available				
12860048 Indian Embassy				Data not Available				
12880046 Taba								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	460.6	275.5	247.5				
1/50	2.00	485.5	235.6	227.3		Data		
1/20	5.00	525.4	185.3	198.9		Not		
1/10	10.00	563.5	148.5	175.0		Available		
1/5	20.00	613.5	112.2	147.6				
1/2	50.00	721.7	61.8	100.0				

Table E.5.2 Result of Rainfall Probabilty Analysis (2/4)

13340046 Tashitangu								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	929.8	190.3	549.4	33		31	
1/50	2.00	979.0	178.8	454.5	31	Data	30	Data
1/20	5.00	1057.6	162.6	350.4	28	Not	28	Not
1/10	10.00	1132.7	149.5	285.7	26	Available	26	Available
1/5	20.00	1230.9	134.8	231.4	23		24	
1/2	50.00	1442.9	110.5	172.9	19		21	
13390046 Phobjikha								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00		101.0	235.5		116		129
1/50	2.00	Data	90.7	212.6	Data	111	Data	129
1/20	5.00	Not	77.5	182.4	Not	103	Not	128
1/10	10.00	Available	67.8	159.1	Available	96	Available	127
1/5	20.00		58.0	134.8		89		126
1/2	50.00		44.0	98.0		76		124
13410046 Uma(Daga)				Data not Available				
13440044 Baso/Ruru Chhu				Data not Available				
13470046 Gaselo								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	368.1	234.83	513.3	20		56	
1/50	2.00	378.9	194.92	411.9	19	Data	52	Data
1/20	5.00	399.5	147.32	296.2	18	Not	47	Not
1/10	10.00	423.5	114.70	220.7	17	Available	42	Available
1/5	20.00	462.0	84.49	154.4	16		38	
1/2	50.00	578.1	46.55	77.4	14		30	

Table E.5.2 Result of Rainfall Probabilty Analysis (3/4)

13530046 Samtengang								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	798.7	128.7	295.9	37	106	54	171
1/50	2.00	811.2	118.3	256.2	33	98	47	170
1/20	5.00	833.8	104.2	207.7	27	87	38	167
1/10	10.00	858.4	93.0	173.6	23	78	31	165
1/5	20.00	895.1	80.9	141.3	18	68	25	163
1/2	50.00	994.3	61.8	99.0	12	52	17	158
13550046 Nobding								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	1180.9	258.5	334.9	28	139	23	174
1/50	2.00	1231.7	211.6	292.0	25	138	21	172
1/20	5.00	1309.1	158.5	239.1	20	136	19	170
1/10	10.00	1379.4	124.2	201.3	17	113	17	168
1/5	20.00	1466.4	94.4	165.0	13	84	16	166
1/2	50.00	1638.8	60.4	116.4	9	50	13	161
13560044 Pele-la		Data not Available						
13620048 W/Phodrang		Data not Available						
13640046 Wangdi(CARD)								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	461.7	175.3	427.2		82		130
1/50	2.00	481.6	151.9	348.7	Data	78	Data	130
1/20	5.00	513.3	122.8	259.6	Not	71	Not	128
1/10	10.00	543.4	101.7	201.8	Available	66	Available	127
1/5	20.00	582.3	81.1	151.4		59		126
1/2	50.00	665.2	58.8	93.3		46		124
13660044 Lumichawa		Data not Available						

Table E.5.2 Result of Rainfall Probabilty Analysis (4/4)

13670046 Punakha								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	328.0	156.0	168.2				
1/50	2.00	357.3	139.4	155.8		Data		
1/20	5.00	408.1	117.6	139.2		Not		
1/10	10.00	461.5	100.9	126.0		Available		
1/ 5	20.00	538.5	83.5	111.8				
1/ 2	50.00	734.2	57.4	89.4				
13760046 Gasakhatey								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	924.2	172.3	261.4	53		84	
1/50	2.00	996.2	158.1	240.1	41	Data	67	Data
1/20	5.00	1114.7	138.2	210.8	28	Not	49	Not
1/10	10.00	1231.7	121.8	187.1	21	Available	37	Available
1/ 5	20.00	1390.0	103.4	161.2	14		26	
1/ 2	50.00	1751.7	72.6	118.9	8		14	
13780046 Lingishi								
Return Period	F[%]	Annual Rainfall (mm)	Maximum 24 hr Rainfall (mm)	Maximum 3 Day Rainfall (mm)	Continuous days without Rainfall (days)			
					less than 0.1 mm		less than 5.0 mm	
					Rainy Season	Dry Season	Rainy Season	Dry Season
1/100	1.00	201.4	66.0	131.3				
1/50	2.00	224.7	54.8	103.3		Data		
1/20	5.00	260.1	41.7	74.1		Not		
1/10	10.00	292.0	32.9	56.9		Available		
1/ 5	20.00	331.5	24.9	43.3				
1/ 2	50.00	409.1	15.2	29.9				

