Appendix B

Meteo-hydorology

Appendix B
Meteo-hydorology

Table of Contents

Page

List of Tables

Page

List of Figures

Page

Appendix B Meteo-hydorology

1 BANG GIANG AND KY CUNG RIVER BASIN

1.1 Basin Characteristics

1.1.1 River Basin

Bang Giang and Ky Cung River Basin lies in the north east of Vietnam and it is situated between 21°30' to 23°00' north latitude and 105°45' to 107°20' east longitude.

The Bang Giang and the Ky Cung are both part of the upper limit of the Tay Giang basin that debouches into the East Sea (South China Sea) near Hong Kong. The two tributaries have their confluence at Long Zhou in China, some 20 km east of the border inside China. The catchment area of the respective sub-basins at the boundary with China as follows:

Ky Cung :	6,790km^2
Bang Giang :	4,460km^2
Total :	11,250km^2

For the location map of the basin reference is made to Figure B.1.

1.1.2 Climatological Features

Mean annual temperature of this basin varies from 20°C to 22°C. Evaporation varies from 700mm to 800mm. Mean annual rainfall varies from 1200 mm to 1600 mm. Rainy season lasts from May to September.

1.2 Natural Runoff

For the assessment of the availability of water in the Vietnamese part of the Bang Giang and Ky Cung basin, an estimate has been made of the natural runoff at the locations where the two tributaries of this basin leave the Vietnamese territory. The catchment area of the respective sub-basins at the boundary with China is as follows:

Ky Cung	6,790 km^2
Bang Giang	4,460 km^2

The measurement intensity in the basin is very low and especially the availability of historic discharge data is limited.

In the Ky Cung sub-basin two discharge measurement stations were identified. In the Bang Giang sub-basin no historic discharge date could be made available. However, discharge data are available of a station in the Quay Son sub-catchment adjacent to the Bang Giang sub-basin. The runoff observations used in the present analysis refer to:

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Lang Son	106.45	21.50	1,560km^2	Ky Cung	1958-2000
Van Miich	106.22	22.06	2,360km^2	BacGiang	1960-1974
Ban Gioc	106.42	22.51	2,123km^2	Quay Son	1960-1976

In addition to these daily discharge data, the following records of daily precipitation have been made available:

Station	Longitude	Latitude	Province	Observation Period
Dinh Lap	107.06	21.32	Lang Son	1976-2000
Lang Son	106.46	21.50	Lang Son	1976-2000
Ngan Son	105.59	22.26	Cao Bang	1976-2000
LocBinh	106.55	21.45	Cao Bang	1976-1978 .1980-1989. 1991-2000
Cao Bang	106.14	22.39	Cao Bang	1976-2000

It is noted that the observation periods of the runoff series in the respective sub-basins have no overlap with the rainfall series. Only for the Ky Cung sub-basin upstream of Long Sang, the overlap corresponds with the full length of the rainfall series.

For the preparation of discharge series for both sub-basins, the following alternative approaches have been considered:

a. to use the simultaneous Lang Son discharge and rainfall series for the assessment of a rainfall runoff relation for the catchment u/s of Lang Son, and apply the relation of this upper catchment for both sub-basins using the 25 year historical rainfall data;

b. to prepare the runoff series for the 15 year period for which most direct discharge information is available.

The second approach has been selected for the following reasons:

a. The Lang Son catchment represents only 23% of the Ky Cung sub-basin and 14% of the combined Ky Cung and Bang Giang sub-basins.

b. The Lang Son catchment is located in the southern edge of the combined catchment, that has significantly different topographical features as compared to the northern part of the Bang Giang sub-basin. Moreover, the geological features of the Lang Son upper catchment are essentially different from the rest of the sub-basins (reference is made to the Satellite Image Analysis carried out in the framework of the present study).

c. Although the area rainfall in both sub-basins is quite similar (a difference between both sub-basins of some 6% was found), it is anticipated that the assumption of the rainfall runoff relation of the upper Ky Cung to be valid for the combined basins may create a substantial error in the runoff estimate.

d. For the period 1960 - 1974 runoff data are available at Lang Son and Van Mich, together representing 58% of the Ky Cung sub-basin. The transformation of the combined Lang Son – Van My series into Ky Cung sub-basin series is anticipated to give more reliable results than by making use of the above mentioned rainfall runoff relation.

e. No discharge data are available of the Bang Giang sub-basin. Examination of the topographical and geological features of the Bang Giang sub-basin (reference is made to the Satellite Image Analysis) reveals that the southern part of this sub-basin has basically different characteristics as compared to the northern part. The southern part bears clear resemblance with the Bac Giang catchment u/s Van Mich, while the characteristics of the northern part are similar to those of the Quay Son sub-catchment u/s Ban Gioc.

f. It is anticipated that the runoff of the southern part of the Bang Giang basin shows the same characteristics as the runoff at Van Mich, while the northern runoff is similar to the Ban Gioc discharge. Moreover, the size of the southern and northern part are similar to the size of the catchment of Van Mich and Ban Gioc respectively.

g. Based on above observations it is taken that the combined use of the historical monthly runoff series of Van Mich and Ban Gioc provides a fairly accurate estimate of the runoff of the Bang Giang sub-basin.

Based on above analysis, the 15 years natural runoff series for both the Ky Cung and the Bang Giang sub-basins have been compiled with the help of the historical runoff series of Lang Son, Van Mich and Ban Gioc for the period 1960 – 1974.

The Ky Cung runoff is estimated assuming that the combined Lang Son / Van Mich runoff per km^2 is representative for the entire sub-basin within the Vietnamese territory.

The Bang Giang runoff is estimated under the assumption that the average of the runoff per km^2 of the Van Mich and the Ban Gioc catchments is representative for the Bang Giang sub-basin within the Vietnamese territory.

The generated 15 years monthly runoff series of both sub-basins are presented in the Tables B.1.

On the basis of the generated monthly runoff series, the monthly natural runoff for different levels of dependability has been assessed as shown in the following table. It is noted that the dependable monthly runoff volumes have been calculated for each month separately. As a consequence, the succession of, for instance, 10% dry months should not be considered as a 10% dry year.

Dependable Monthly Natural Runoff at the boundary with China (A= 11,250km^2)

unit million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	116	93	109	183	315	831	1,238	1,502	917	429	225	145
75%	96	85	87	117	208	550	837	1,031	650	314	181	118
90%	81	79	71	79	143	379	588	735	476	237	149	98

1.3 Flood Runoff

To estimate the flood runoff in the Bang Giang and Ky Cung basin, an analysis has been made of the observed peak flows in the basin and of the rainfall intensities.

Data on monthly instantaneous peak flows are available for the Lang Son station in the Ky Cung catchment for the period 1958 – 2000. From this series the following probable discharges have been calculated assuming a Log-normal and Pearson-3 probability distribution respectively. The frequency distributions are shown in Figure B.2.

Probable yearly peak discharges at Lang Son in the Ky Cung sub-basin in m^3/s

Return Period in years	2	3	5	10	20	50	100
Log- Normal Function	1,153	1,473	1,862	2,394	2,945	3,718	4,343
Pearson 3 Function	1,185	1,551	1,960	2,471	2,952	3,555	3,998
Round average	1,200	1,550	1,950	2,450	2,950	3,650	4,200

The catchment area upstream of the Lang Son station amounts to 1,560 km^2. The specific peak discharge at that location is, consequently, calculated at some 770 l/s/ km^2 at the once in two year flood, increasing to some 2,700 l/s/ km^2 during the once in 100 years flood.

The concentration time of the basin is estimated of the order of 1-2 days. It is, therefore, anticipated that intensities corresponding with one to two day rainfall are indicative for the peak floods.