Table E.5.3 Summary of River Discharge at Selected Stations

(unit m3/s)

12440045 Damchuzam on Haa Chhu

336 km2 2690 m 27-21'41N 89-18'14E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	2.45	2.36	2.20	3.05	3.81	9.48	19.62	31.68	25.67	7.17	4.05	2.86	9.56
Max.	2.65	2.78	2.65	6.92	6.40	23.57	55.79	77.20	143.75	16.55	5.06	3.56	143.75
Min.	2.23	2.03	1.93	1.63	2.69	3.84	6.82	12.66	7.99	4.53	2.92	2.19	1.63

12800045 Lungtenphu on Thimphu Chhu

663 km2 2260 m 27-26'48N 89-39'40E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	5.35	4.39	4.55	5.78	10.90	24.18	45.16	70.36	54.88	19.99	10.57	6.89	21.99
Max.	5.69	4.91	3.20	11.44	18.38	66.08	77.99	143.78	132.78	40.33	14.01	9.23	143.78
Min.	4.87	3.64	3.67	3.93	6.37	8.75	19.34	40.55	28.16	11.97	7.84	5.69	3.64

13490045 Wangdi Rapids on Pho-Mo Chhu

5640 km2 1190 m 27-27'45N 89-54'11E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	69.46	63.23	75.18	111.41	195.27	275.73	561.54	761.43	550.40	255.02	133.27	91.73	263.00
Max.	78.30	75.10	138.70	170.90	329.00	612.70	935.20	1163.60	964.00	423.10	181.70	119.60	1163.60
Min.	64.50	55.00	54.70	67.69	125.00	153.60	350.50	441.90	270.50	158.50	98.90	71.80	54.70

13700045 Yebesa on Mo Chhu

2320 km2 1230 m 27-37'59N 89-49'3E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	27.60	25.74	31.51	47.12	84.96	152.94	245.30	335.44	234.68	105.83	52.04	34.79	115.24
Max.	29.42	30.47	61.06	81.30	158.66	305.54	448.29	483.18	432.28	175.65	72.37	44.56	483.18
Min.	25.85	22.44	23.24	28.05	46.04	66.22	141.14	169.66	107.49	61.21	38.40	28.38	22.44

14190045 Tinhtibi on Mangde Chhu

3200 km2 565 m 27-8'44N 90-41'36E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	42.80	41.18	49.31	68.73	102.69	198.55	302.86	357.17	268.09	136.29	74.31	50.33	141.45
Max.	56.00	49.49	97.44	103.38	149.36	514.38	658.73	630.34	690.94	202.04	103.21	79.09	690.94
Min.	33.45	29.92	29.01	40.43	71.72	94.34	156.27	199.13	149.73	71.90	40.14	25.29	25.29

15490045 Kurjey on Chamkhar Chhu

1350 km2 2600 m 27-35'13N 90-44'13E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	11.11	10.18	11.91	18.67	33.75	70.36	106.26	149.55	103.02	42.46	21.80	14.40	49.63
Max.	12.32	12.13	21.14	30.86	51.96	214.00	225.05	313.97	273.32	68.60	30.92	18.46	313.97
Min.	10.15	8.53	8.61	12.72	19.42	27.84	54.78	89.09	53.27	25.20	15.33	11.81	8.53

16200045 Kurizampa on Kuri Chhu

8600 km2 540 m 27-16'27N 91-11'47E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	68.55	66.02	95.96	152.18	237.90	424.80	616.94	816.85	551.43	286.60	125.93	95.77	295.96
Max.	81.87	96.51	180.71	246.72	436.57	843.56	1113.00	1133.00	1084.40	492.94	162.58	134.32	1133.00
Min.	55.62	47.83	50.98	81.65	143.75	203.23	278.43	473.56	258.03	137.02	100.40	68.23	47.83