For both the Ky Cung sub-basin and the Bang Giang sub-basin, the maximum one-day and two day rainfall has been analysed. The following daily rainfall data have been used:

Cao Bang	1976 – 2000 (with minor gaps)
Ngan Son	1976 – 2000 (with minor gaps)
Loc Binh	1976 – 1978, 1980 – 1989, 1990 - 2000 (with minor gaps)
Lang Son	1976 – 2000 (with minor gap)
Dinh Lap	1976 – 2000 (complete)

The minor gaps in the Cao Bang and Ngan Son series have been mutually filled. The Lang Son series have been completed with the help of Dinh Lap data. Loc Binh series have been completed with the help of the completed Lang Son series.

The area rainfall on the Ky Cung sub-catchment and the Bang Giang sub-catchment has been calculated on the basis of the following weights of the respective stations:

Sub-catchment	Rainfall stations			
	Cao Bang	Ngan Son	Loc Binh	Lang Son
Ky Cung	-	25%	15%	60%
Bang Giang	85%	15%	-	-

Twenty-five years daily area rainfall series have been compiled and the following one and two-day probable rainfall intensities have been calculated assuming a log-normal distribution of the yearly maximum values.

Maximum yearly area rainfall on the Ky Cung basin

Return period in years	10	20	50	100
One-day	114	128	148	162
Two-day	148	165	188	204

Maximum yearly area rainfall on the Bang Giang basin

Return period in years	10	20	50	100
One-day	131	142	157	167
Two-day	157	168	182	192

From these rainfall intensities it can be estimated that the following flood volumes may pass, assuming a runoff of some 60% of the rainfall volume, at the mentioned locations.

Estimated flood volumes (Mm^3)

Return period in years	10	20	50	100
Ban Lai Dam-site	45	50	60	70
Lang Son	100	120	140	150
Ky Cung at border crossing	500	600	700	750
Bang Giang at border crossing	350			500

A first approximation of peak discharges corresponding with these flood volumes is as follows:

Approximate peak discharges (m^3/s)

Return period in years	10	20	50	100
Ban Lai Dam-site	2,000	2,300	2,800	3,200
Lang Son	2,450	2,950	3,650	4,200
Ky Cung at border crossing	6,500	8,000	9,000	10,000

Rainfall intensities in the period January – August, have been calculated as follows:

Maximum January - August area rainfall on the Ky Cung basin

Return period in years	2	3	5	10	20
One-day	72	84	97	114	131
Two-day	98	112	128	147	165

Maximum January - August area rainfall on the Bang Giang basin

Return period in years	2	3	5	10	20
One-day	96	106	118	132	144
Two-day	121	132	144	159	170

These intensities correspond essentially with the yearly maximum values, since the rainy season is almost completely included in the period ending the end of August.

From these rainfall intensities it can be estimated that the following flood volumes may pass, assuming a runoff of some 60% of the rainfall volume, at the mentioned locations.

Estimated flood volumes (Mm^3)

Return period in years	2	3	5	10	20
Ban Lai Dam-site	30	35	40	45	50
Lang Son	70	80	90	100	120
Ky Cung at border crossing	350	400	450	500	600
Bang Giang at border crossing	250	280	300	350	400

A first approximation of peak discharges corresponding with these flood volumes is as follows:

Approximate peak discharges (m^3/s)

Return period in years	2	3	5	10	20
Ban Lai Dam-site	1,000	1,200	1,500	2,000	2,300
Lang Son	1,200	1,550	1,950	2,450	2,950
Ky Cung at border crossing	4,500	5,000	6,000	6,500	8,000

A typical flood at Lang Son is shown Figure B.3, presenting the July 1980 flood, with peak discharge of 2,800 m^3/s following a two day storm with total area rainfall of some 170 mm.

2 RED RIVER / THAI BINH RIVER BASIN

2.1 Basin Characteristics

2.1.1 River Basin

The Red River flows from north-west in the south-easterly direction towards the Gulf of Tonkin. The main tributaries of the Red River basin, i.e. the Da and Thao rivers, originate in China, between 25^o and 26^o north latitude. The Lo river also has its origin in China at a north latitude between 23^o and 24^o. These three tributaries enter Vietnamese territory at north latitude between 22^o and 23^o and enter the Gulf of Tonkin between latitude 20^o and 21^o and eastern longitude 106^o – 107^o.

The catchment area of the Red River is 169,000 km^2. Nearly 50% of this area lies within China. This area includes the Thai Binh basin that joins with the Red river in their common delta area.

The Thai Binh is located on the eastern edge of the basin. Its upper catchment, drained by the Cau River, contributes for about 25% to the discharge of the Thai Binh River, while this river receives most of its water (75%) from the Red River through the Duong River that bifurcates from the Red River just upstream of Hanoi. The main tributaries of the Red River are listed below:

Red and Thai Binh River (Total)	169,040km^2
Major Sub-basins	
Thao :	51,800km^2
Da :	52,900km^2
Lo :	39,000km^2
Cau & Thuong & LucNam :	12,700km^2
Red & ThaiBinh Delta :	12,640km^2

The location plan of the Red River and Thai Binh basin is presented in Figure B.4.

2.1.2 Climatological Features

Mean annual rainfall varies from 1200 mm to 4800 mm. This variation is much less significant in the Red River Delta, which has average rainfall of 1,740mm. However, seasonal variations are significant everywhere. From November to March is the dry season in the basin. Rainy season lasts from May to September. The mean temperature in this basin varies greater within the year.

2.2 Natural Runoff

Runoff of the Red River and Thai Binh basin has extensively been addressed in the framework of the Red River Delta Master Plan, 1994, the National Hydropower Plan Study, 1999 and the Red River Basin Water Resources Management project, 2001. The latter presents information about water resources data, rather then analysing the data.

The present study does not allow a more detailed hydrological study of the Red River basin than the ones that have been carried out previously. Therefore, for the estimate of runoff and water availability at the base point of the Red River and Thai Binh basin, use is made, with due care, of the results of these previous studies, rather then making a full analysis on the basis of basic rainfall and runoff data as has been done for the other basins.

The base point of the Red River and Thai Binh basin is difficult to define. Since the runoff analysis is made in view of the assessment of the water resources potential of the basin, it is considered appropriate to establish runoff and availability just upstream of the area where the major part of the water use occurs, i.e. the delta area. For that reason, the runoff is analysed at Son Thay (Red River basin runoff). The run-off of the Thai Binh sub-basin at Pha Lai, where the Thai Binh meets the Red River Delta, is considered of minor importance at the entire Red River – Thai Binh basin level, since this runoff, estimated at some 4,000 Mm^3 per year, corresponds with some 3% of the basin runoff only.

The runoff at Son Tay is to a considerable extent effected by the main upstream reservoir at Hoa Binh on the Da River and, to a less extent by Thac Ba on the Chay River. The influence of the Thac Ba reservoir, that came into operation in 1974, is limited since its capacity is rather small. However, the observed discharges at Son Tay cannot be considered as the natural basin run-off as from 1986, the year in which the filling of the Hoa Binh reservoir was commenced. Therefore, for the assessment of the natural basin runoff, either the Son Tay discharges are corrected as from 1986, or only the observations prior to this year are used. The latter option has been chosen, that is to say that for the analysis of natural runoff only the existing discharge series 1957 – 1986 have been used.