17400045 Uzorong on Gongri Chhu

8560 km2 570 m 27-15'40N 91-25'3E

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	66.61	68.17	77.34	102.13	140.52	210.40	234.46	293.72	184.66	139.03	91.30	75.29	140.62
Max.	68.33	76.52	139.49	169.63	220.04	403.82	347.12	451.98	255.65	282.62	106.52	83.73	451.98
Min.	65.28	65.58	62.16	65.14	101.12	104.06	171.81	207.73	136.02	103.33	78.79	65.87	62.16

Table E.5.4 Monthly Discharge at Wangdue Rapids and Yebesa

(Unit: m^3/s)

13490045 Wangdue Rapids on Pho-Mo Chhu 5640 km^2		1190 m		27-27'45N		89-54'11E							
Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1991	Mean	-	-	-	-	-	-	-	-	680.03	251.07	130.04	89.50	-
	Max.	-	-	-	-	-	-	-	-	964.00	365.20	158.80	106.30	-
	Min.	-	-	-	-	-	-	-	-	370.10	159.90	107.50	78.60	-
1992	Mean	69.17	59.97	88.53	120.57	164.67	318.73	590.46	711.27	439.02	224.54	123.31	84.63	249.57
	Max.	78.30	67.20	138.70	170.90	236.60	612.70	867.50	1,094.70	590.50	289.00	155.60	98.30	1,094.70
	Min.	64.50	55.00	54.70	84.50	125.00	184.20	350.50	441.90	270.50	158.50	98.90	71.80	54.70
1993	Mean	69.75	66.61	61.85	102.27	225.89	232.74	532.63	811.61	532.17	289.46	146.48	101.07	264.38
	Max.	77.90	75.10	71.00	164.90	329.00	425.70	935.20	1,163.60	752.80	423.10	181.70	119.60	1,163.60
	Min.	64.50	58.90	59.30	67.70	153.60	153.60	363.00	620.90	401.80	186.10	119.50	84.50	58.90
1994	Mean	76.58	65.25	75.88	133.23	200.49	406.45	431.78	609.18	461.05	295.25	121.86	86.65	246.97
	Max.	83.50	70.40	110.20	1,114.80	292.90	790.60	738.50	833.00	711.30	2,539.20	168.00	98.10	2,539.20
	Min.	70.90	60.60	60.20	81.90	124.30	208.80	232.60	428.10	296.30	158.60	99.10	76.60	60.20
Total	Mean	71.83	63.94	75.42	118.69	197.02	319.31	518.29	710.69	528.07	265.08	130.42	90.46	257.43
	Max.	83.50	75.10	138.70	1,114.80	329.00	790.60	935.20	1,163.60	964.00	2,539.20	181.70	119.60	2,539.20
	Min.	64.50	55.00	54.70	67.70	124.30	153.60	232.60	428.10	270.50	158.50	98.90	71.80	54.70
13700045 Yebesa on Mo Chhu 2320 km^2		1230 m		27-37'59N		89-49'3E								
Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1991	Mean	-	-	-	-	-	-	-	391.75	300.70	103.07	50.05	34.19	-
	Max.	-	-	-	-	-	-	-	483.18	432.28	171.02	62.26	40.17	-
	Min.	-	-	-	-	-	-	-	258.31	158.73	62.61	39.48	29.42	-
1992	Mean	27.70	24.11	37.98	51.39	75.99	144.70	245.30	288.26	186.06	93.90	48.56	33.24	104.76
	Max.	29.42	25.74	61.06	81.30	136.29	254.50	448.29	471.92	361.21	127.98	61.73	38.26	471.92
	Min.	25.85	22.44	23.55	39.34	46.04	66.22	141.14	169.66	107.49	61.21	38.40	28.38	22.44
1993	Mean	27.52	27.43	25.06	42.86	93.95	161.18	219.12	326.32	217.31	120.55	57.53	36.95	112.98
	Max.	29.30	30.47	27.38	68.83	158.66	305.55	440.54	467.56	319.07	175.65	72.37	44.56	467.56
	Min.	26.61	24.06	23.24	28.05	64.75	91.95	136.48	267.76	165.36	75.27	45.15	31.17	23.24
1994	Mean	28.24	25.20	30.26	39.64	79.26	161.35	163.04	203.46	164.29	79.31	41.41	29.18	87.05
	Max.	31.08	32.50	48.89	56.34	166.03	242.96	345.52	285.20	252.20	114.81	55.30	33.90	345.52
	Min.	25.92	23.25	23.80	32.47	44.05	94.24	101.49	140.05	99.87	53.96	34.42	25.02	23.25
Total	Mean	27.82	25.58	31.10	44.63	83.07	155.75	209.16	302.45	217.09	99.21	49.39	33.39	106.55
	Max.	31.08	32.50	61.06	81.30	166.03	305.55	448.29	483.18	432.28	175.65	72.37	44.56	483.18
	Min.	25.85	22.44	23.24	28.05	44.05	66.22	101.49	140.05	99.87	53.96	34.42	25.02	22.44

Table E.5.5 Summary of Estimated River Discharge (m^3/s)

River: Pe Chhu

Station:SR1

Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	Mean	-	-	-	-	-	5.357	7.860	13.222	15.125	9.279	7.013	5.793
	Max.	-	-	-	-	-	11.851	9.296	17.502	17.886	17.311	8.275	6.123
	Min.	-	-	-	-	-	3.246	5.817	8.777	11.252	8.031	6.020	4.007
1995	Mean	5.405	4.695	4.515	4.466	4.371	4.924	8.622	12.085	-	-	-	-
	Max.	5.918	5.618	4.773	4.596	5.233	5.618	11.699	12.784	-	-	-	-
	Min.	4.684	4.171	4.338	4.254	3.692	3.848	5.233	10.959	-	-	-	-

River: Dang Chhu

Station:SR2

Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	Mean	-	-	-	-	-	28.061	-	36.525	33.621	18.815	-	11.474
	Max.	-	-	-	-	-	44.966	-	52.769	39.245	23.376	-	13.506
	Min.	-	-	-	-	-	16.083	-	29.149	24.057	15.020	-	10.544
1995	Mean	-	10.757	-	14.417	17.939	23.271	25.525	31.374	-	-	-	-
	Max.	-	10.757	-	21.083	21.083	40.167	29.534	49.036	-	-	-	-
	Min.	-	10.757	-	11.632	16.355	17.471	23.376	25.809	-	-	-	-

River: Dang Chhu

Station:SR3

Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	Mean	-	-	-	-	-	-	33.773	63.267	56.996	30.568	-	-
	Max.	-	-	-	-	-	-	44.365	100.914	74.552	40.738	-	-
	Min.	-	-	-	-	-	-	20.083	43.624	41.448	20.996	-	-
1995	Mean	-	10.942	9.722	13.206	17.634	31.188	-	70.983	-	-	-	-
	Max.	-	12.650	11.354	17.914	21.462	68.493	-	100.914	-	-	-	-
	Min.	-	9.296	9.296	10.739	16.687	17.914	-	62.756	-	-	-	-

River: Limti Chhu

Station:SR4

Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	Mean	-	-	-	-	-	-	-	-	0.056	0.074	-	0.073
	Max.	-	-	-	-	-	-	-	-	0.207	0.132	-	0.121
	Min.	-	-	-	-	-	-	-	-	0.020	0.017	-	0.048
1995	Mean	0.066	0.043	0.023	0.025	-	-	-	-	-	-	-	-
	Max.	0.132	0.076	0.048	0.043	-	-	-	-	-	-	-	-
	Min.	0.043	0.020	0.014	0.017	-	-	-	-	-	-	-	-

River: Tabe Rongchhu

Station:SR5

Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	Mean	-	-	-	-	-	8.878	11.279	15.511	14.501	9.102	5.917	5.550
	Max.	-	-	-	-	-	65.544	29.655	26.351	21.561	11.307	7.342	6.512
	Min.	-	-	-	-	-	1.355	4.811	9.866	7.930	6.782	4.811	3.786
1995	Mean	3.850	3.913	3.556	2.388	2.266	-	12.307	-	-	-	-	-
	Max.	4.594	5.035	3.599	2.910	2.752	-	16.391	-	-	-	-	-
	Min.	2.451	3.599	3.418	1.914	1.676	-	6.512	-	-	-	-	-

River: Tabe Rongchhu

Station:SR6

Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	Mean	-	-	-	-	-	5.046	7.445	5.104	-	-	-	3.897
	Max.	-	-	-	-	-	15.517	30.468	9.177	-	-	-	4.258
	Min.	-	-	-	-	-	1.057	2.975	2.063	-	-	-	3.653
1995	Mean	2.850	3.369	-	-	-	-	-	-	-	-	-	-
	Max.	2.850	3.653	-	-	-	-	-	-	-	-	-	-
	Min.	2.850	2.850	-	-	-	-	-	-	-	-	-	-