From these series, the following monthly average runoffs have been derived for the main sub-catchments:

Month	Monthly mean natural runoff (Mm^3)			
	Da sub-basin at Hoa Binh	Thao sub-basin at Yen Bai	Lo sub-basin at Vu Quang	Red River basin at Son Tay
January	1,482	883	1,030	3,453
February	1,059	684	862	2,632
March	933	638	864	2,441
April	1,007	725	1,029	2,823
May	1,925	1,078	1,991	5,060
June	5,714	2,290	3,966	12,023
July	11,008	3,500	5,884	20,699
August	12,218	4,828	6,423	24,043
September	7,837	3,817	4,588	17,137
October	4,861	2,867	2,912	11,112
November	3,185	1,808	1,984	7,269
December	2,039	1,190	1,270	4,591
Year	53,268	24,307	32,805	113,282

Taking into account the estimated 4,000 Mm^3 yearly average Thai Binh runoff, the following distribution of the tributaries to the basin runoff can be derived:

- Da sub-basin: 47 %
- Thao sub-basin: 21 %
- Lo sub-basin: 29 %
- Thai Binh sub-basin 3 %

The thirty years 1957 – 1986 runoff series of the basin at Son Tay and of the main tributaries is presented in the Tables B.2.

On the basis of these series the duration curve of monthly discharges has been established for each station and for each month. From these curves the discharges with different levels of dependability have been assessed, as presented in the tables. These discharges are summarised in the following tables.

Dependable Monthly Natural Runoff at Hoa Binh (A= 51,800km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	1,449	1.041	916	970	1,719	5,336	10,589	11,809	7,615	4,768	3,017	1,965
75%	1,219	894	785	772	1,153	3,904	8,458	9,640	6,238	4,068	2,306	1,579
90%	1,098	815	715	674	907	3,237	7,391	8,534	5,535	3,698	1,962	1,385

Dependable Monthly Natural Runoff at Yen Bai (A= 48,000km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	866	673	617	697	1,010	2,137	3,310	4,610	3,673	2,773	1,727	1,144
75%	736	579	507	552	749	1,556	2,526	3,709	2,917	2,259	1,345	919
90%	667	529	451	480	626	1,287	2,148	3,255	2,540	1,997	1,158	807

Dependable Monthly Natural Runoff at Son Tay (A= 144,000km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	3,384	2,593	2,380	2,721	4,659	11,293	19,879	23,221	16,595	10,899	6,925	4,442
75%	2,870	2,245	2,027	2,173	3,326	8,371	15,763	19,107	13,448	9,183	5,342	3,595
90%	2,601	2,058	1,840	1,899	2,717	6,994	13,715	16,997	11,855	8,291	4,572	3,166

Dependable Monthly Natural Runoff at Vu Quang (A= 37,000km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	994	826	820	964	1,828	3,633	5,633	6,111	4,347	2,811	1,868	1,230
75%	799	651	637	722	1,301	2,551	4,399	4,776	3,305	2,255	1,402	996
90%	700	564	547	607	1,061	2,063	3,792	4,119	2,804	1,976	1,180	877

The natural runoff that was presented in the previous section corresponds with the runoff of the Red River basin without taking into account the effect of the Hoa Binh reservoir. For the assessment of the availability of water in the Red River Delta, this effect needs to be taken into account. However, this effect is subject to the operating rules that are applied in the Hoa Binh scheme.

For the current operation policy for Hoa Binh and Thac Ba simulations were carried out of the Son Tay runoff for the period 1957 – 1990 in the framework of the Red River Delta Master Plan Study. The results of these simulations show that the reservoirs contribute considerably to the low flows during the period December – May. The effects for different levels of dependability are presented in the following table:

Mean monthly water availability at Son Tay in Mm3 with different levels of dependability

	December	January	February	March	April	May
Natural runoff						
75%	3,595	2,870	2,245	2,027	2,173	3,326
90%	3,166	2,601	2,058	1,840	1,899	2,717
Effect reservoirs						
75%	482	937	1,123	1,446	1,555	1,553
90%	723	1,071	1,245	1,446	1,555	1,553
Water availability						
75% (round)	4,071	3,803	3,368	3,482	3,732	4,875
90% (round)	3,884	3,669	3,295	3,294	3,447	4,259

2.3 Flood Runoff

Flood runoff of the Red River and Thai Binh basin has extensively been addressed in the framework of the Red River Delta Master Plan, 1994. This study recommended on the basis of an extensive analysis that it would be prudent to assume a log normal distribution of extreme values for designing the flood protection measures in the Red River Delta.

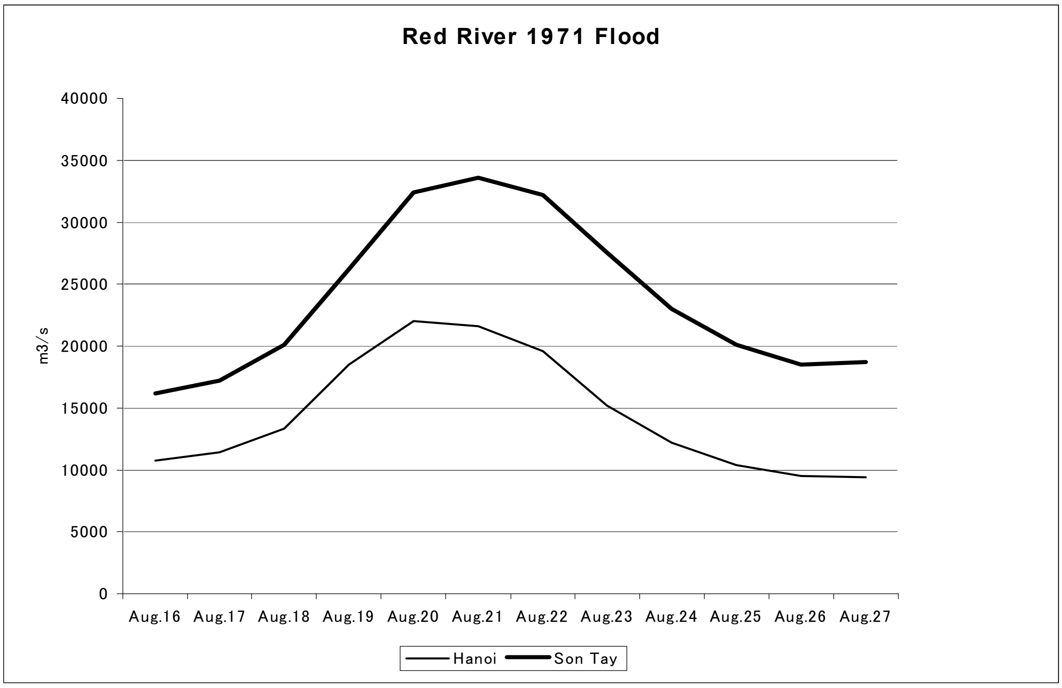
Maximum instantaneous discharges for the years 1956 – 1986 (so prior to the functioning of the Hoa Binh reservoir) were used for the statistical analysis of flood discharges. The data after 1986 when the Hoa Binh Dam commenced its operation were not used, since the flood discharges to downstream were ones which were already regulated by the reservoir and not proper for the use in the statistical analysis. The log normal distribution function on the basis of historic observation gives the following probable peak discharges for Son Tay and Hanoi:

Estimated peak discharges (m^3/s)						
Return period	10 years	20 years	50 years	100 years	500 years	1000 years
Son Tay	23,500	27,000	32,050	35,730	46,390	51,580
Hanoi	16,150	18,020	20,540	22,230	26,860	28,970

In connection with the probable discharges at Hanoi(the Red River), the following is noted:

The Red River bifurcates to the Red River and the Duong River in the downstream of Son Tay. Although the discharges at Hanoi in the Red River after the bifurcation are as shown in the above table on the basis of the statistic analysis with historical observations, the discharges in the Duong River are not always the difference between the discharge at Son Tay and the discharge at Hanoi due to the possible right bank overflow between Son Tay and Hanoi in the occurrence of large floods. The discharges of the Duong River are not shown due to lack of data for the said right bank overflow in the historical events.

The maximum peak discharges observed at these locations refer to the 1971 flood with following hydrograph.



It is observed that the discharges in Son Tay were still rising while in downstream located Hanoi the peak already had passed. This phenomena could be explained by a sudden diversion of flood waters between Son Tay and Hanoi, possibly caused by a dike breach.

The observed maximum discharges in 1971 and corresponding estimated return period are as follows:

	Son Tay	Hanoi
Peak discharge (m^3/s) 1)	34,200	22,200
Estimated return period (years)	72	90

1) these discharges were distracted from the data base presented in the Background Report 1 on Hydrology and Meteorology, Volume 3, of the Red River Delta Master Plan, Binnie & Partners et al, 1994. In the Master Plan report also an other reference is made to the 1971 peak discharge in Son Tay being 38400 m^3/s. Such discharge would have a Return Period of 141 years, applying the log normal distribution function.

The historic flood events of 1968 (Q_{max} at Son Tay: 24,000 m^3/s), 1969 (Q_{max} at Son Tay: 28,300 m^3/s) and 1945 (Q_{max} at Son Tay: 33,500 m^3/s), correspond approximately with floods with an estimated return period of 11, 25 and 64 years respectively. The corresponding flood volumes at Son Tay over 8 days flood duration are as follows (source Red River Master Plan):

year	Qmax (m^3/s)	Estimated Return Period	8- day Flood Volume (Mm^3)
1968	24,000	11 years	12,960
1969	28,300	25 years	16,500
1945	33,500	64 years	18,800
1971[1)]	38,400	141 years	19,600

1) see above note on 1971 Son Tay peak discharges

For the same historic floods the contribution from the different sub-basins to the peak discharge was estimated as follows (source Red River Master Plan):

year	Qmax (m^3/s)	Hoa Binh (Da River)	Yen Bai (Thao River)	Phu Ninh (Lo River)
1968	24000	39%	28%	25%
1969	28300	54%	17%	31%
1945	33500	54%	20%	25%
1971[1)]	38400	38%	25%	39%

1) see above note on 1971 Son Tay peak discharges

3 MA RIVER BASIN

3.1 Basin Characteristics

3.1.1 River Basin

The Ma basin is located in the north-central Vietnam and borders with Laos. The river basin are situated between 19°30' to 21°30' north latitude and between 103° to 106° east longitude.

Ma river basin covers a total catchment area of 31,060 km^2, which included Yen River Basin and some small river Basins located coastal Area. The Yen river basin borders the Chu basin, in the lower part there is no clear divide between these two basins. About 35% of catchment area is located in Laos.

Ma River Basin (Total)	31,060km^2
Major Sub-basins	
Chu :	7,460km^2
Yen :	720km^2
Lower Area (Delta):	3,060km^2

For the location map of the Ma basin reference is made to Figure B.5.

3.1.2 Climatological Features

Mean annual temperature is 23.4°C. Mean annual humidity is 85% and annual evaporation varies from 640mm to 860mm.

Mean annual rainfall distribution is different from regions, 1,200-1,600mm in the upstream and 1,600-2,200mm in the down stream. The rainy season lasts from May to October.

3.2 Natural Runoff

For the selection of the data series to be used for the assessment of the water resources potential of the Ma Basin, it has been recognised that for such assessment, and the eventual planning of the use of this potential, it is inevitable to consider the two main catchments, the Chu sub-basin and the Ma Basin upstream of the confluence with the Chu river. The Yen river basin borders the Chu basin, in the lower part there is no clear divide between these two basins. In the present study, the Yen river is considered as a sub-basin of the Ma river.

The Ma river bifurcates in its lower stretch into a number of branches, forming a delta area. The base point of the basin is not clearly defined. For the assessment of the basin runoff a distinction has been made between the upper and middle part of the basin on one side and the lower area. The transition between the two areas coincides approximately with the confluence of the Ma and Buoi river and the intake in the Chu river at Bai Thoung.

The discharge measurement stations that cover largest part of the respective sub-basins are located at Cua Dat in the Chu river and Cam Thuy in the Ma river. In addition to these stations, the Xuan Khanh station with a six year record was selected, since this station covers almost the entire Chu catchment and allows, consequently the assessment of the downstream Cua Dat runoff of the Chu basin. The catchments covered by Xuan Khanh and Cam Thuy correspond with 82% of the total Ma basin catchment area, including the delta area.

The series of observations in Cam Thuy show a substantial gap during the period 1989 – 1994. To enable the completion of the Cam Thuy series, it was found convenient to collect the complete series of observations at Xa La as well. Moreover, this series allows also for the assessment of the runoff of the upper Ma basin before it enters Lao territory.

The full set of discharge data used in the present analysis refers to:

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Cua Dat	105.17	19.52	6,170km^2	Chu	1978-2000
Xuan Khanh	105.34	19.55	7,460km^2	Chu	1976-1978
Cam Thuy	105.28	20.12	17,500km^2	Ma	1976-1988. 1995-2000
Xa La	103.55	20.56	6,430km^2	Ma	1976-2000

In addition to the discharge observations, the following set of rainfall data have been processed and introduced in the data base.

Station	Longitude	Latitud	Province	Observation Period
Thuong Xuan (Cua Dat)	105.14	19.49	Thanh Hoa	1976. 1978-1990
Bat Mot (BatBot)	105.03	20.01	Thanh Hoa	1976-2000
Lang Chanh	105.14	20.09	Thanh Hoa	1976-2000
Ba Thuoc (CanhNong)	105.13	20.21	Thanh Hoa	1976-1979. 1981-1990
Song Ma	103.44	21.04	Son La	1976-2000
Tuan Giao (LaiChau)	103.25	21.35	Lai Chau	1976-2000
Thanh Hoa	105.46	19.49	Thanh Hoa	1976-1985, 1987-2000

For the preparation of the monthly natural runoff series of the Ma basin just downstream of the confluence of the Buoi and Ma rivers, use has been made of the observed discharges at Cam Thuy. These discharges are considered natural, the impact of minor storage facilities upstream of Cam Thuy on the river discharges at this station is considered negligible as are the withdrawals upstream of Cam Thuy for water supply and irrigation. Since the discharges at Cam Thuy represent almost 90% of the Ma catchment at the Buoi confluence, it is deemed acceptable to apply a simple area proportionality factor for the estimate of the natural runoff at this confluence.

For the completion of the Cam Thuy series of observations, different relations have been investigated between Cam Thuy discharges and monthly catchment rainfall and also between Cam Thuy discharges and the discharges in the upstream Xa La and the neighbouring Chu basin at Cua Dat. It was found that correlation between Xa La discharges and the Cam Thuy discharges is rather poor. It is concluded that the runoff characteristics of the upper catchment are substantially different from the runoff characteristics of the middle part of the catchment. Also the correlation between Cua Dat discharges and Cam Thuy is weak. Finally it was found that the best correlation is found when a relation is sought between the Cam Thuy discharges and the combination of Xa La and Cua Dat discharges. Apparently, the runoff of the Ma sub-basin shows the combined characteristics of the upper Ma catchment and the Chu basin. The relation that has been used for the completion of the Cam Thuy series of the average monthly discharge in m^3/s reads as follows:

$$Q_{CamThuy} = 0.6775(Q_{XaLa} + Q_{CuaDat}) + 13.9$$

The corresponding correlation coefficient amounts to R^2=0.933

For the preparation of the monthly runoff series of the Chu sub-basin just downstream the confluence with the Am river (total catchment area: 7,460 km^2), use has been made of the observed discharges at Cua Dat. The discharges observed at Cua Dat represent 83% of the natural runoff of the sub-basin at the Am confluence. For that reason, it is also for this sub-basin deemed adequate to apply an area proportionality factor for the calculation of natural runoff.

Finally, the series of the monthly runoff of the entire Ma basin at its base point has been prepared by summation of runoff of both sub-basins and the runoff of the lower basin, which has been estimated on the basis of the net rainfall on this lower area as explained in the previous section.