Table E.5.6 Estimated Sediment Runoff at the Chang Chhu

13490045				Wangdue Rapids on Pho-Mo Chhu					Catchment Area	5640 km2				
Suspended Sediment Runoff (t/d)														
Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1991	Mean	-	-	-	-	-	-	-	-	4620.1	628.4	158.8	74.3	-
	Max.	-	-	-	-	-	-	-	-	8739.0	1243.4	233.3	104.2	-
	Min.	-	-	-	-	-	-	-	-	1277.1	236.6	106.6	56.8	-
1992	Mean	44.1	33.1	76.9	139.5	258.5	1118.6	3442.8	5026.9	1897.3	479.8	143.0	66.5	1060.6
	Max.	56.4	41.5	177.8	270.4	519.8	3515.9	7070.3	11282.1	3264.7	777.0	224.0	89.0	11282.1
	Min.	38.2	27.7	27.4	65.7	144.3	314.4	1144.9	1823.6	680.3	232.5	90.1	47.4	27.4
1993	Mean	44.8	41.0	35.2	102.4	491.0	532.7	2817.6	6336.7	2736.5	819.5	201.3	95.1	1187.8
	Max.	55.8	51.8	46.3	251.7	1008.1	1691.8	8222.4	12754.0	5317.5	1671.1	305.9	132.0	12754.0
	Min.	38.2	31.8	32.3	42.1	218.2	218.2	1228.4	3611.1	1506.3	320.9	131.8	65.7	31.8
1994	Mean	54.0	39.2	54.6	93.2	387.6	1730.0	1869.2	3592.7	2091.7	2433.5	140.5	69.6	1046.3
	Max.	64.1	45.5	112.0	149.2	798.2	5867.5	5116.5	6516.7	4744.9	61159.7	261.3	88.7	61159.7
	Min.	46.2	33.7	33.2	61.7	142.7	404.4	502.3	1711.0	816.9	232.8	90.5	53.9	33.2
Mean	Mean	47.6	37.8	55.6	111.7	379.0	1127.1	2709.9	4985.4	2836.4	885.4	160.9	76.4	1117.8
	Max.	64.1	51.8	177.8	270.4	1008.1	5867.5	8222.4	12754.0	8739.0	1671.1	305.9	132.0	12754.0
	Min.	38.2	27.7	27.4	42.1	142.7	218.2	502.3	1711.0	680.3	232.5	90.1	47.4	27.4
Specific Suspended Sediment Runoff (m3/km2)														
Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1991		-	-	-	-	-	-	-	-	39.32	5.35	1.35	0.63	-
1992		0.38	0.28	0.65	1.19	2.20	9.52	29.30	42.78	16.15	4.08	1.22	0.57	108.31
1993		0.38	0.35	0.30	0.87	4.18	4.53	23.98	53.93	23.29	6.97	1.71	0.81	121.31
1994		0.46	0.33	0.46	0.79	3.30	14.72	15.91	30.58	17.80	20.71	1.20	0.59	106.86
Mean		0.41	0.32	0.47	0.95	3.23	9.59	23.06	42.43	24.14	5.47	1.37	0.65	112.09
13700045				Yebesa on Mo Chhu					Catchment Area	2320 km2				
Suspended Sediment Runoff (t/d)														
Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1991	Mean	-	-	-	-	-	-	-	2963.1	1782.6	195.4	39.7	17.6	-
	Max.	-	-	-	-	-	-	-	4451.3	3526.9	507.4	61.3	24.5	-
	Min.	-	-	-	-	-	-	-	1201.7	434.1	62.1	23.7	12.8	-
1992	Mean	11.3	8.5	23.5	43.3	105.5	442.3	1173.4	1660.7	674.9	150.9	37.4	16.7	362.4
	Max.	12.8	9.7	58.9	107.2	315.6	1164.9	3805.6	4237.1	2422.6	276.7	60.2	22.2	4237.1
	Min.	9.8	7.3	8.0	23.5	32.6	69.8	339.6	499.0	192.1	59.2	22.3	11.9	7.3
1993	Mean	11.1	11.1	9.2	30.2	154.6	498.1	1004.2	2020.2	865.5	258.0	53.3	20.9	411.4
	Max.	12.7	13.8	11.0	75.6	433.7	1707.3	3669.3	4155.7	1869.1	536.5	84.0	30.5	4155.7
	Min.	10.4	8.4	7.8	11.6	66.6	138.6	316.5	1295.5	472.9	91.2	31.3	14.4	7.8
1994	Mean	11.8	9.3	14.1	24.3	119.7	486.7	517.1	759.1	492.5	108.3	26.9	12.7	215.2
	Max.	14.3	15.8	37.0	49.8	476.9	1057.2	2207.8	1478.2	1143.0	220.5	47.9	17.2	2207.8
	Min.	9.8	7.8	8.2	15.7	29.8	145.9	170.4	334.1	164.7	45.5	17.8	9.1	7.8
Mean	Mean	11.4	9.6	15.6	32.6	126.6	475.7	898.3	1850.8	953.9	178.2	39.3	17.0	384.1
	Max.	14.3	15.8	58.9	107.2	476.9	1707.3	3805.6	4451.3	3526.9	536.5	84.0	30.5	4237.1
	Min.	9.8	7.3	7.8	11.6	29.8	69.8	170.4	334.1	164.7	45.5	17.8	9.1	7.3
Specific Suspended Sediment Runoff (m3/km2)														
Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1991		-	-	-	-	-	-	-	61.31	36.88	4.04	0.82	0.36	-
1992		0.23	0.17	0.49	0.90	2.18	9.15	24.28	34.36	13.96	3.12	0.77	0.35	89.97
1993		0.23	0.23	0.19	0.63	3.20	10.31	20.78	41.80	17.91	5.34	1.10	0.43	102.13
1994		0.24	0.19	0.29	0.50	2.48	10.07	10.70	15.71	10.19	2.24	0.56	0.26	53.43
Mean		0.24	0.20	0.32	0.67	2.62	9.84	18.58	38.29	19.74	3.69	0.81	0.35	95.4