The generated series of monthly runoff of both sub-basins and of the entire basin are presented in the Tables B.3. The dependable basin runoff has been estimated as follows:

Dependable Monthly Natural Runoff in the whole basin (A= 31,060km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	538	407	410	415	683	1,151	1,828	2,501	2,541	1,832	972	671
75%	451	342	345	342	556	851	1,382	1,824	1,880	1,306	739	561
90%	384	292	295	288	462	648	1,074	1,373	1,433	963	577	478

3.3 Flood Runoff

3.3.1 Flood Runoff Chu Sub-basin

The flood runoff of the Chu basin has been estimated at Cua Dat, just upstream of the flood prone area of the Chu basin. Instantaneous yearly peak discharges at Cua Dat stations have been collected and processed for the period 1976 – 2000. It is noted that the availability of only twenty five observed maximum year discharges provides a rather weak basis for the frequency analysis of peak discharges.

The frequency analysis has been carried out using a number of probability distribution functions. The goodness-of-fit tests and the confidence intervals indicate that the normal distribution describes best the probability of occurrence of the peak discharges. Also the Log Pearson, Gumbel and Goodrich give above average results. The results of the frequency analysis are summarised below for these distribution functions and some are presented in Figure B.6.

Unit: m^3/s

Estimated Peak Discharges at Cua Dat with corresponding Return Period				
Return Period	10 years	20 years	50 years	100 years
Normal	3,565	3,912	4,302	4,563
Log-Pearson	3,771	4,745	5,328	6,031
Gumbel	3,587	4,123	4,816	5,336
Goodrich	3,577	3,934	4,360	4,634
Average round values	3,650	4,200	4,700	5,150

For the estimate of volumes of floods that are generated by 1,2 and 3-day peak rainfall on the Chu basin, an analysis has been made of the daily rainfall data from the rainfall stations upstream of Bai Thuong, the downstream location of the upper and middle Chu catchment. These stations are:

Thuong Xuan (Cua Dat)	1976, 1978 – 1990
Lang Chanh	1976 – 2000 (with minor gaps)
Bat Mot	1976 – 2000 (with minor gaps)
Song Ma	1976 – 2000 (complete)

The Thoung Xuan data series has been combined with the Lang Chang series to obtain a complete series that represents the rainfall in the lower 10% of the catchment area under consideration. The minor gaps in the Bat Mot series were filled with Lang Chang data, to obtain a complete series that represent the rainfall on the central 75% of the area. Song Ma data series represent the rainfall on the upper 15% of the Chu catchment. 25 year of area daily rainfall series have been compiled using the above mentioned series and corresponding weights. Also series were compiled of two and three consecutive days area rainfall. From all these series the yearly maximum values were selected, which were put through a frequency analysis. The results are given in the table below using the log-normal and Gumbel probability distribution functions. These functions gave the best fit.

Maximum yearly one-day Chu area rainfall in mm

Return period	10 years	20 years	50 years	100 years
Log-normal	179	202	229	250
Gumbel	179	202	231	254

Maximum yearly two-day Chu area rainfall in mm

Return period	10 years	20 years	50 years	100 years
Log-normal	267	305	346	379
Gumbel	267	302	348	383

Maximum yearly three-day Chu rainfall in mm

Return period	10 years	20 years	50 years	100 years
Log-normal	315	356	414	456
Gumbel	314	358	415	457

These rainfall intensities correspond with the following n-day precipitation volumes in the Chu basin upstream of Bai Thuong (7,460 km^2)

Maximum yearly n-day rainfall volume on Chu basin u/s Bai Thuong in Mm^3

Return period	1 day	2 days	3 days
10 years	1,335	1,992	2,346
20 years	1,507	2,264	2,663
50 years	1,716	2,589	3,092
100 years	1,880	2,842	3,405

Maximum yearly n-day rainfall volume on Chu basin u/s Cua Dat (6170 km^2) in Mm^3

Return period	1 day	2 days	3 days
10 years	1,104	1,648	1,940
20 years	1,246	1,873	2,203
50 years	1,419	2,141	2,557
100 years	1,555	2,351	2,816

Some typical floods and corresponding rainfall are presented in Figure B.7.

3.3.2 Flood Runoff Ma Basin

Observed peak discharges at Cam Thuy are extremely scanty. From the available discharge data between 1975 and 2000, only 8 maximum year discharges could be derived and 20 maximum daily discharges. The observed instantaneous peak discharges are insufficient for a frequency analysis, while the daily data can deviate substantially from the real peak discharges as a consequence of the flashy character of the floods.

For the estimate of probable peak discharges, use could be made of the estimated peak discharges at Xa La and Cua Dat, assuming Creager type of relation between the respective flood discharges. This relation assumes that the peak discharge is proportional to A to the power $A^{-0.05}$, with A is the catchment area. The respective catchment areas are as follows:

Xa La	6,430 km^2
Cua Dat	6,170 km^2
Cam Thuy	17,500 km^2
Ma – Chu confluence	28,000 km^2

Based on these areas, the following proportionality factors are calculated:

Cam Thuy / Xa La	1.40
Cam Thuy / Cua Dat	1.42
Ma – Chu / Cam Thuy	1.15

Comparison of the estimated peak discharges at Xa La and Cua Dat, indicate however that the probable floods at Cua Dat are 50 – 60% higher than the Xa La floods, in spite of the fact that the Xa La area is slightly bigger than the Cua Dat area. From this comparison it is concluded that, if the observed and estimated peak discharges are merely correct, then there is a significant difference between the runoff of both areas.

For the monthly discharges at the respective stations, a fairly good correlation was found between the Cam Thuy discharge and the sum of the Xa La and Cua Dat discharges. The correlation between Cam Thuy and each of the two stations separately appeared to be poor. It is, therefore, concluded that the runoff at Cam Thuy shows characteristics of both the runoff of the upper Ma catchment (at Xa La) and the Chu tributary (at Cua Dat).

Therefore, for a first estimate of peak discharges at Cam Thuy, use is made of the average of the probable discharges at Xa La and Cua Dat, and applying the above mentioned proportionality factors. The result is as follows:

Estimated Peak discharges in m^3/s at Cam Thuy with corresponding Return Period

Return Period	10 years	20 years	50 years	100 years
Peak Discharge	4100	4800	5500	6100

Similarly, the peak discharges of the Ma river downstream of the Chu confluence can be estimated, applying the area related Creager proportionality to the Cam Thuy discharges.

Estimated Peak discharges in m^3/s at Ma – Chu confluence with corresponding Return Period

Return Period	10 years	20 years	50 years	100 years
Peak Discharge	4700	5500	6300	7000

From above analysis it became apparent that an adequate rainfall – runoff modelling is essential for a more accurate estimate of the probable floods in the lower part of the basin.

A typical historical flood and corresponding area rainfall is shown in Figure B.8.

For the estimate of volumes of floods that are generated by 1,2 and 3-day peak rainfall on the Ma basin upstream of the flood prone area, an analysis has been made of the daily rainfall upstream of Ma - Buoi confluence. The following daily rainfall data have been used:

Thanh Hoa	1976 – 1985, 1987 – 2000 (with minor gaps)
Lang Chanh	1976 – 2000
Bat Mot	1976 – 2000 (completed)
Song Ma	1976 – 2000 (complete)
Tuan Giao	1976 – 2000 (complete)

The Thanh Hoa data series has been completed with Lang Chang series to obtain a complete series that represents the rainfall in the lower 5% of the catchment area under consideration. The minor gaps in the Bat Mot series were filled with Lang Chang data, to obtain a complete series that represent the rainfall on the central 60% of the area. Song Ma and Tuan Giao data series represent the rainfal on respectively the upper 20% and 15% of the Ma catchment. 25 year of areal daily rainfall series have been compiled using the above mentioned series and corresponding weights. Also series were compiled of two and three consecutive days area rainfall. From all these series the yearly maximum values were selected, which were put through a frequency analysis. The results are given in the table below using the log-normal and Gumbel probability distribution functions. These functions gave the best fit.