Table E.5.7 Summary of Sediment Data at New Stream Gauge Stations (1/2)

Station	Catchment Area (km2)	Sampling Date	Estimated Discharge (m3/s)	Suspended Sediment			Average (ppm)
				Sample 1 (ppm)	Sample 2 (ppm)	Sample 3 (ppm)	
SR1	145.80	18/Apr./94	6.530	10.1	9.1	-	9.6
		5/Jun./94	7.888	16.5	18.1	-	17.3
		29/Jun./94	15.264	292.0	163.0	-	227.5
		8/Jul./94	17.416	18.0	17.0	-	17.5
		23/Aug./94	9.598	58.0	10.0	-	34.0
		20/Sep./94	12.400	333.0	185.6	-	259.3
		28/Oct/94	-	293.2	144.7	-	219.0
		7/Dec./94	5.878	13.6	97.8	-	55.7
		4/Jan./95	6.699	42.5	7.8	-	25.2
		21/Feb./95	3.139	12.5	13.0	-	12.8
		13/Mar./95	8.329	7.2	21.0	-	14.1
		4/Apr./95	6.126	12.1	2.5	-	7.3
		23/May/95	6.165	1.6	4.8	-	3.2
		3/Jul./95	4.023	15.3	14.3	-	14.8
		30/Jul./95	8.668	37.7	33.4	-	35.6
		23/Aug./95	11.198	26.1	30.4	-	28.3
SR2	489.78	19/Apr./94	11.217	5.0	4.1	-	4.6
		5/Jun./94	35.820	11.2	12.0	-	11.6
		29/Jun./94	57.084	83.0	97.0	-	90.0
		8/Jul./94	42.678	7.0	5.0	-	6.0
		23/Aug./94	40.876	62.0	65.0	-	63.5
		20/Sep./94	34.956	110.0	121.0	-	115.5
		28/Oct/94	16.894	73.8	34.5	-	54.2
		7/Dec./94	19.489	30.1	101.3	-	65.7
		4/Jan./95	16.912	3.0	3.0	-	3.0
		21/Feb./95	16.792	3.5	12.0	-	7.8
		13/Mar./95	10.399	5.6	4.0	-	4.8
		4/Apr./95	-	10.6	3.5	-	7.1
		23/May/95	20.723	26.2	22.1	-	24.1
		3/Jul./95	41.126	99.0	155.4	-	127.2
		30/Jul./95	33.136	71.5	72.4	-	72.0
		23/Aug./95	87.780	29.7	31.4	-	30.5
SR3	678.95	19/Apr./94	17.677	16.2	6.1	-	11.1
		5/Jun./94	50.716	12.0	22.0	-	17.0
		29/Jun./94	84.864	204.0	196.0	-	200.0
		8/Jul./94	34.206	11.0	10.0	-	10.5
		23/Aug./94	75.511	53.0	48.0	-	50.5
		20/Sep./94	49.148	201.5	214.4	-	207.9
		28/Oct/94	25.895	188.9	185.7	-	187.3
		7/Dec./94	21.981	667.1	7.5	-	337.3
		4/Jan./95	39.830	3.6	3.4	-	3.5
		21/Feb./95	11.583	6.1	12.4	-	9.3
		13/Mar./95	10.141	6.6	5.5	-	6.1
		4/Apr./95	-	5.0	-	-	5.0
		23/May/95	22.973	39.2	821.0	-	430.1
		3/Jul./95	58.827	266.7	126.7	-	196.7
		30/Jul./95	54.536	65.0	67.6	-	66.3
		23/Aug./95	55.102	37.1	31.1	-	34.1