Maximum yearly one-day Ma area (excluding Chu basin) rainfall in mm

Return Period	10 years	20 years	50 years	100 years
Log-normal	141	159	179	194
Gumbel	141	158	181	198

Maximum yearly two-day Ma area (excluding Chu basin) rainfall in mm

Return Period	10 years	20 years	50 years	100 years
Log-normal	213	238	275	301
Gumbel	212	240	277	304

Maximum yearly three-day Ma area (excluding Chu basin) rainfall in mm

Return Period	10 years	20 years	50 years	100 years
Log-normal	253	291	333	367
Gumbel	253	288	333	368

These rainfall intensities correspond with the following n-day precipitation volumes on the Ma basin upstream of the Ma – Buoi confluence (19,820 km^2)

Maximum yearly n-day rainfall volume on Ma basin u/s Ma – Buoi confluence in Mm^3

Return period	10 years	20 years	50 years	100 years
1 day	2,800	3,100	3,600	3,900
2 days	4,200	4,700	5,500	6,000
3 days	5,000	5,700	6,600	7,300

4 CA RIVER BASIN

4.1 Basin Characteristics

4.1.1 River Basin

The Ca basin is located in the north-central Vietnam and borders with Laos. The river basin are situated between 18°00' to 20°30' north latitude and between 103°30' to 106°00' east longitude.

The catchment area of Ca river basin covers about 30,000 km^2, which included some small basins located coastal Area. About some 30% of catchment area are located in Laos. Major tributaries in the Ca system are:

Ca River Basin (Total)	29,850km^2
Major Sub-basins	
Hieu :	5,290km^2
Giang :	1,090km^2
Ngan Pho :	1,120km^2
Ngan Sau :	2,090km^2
Lower Area (Delta)	4,420km^2

For the location map of the basin reference is made to Figure B.9.

4.1.2 Climatological Features

Mean annual temperature varies from 20°C to 23°C with the minimum temperature of 17°C and the maximum temperature of 29°C. Mean annual humidity varies from some 75% on the higher elevated areas of the upper basin to 85% close to sea.

Mean annual rainfall varies from 1200mm to 2400mm. Heavy rains concentrate from August to October. There are two rainfall peaks, i.e. small in May and main rainfall in August to November.

4.2 Natural Runoff

Availability of water in the Ca basin is most important in the lower section of this basin downstream of Do Luong. At this location Ca waters are diverted to the coastal area north of the Ca basin. The natural runoff at Do Luong is therefore an important factor in the assessment of the water resources potential of Ca basin.

Downstream of Do Luong several small sub-catchment areas contribute to the availability of water in the lower Ca basin i.e. the Giang river and the Ngan Pho and Ngan Sau. The contribution of the Giang river is measured at the Yen Thuong station in the Ca river, downstream of the confluence with the Giang river. However, this contribution can only be estimated in an indirect way, since the discharge in the Ca river just upstream of this confluence is not known (as a consequence of the unknown volumes that are diverted at

Do Luong).

The contribution of the Ngan Sau and the Ngan Pho are observed directly in respectively the Hoa Duyet station and the Son Diem station.

For the analysis of the basin runoff, the following discharge data have been collected and stored in the data base.

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Yen Thuong	105.38	18.34	23,000km^2	Ca	1976-2000
Dua	105.02	18.59	20,800km^2	Ca	1976-2000
Hoa Duyet	105.35	18.22	1,880km^2	Ngan Sau	1976-1981. 1997-2000
Son Diem	105.21	18.30	790km^2	Ngan Pho	1976-1981. 1997-2000

In addition to these discharge data, the following rainfall data have been collected:

Station	Longitude	Latitude	Province	Observation Period
Hoa Duyet	105.35	18.22	Ha Tinh	1976-2000
Son Diem	105.20	18.30	Ha Tinh	1976-2000
Do Luong	105.18	18.54	Nghe An	1976-2000
Mon Son	104.55	18.53	Nghe An	1976-1990
Con Cuong	104.53	19.02	Nghe An	1976-1989. 1991-2000
Nghia Khanh	105.20	19.26	Nghe An	1977-2000
Quy Chau	105.06	19.34	Nghe An	1976-2000
Muong Xen	104.08	19.24	Nghe An	1976-2000
Vinh	105.40	18.40	Nghe An	1976-2000

The runoff that is observed at Dua, corresponds with the runoff of more than 98% of the catchment area at Do Luong. It is therefore considered justified to derive the natural runoff at Do Luong directly from the discharge series of Dua station. Storage facilities upstream of this station are insignificant and the impact on the runoff is neglected.

For the contribution of the Giang river to the basin runoff, it is assumed that the runoff of this sub-basin per km^2 is the same as for the rest of the middle and upper catchment of the Ma basin, including Ngan Pho and Ngan Sau.

The contribution of the latter two sub-basins has been derived from the observed discharges in the respective rivers. However, discharge series of these two stations were incomplete, making it necessary to find a relation to complete these series. The best relation was found by comparing the combined monthly runoff at Ngan Pho and Ngan Sau with the runoff at Dua. This relation reads as follows:

$$Q_{HoaDuyet} + Q_{SonDiem} = 0.103Q_{Dua} + 54 \text{ (in } m^3/s)$$

The runoff of the lower basin has been has been estimated on the basis of the net rainfall on this area, as explained previously.

The series of monthly basin runoff for the period 1976 – 2000 is presented in Table B.4. The corresponding dependable discharges are as follows:

Dependable Monthly Natural Runoff in the whole basin (A= 29,850km²)

unit :million m³

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	714	564	546	547	897	1,219	1,573	2,623	4,315	4,444	1,839	952
75%	605	482	464	472	694	895	1,187	1,924	2,916	2,914	1,258	775
90%	521	419	400	413	551	677	922	1,457	2,049	1,994	894	645

4.3 Flood Runoff

The flood prone area of the Ca basin is situated downstream of Do Luong. At this location Ca waters are diverted to the coastal area north of the Ca basin. The peak discharges at Do Luong are therefore an important factor in the formulation of flood mitigation measures in the Ca basin.

Discharges measured at Dua station correspond to more than 98% of the catchment area at Do Luong. As a consequence, peak discharges at Do Luong are expected to deviate from the Dua peak discharges by less than 1%. It is, therefore, considered justified to derive the peak discharges at Do Luong directly from the discharge series of Dua station. From the 1976- 2000 discharge series at Dua, the yearly maximum daily discharges were collected and a frequency analysis has been carried out.

Several probability distribution functions have been assumed for the estimate of the peak discharges with corresponding return periods. The results of the most likely distribution functions are presented below and some are shown in Figure B.10.

Estimated Peak discharges at Dua with corresponding Return Period,Unit: m³/s

Return Period (years)	2	5	10	20	50	100
Log Normal	3,329	5,246	6,656	8,090	10,106	11,712
Pearson-3	3,426	5,507	6,862	8,118	9,716	10,874
Log Pearson	3,218	5,351	7,066		11,756	14,162
Gumbel	3,484	5,468	6,781	8,041	9,672	10,894
Average round values	3,400	5,400	6,800	8,200	10,300	11,900

In addition to the above analysis, also historical annual maximum discharges at Yen Thuong have been analysed for the period 1976 - 2000. This station is located downstream of Do Luong. This analysis has given the following results:

Estimated Peak discharges in m^3/s at Yen Thuong with corresponding Return Period, Unit: m^3/s

Return Period (years)	2	5	10	20	50	100
Log Normal	3,621	5,119	6,136	7,070	8,432	9,433
Pearson-3	3,701	5,250	6,206	7,075	8,139	8,902
Gumbel	3,663	5,159	6,149	7,080	8,329	9,250
Average round values	3,700	5,200	6,200	7,100	8,300	9,200

These discharges are some 10% (at the ten years peak) to over 20% (at the 100 years peak), lower than the peak flows at Dua, indicating that part of the peak discharges is diverted at Do Luong and/or stored in the flooded area between Do Luong and Yen Thuong.