Table E.5.7 Summary of Sediment Data at New Stream Gauge Stations (2/2)

Station	Catchment Area (km2)	Sampling Date	Estimated Discharge (m3/s)	Suspended Sediment			Average (ppm)
				Sample 1 (ppm)	Sample 2 (ppm)	Sample 3 (ppm)	
SR4	32.04	19/Apr./94	0.025	84.8	-	-	84.8
		5/Jun./94	-	69.6	-	-	69.6
		29/Jun./94	1.578	402.0	-	-	402.0
		23/Aug./94	-	83.0	-	-	83.0
		9/Sep./94	0.170	416.0	-	-	416.0
		28/Oct/94	0.268	327.8	-	-	327.8
		7/Dec./94	0.319	6.3	-	-	6.3
		4/Jan./95	-	272.4	303.3	-	287.9
		21/Feb./95	0.119	201.0	-	-	201.0
		13/Mar./95	-	101.0	-	-	101.0
		4/Apr./95	-	53.0	3.0	-	28.0
SR5	121.35	18/Apr./94	3.857	7.2	8.6	6.9	7.6
		5/Jun./94	0.822	14.8	12.1	-	13.4
		29/Jun./94	22.100	59.0	78.0	-	68.5
		8/Jul./94	12.256	2.0	-	-	2.0
		23/Aug./94	10.798	49.0	68.0	-	58.5
		20/Sep./94	11.346	60.1	79.4	-	69.8
		28/Oct/94	8.410	57.3	66.4	-	61.9
		7/Dec./94	6.311	91.4	6.5	-	49.0
		4/Jan./95	5.276	6.4	-	-	6.4
		21/Feb./95	3.894	12.5	8.5	-	10.5
		13/Mar./95	2.538	6.7	4.5	-	5.6
		4/Apr./95	3.445	14.5	6.5	-	10.5
		23/May/95	1.571	6.5	4.5	-	5.5
		3/Jul./95	4.053	36.2	-	-	36.2
		30/Jul./95	8.931	23.8	27.6	-	25.7
		23/Aug./95	6.516	72.3	68.3	-	70.3
SR6	116.25	18/Apr./94	2.280	9.5	-	-	9.5
		5/Jun./94	0.780	5.8	16.1	-	10.9
		28/Jun./93	8.784	54.0	66.0	-	60.0
		8/Jul./94	7.998	21.0	11.0	-	16.0
		23/Aug./94	4.966	52.0	45.0	-	48.5
		20/Sep./94	-	65.7	65.9	-	65.8
		28/Oct/94	8.296	43.2	52.4	-	47.8
		7/Dec./94	5.621	2.0	4.0	-	3.0
		4/Jan./95	5.074	4.0	-	-	4.0
		21/Feb./95	2.499	6.0	50.0	87.0	47.7
		13/Mar./95	8.269	4.5	-	-	4.5
		5/Apr./95	1.249	3.5	5.6	-	4.6
		23/May/95	0.348	4.5	6.5	-	5.5
		3/Jul./95	4.156	25.8	26.3	-	26.0
		30/Jul./95	4.760	23.7	32.9	-	28.3
		23/Aug./95	4.040	29.6	26.1	-	27.9