For the estimate of volumes of floods that are generated by 1,2 and 3-day peak rainfall on the Ca basin upstream of the flood prone area, an analysis has been made of the daily rainfall upstream of Do Luong. The following daily rainfall data have been used:

Do Luong	1976 – 2000 (with minor gaps)
Con Cuong	1976 – 1989; 1990 - 2000 (with minor gaps)
Quy Chau	1976 – 2000 (with minor gaps)
Muong Xen	1976 – 2000 (complete)
Mon Son	for gap filling
Nghia Khanh	for gap filling

The Do Luong data series has been completed with Mon Son series to obtain a complete series that represents the rainfall in the lower 5% of the catchment area under consideration. The minor gaps in the Con Cuong series were filled with Mon Son data, to obtain a complete series that represent the rainfall on 15% of the central part of the area. Quy Chau series have been completed with Nghia Khanh data to create a complete series representing 20% of the central part of the catchment. Muong Xen series represent the rainfal on the upper 60% of the Ca catchment. 25 year of area daily rainfall series have been compiled using the above mentioned series and corresponding weights. Also series were compiled of two and three consecutive days area rainfall. From all these series the yearly maximum values were selected, which were put through a frequency analysis. The results are given in the table below using the log-normal and Gumbel probability distribution functions. These functions gave the best fit.

Maximum yearly one-day Ca area upstream of Do Luong rainfall in mm

Return period in years	2	5	10	20	50	100
Log-normal	87	119	140	162	188	209
Gumbel	87	119	141	161	188	208

Maximum yearly two-day Ca area rainfall upstream Do Luong in mm

Return period in years	2	5	10	20	50	100
Log-normal	122	169	200	229	268	297
Gumbel	123	169	199	229	267	295

Maximum yearly three-day Ca area rainfall upstream Do Luong in mm

Return period in years	2	5	10	20	50	100
Log-normal	136	188	223	258	301	334
Gumbel	137	189	223	256	299	331

These rainfall intensities correspond with the following n-day precipitation volumes on the Ca basin upstream of Do Luong (21,130 km^2).

Maximum yearly n-day rainfall volume on Ca basin u/s Do Luong in Mm^3

Return period	1 day	2 days	3 days
2 years	1,800	2,600	2,900
5 years	2,500	3,600	4,000
10 years	3,000	4,200	4,700
20 years	3,400	4,800	5,400
50 years	4,000	5,700	6,300
100 years	4,400	6,300	7,000

A typical historical flood in the Ca basin with corresponding rainfall is shown in Figure B.11.

5 THACH HAN RIVER

5.1 Basin Characteristics

5.1.1 River Basin

Thach Han basin is situated in the middle central of Vietnam between 16°20' to 16°55' north latitude and 106°35' to 107°15' east longitude within Quang Tri province.

Thac Han river basin covers a total catchment area of only 2,550 km^2, completely located in Vietnam.

The main stream of Thac Han River (Quang Tri River) originates from the east slopes of the Truong Son Mountain ranges which border with Lao. In this area, the river flows in the north-west direction. From the confluence with Rao Quan River, Thac Han River flows in the north-east direction and has its outlet to the East Sea at Dong Ha. Major tributaries in Thach Han system are:

Thach Han Basin (Total)	2,550km^2
Major Sub-basins	
Quang Tri u/s Thach Han weir :	1,390km^2
Cam Lo & Vinh Phuoc :	790km^2
Lower Area	370km^2

For the location map of the basin reference is made to Figure B.12.

5.1.2 Climatological Features

Mean annual temperature varies from 22.8°C to 24.9°C with the minimum temperature of 6.8°C and the maximum of 40°C. Mean Annual humidity is 85%. Evaporation varies from 800mm in hilly areas and 1,000mm to 1,500mm in plains.

Mean annual rainfall varies from 2,300mm to 2,800mm. There are 2 rains peaks year, i.e., small rainfall and heavy rainfall. The heavy rainfall concentrates in September to November. In May and June, rains may cause small floods. The dry season starts in January and end in August.

5.2 Natural Runoff

The only record of discharge observations in the Thach Han basin refer to Rao Quang measurement station where during a period of three years (1983 – 1985) the discharge was observed of a catchment of 159 km^2, or 7% of the total Thach Han basin. This record is not considered adequate for the analysis of the basin runoff.

Rainfall data, however, are available to a greater extent, allowing for the estimate of the basin runoff on the basis of a rainfall – runoff relation. The following rainfall data have been collected for this purpose:

Station	Longitude	Latitude	Province	Observation Period
Khe Sanh	106.50	16.38	Quang Tri	1976-2000
Thach Han	107.14	16.45	Quang Tri	1976-2000
Dong Ha	107.05	16.50	Quang Tri	1976-2000

The absence of discharge data complicates the assessment of a rainfall – runoff relation for the Thach Han basin. Coincidentally, however, the present study includes the preparation of a rainfall – runoff model for the neighbouring basin of the Huong river, which has similar characteristics as the Thach Han basin. Size and topographic features are comparable. It is therefor anticipated that model parameters that have been derived from the calibration of the Huong rainfall – runoff model can also be applied in a similar modelling of the Thach Han basin.

Based on this assumption, the runoff of the Thach Han basin has been generated with the help of the Sacramento rainfall – runoff concept and using the series of area rainfall on the Thach Han basin. The model was set up for the Thach Han sub-basin upstream of the Thach Han weir. The area of this sub-basin amounts to 1,390 km^2, or 62% of the entire catchment area. The area rainfall on this sub-basin was assessed on the basis of the following rainfall stations and the corresponding weights:

Sub-basin	Rainfall station		
	Thach Han	Aluoi	Khe Sanh
ThachHan-QuangTri	20%	25%	55%

Series of daily rainfall have been used for the period 1977 – 2000. Gaps in the series of rainfall data have been filled as follows:

- Thach Han series completed with Dong Ha data;
- Khe San series completed with A Luoi data.

The runoff of the entire Thach Han basin is composed of the runoff at the Thach Han weir, increased by the contribution of the Cam Lo river and the Vinh Phuoc river and the runoff of the lower area. This latter runoff has been estimated on the basis of the net rainfall on this area of 370 km^2. The contribution of the Cam Lo and Vinh Phuoc, with a joint area of 790 km^2, has been estimated on the assumption that the runoff of these sub-basins per km^2 is the same as the runoff per km^2 of the Thach Han sub-basin. The resulting generated basin runoff is presented in the Table B.5. The corresponding dependable monthly runoff is calculated as follows:

Dependable Monthly Natural Runoff in the whole basin (A= 2,550km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	243	135	94	63	75	78	71	113	320	850	836	513
75%	191	107	75	47	50	48	43	68	189	612	587	384
90%	154	87	61	36	35	31	27	43	117	456	427	296

5.3 Flood Runoff

As mentioned above, long series of historic data of flood events in the Thach Han basin are absent. The estimate of probable floods on the basis of a frequency analysis of historic data is, therefore, not feasible. On the other hand, long records of daily rainfall in the Thach Han basin exist, allowing for a frequency analysis of storm events in the basin. However, no discharge measurements during storm events are available and, therefore, calibration of rainfall – runoff modelling is not possible for the Thach Han basin. For the neighbouring Huong basin, such modelling was done and calibrated. The calibration results, in the form of parameters for the Sacramento model, have been used for the Thach Han basin as well, in combination with the area rainfall data of this basin.

For the present study the following relevant rainfall data were available:

Available daily rainfall data Thach Han basin	
Thach Han	August 1976 – 2000 (with 1 month gap)
Dong Ha	1976 - 2000 (with one month gap)
Khe San	July 1976 – 2000 (with 4 months gaps)
A Luoi	1976 – 2000 (complete)

The first two stations are located in the lower basin area. Khe San is located in the upper part of the basin, however at a relatively low location in the river valley, showing substantial lower rainfall than the higher area, that are represented better by the A Luoi station.

The gaps in the Thach Han and Dong Ha series have been filled mutually. The minor gaps in the Khe San series have been filled with A Luoi data.

For the estimate of the area rainfall, the following weights have been used:

Sub-basin	Rainfall station			
	Thach Han	Dong Ha	Khe San	A Luoi
Thach Han – Quang Tri	20%	-	55%	25%
Lower area	-	100%	-	-

Frequency analyses were carried out using both the Gumbel and the Log-Normal probability distribution functions. The analyses were carried out for the yearly maximum area rainfall values and for the “early flood” rainfall values (maximum rainfall in period January – August). The Figures B.13. show the frequency curves for both types of storms.

The results (averaged and rounded Gumbel and Log Normal values) are given in the tables below:

One day maximum year rainfall in mm

Return Period (years)	2	10	20	50	100
Upper and middle Thach Han basin	175	275	315	370	410

One day maximum “early flood” rainfall in mm

Return Period (years)	2	10	20	50	100
Upper and middle Thach Han basin	95	170	200	245	275

These values are substantially lower than the estimated peak rainfall in the Huong basin. During the main flood season, the Huong rainfall intensities are over 50% higher than in the Thach Han basin. During the early flood season this difference is of the order of 30%.

For the simulation of the flood runoff, a hourly distribution of the above daily rainfall values is assumed similar to the distribution in the Huong basin. Maximum hourly intensities have been estimated between 35 mm (10 years storm) and 60 mm (100 years storm) during the main flood season and between 25 mm (10 years storm) and 40 mm (100 years storm) during the early flood season.

The response of the Quang Tri sub-basin upstream of the Thach Han weir to storms is supposed to be similar to the response of the Bo sub-basin to similar storms. However, the shape of the Quang Tri sub-basin and the length of the river branches justify the assumption that the Quang Tri floods are subject to more attenuation on their way down to the flood prone area then the Huong flood waves are. This phenomenon has been reflected by applying a Muskingum parameter K value of 7 (hours) as compared to 5 in the Bo basin. The estimated peak discharges and corresponding flood volumes resulting from a one day storm are as follows.

Main flood at Thach Han weir

Return Period (years)	2	10	20	50	100
Peak discharge (m^3/s) Flood volume (Mm^3)	1830 95	3,500 200	4,300 250	5,200 310	6,100 360
Runoff Coefficient	0.39	0.54	0.57	0.61	0.63

Early flood at Thach Han weir

Return Period (years)	2	10	20	50	100
Peak discharge (m^3/s) Flood volume (Mm^3)	870 35	1,800 90	2,300 120	3,000 170	3,500 200
Runoff Coefficient	0.26	0.39	0.44	0.50	0.53

The above flood simulation has been made for the floods at the Thach Han weir. The confluences of the Vinh Phuoc and the Cam Lo river with the Thach Han river are situated in the flood prone area. If flood control measures are taken that prevent waters from both the Thach Han, the Vinh Phuoc and the Cam Lo to spill or divert from the respective river channels, than peak discharges at the Cam Lo confluence could be estimated by applying a Creager factor to the Thach Han weir peak discharges. This implies that the peak discharges at the Cam Lo confluence would be some 20% higher than the peak discharges with corresponding return period at Thach han weir.

6 HUONG RIVER BASIN

6.1 Basin Characteristics

6.1.1 River Basin

The Huong basin is located in the north-central Vietnam. The river basin are situated between 16°00’ to 16°40’ north latitude and between 107°15’ to 108° east longitude within Thua Thien Hue province.

The Huong river basin covers a total catchment area about 3,300 km^2, which included Truoi River basin and around lagoon area. The Huong River originates from the east slopes of the Truong Son Mountain ranges which border with Lao. The Huong River flows in the north and has its outlet to the Tam Giang Lagoon at Hue.

Huong River Basin (Taotal)	3,300km^2
Major Sub-basins	
Ta Trach (at Tuan) :	790km^2
Huu Trach (at Tuan) :	670km^2
Bo (at CoBi):	720km^2
Lower Huong (Delta) :	460km^2
Lagoon and Truoi Basin	660km^2

For the location map of the basin reference is made to Figure B.14.

6.1.2 Climatological Features

Mean annual temperature varies from 21°C to 25°C with the minimum temperature of 16°C and the maximum temperature of 29°C. Mean Annual humidity is 82%.

Mean annual rainfall varies from 2,800mm to 3,500mm. In the mountain area, i.e. Nam Dong and A Luoi areas have biggest rainfall. Heavy rains concentrate from September to beginning of December. Small rains occur in May and June. The dry season starts in end of December and lasts until July or beginning of August.

6.2 Natural Runoff

The Huong basin is considered a priority basin for which a comprehensive water resources management master plan is to be formulated in the framework of the present study.

In accordance with the Terms of Reference, special treatment has been given to the generation of the series of monthly runoff in this basin. This special approach is not only related to the importance that has been given to this basin, but also a consequence of the fact that in this basin no long records of discharge observations are available. The following discharge data could be collected:

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Thuong Nhat	107.41	16.07	$208km^2$	Ta Track	1981-2000
Truoi	107.46	16.15	$70km^2$	Truoi	1992-1996
Binh Dien	107.30	16.20	$570km^2$	Huu Track	1979-1985
Co Bi	107.25	16.28	$720km^2$	Bo	1979-1985
Duong Hoa	107.38	16.18	$717km^2$	Ta Track	1986-1987

For the generation of series of runoff in the respective sub-basins of the Huong, use has been made of rainfall-runoff modelling. The runoff series have been generated with the help of area rainfall series of the period 1977 – 2000 that have been compiled on the basis of the following set of collected daily rainfall data:

Station	Longitude	Latitude	Province	Observation Period
Nam Dong	107.43	16.09	Thua Thien Hue	1977-2000
Phu Loc	107.53	16.15	Thua Thien Hue	1978-1990
Hue	107.34	16.25	Thua Thien Hue	1976-2000
Phuoc	107.28	16.32	Thua Thien Hue	1977.1980-2000
A Luoi	107.13	16.15	Thua Thien Hue	1976-2000

With the help of the rainfall – runoff modelling series have been generated for several key locations in the basin. In the Tables B.6, these series are presented for the Bo river at Co Bi, the Huu Trach – Ta Trach basin at the confluence at Tuan and for the entire basin. The latter series has been composed by adding up the runoff volumes of the Bo and the Ta Trach – Huu Trach and the runoff of the lower area that has been estimated with the help of the net rainfall on that area.

The dependable monthly runoff volumes at Co Bi, Tuan and for the entire basin are presented below:

Co Bi (A=720km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	95	48	33	32	45	41	32	32	85	298	363	251
75%	58	30	22	21	32	27	21	22	52	205	254	181
90%	38	20	16	16	23	18	15	15	33	147	185	135

Tuan (A=1,460km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	210	109	71	52	68	69	53	57	148	589	726	498
75%	144	79	53	35	40	40	32	36	84	370	497	354
90%	102	59	40	24	26	24	20	23	51	243	353	260

Entire Basin (A=3,300km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	342	166	112	86	120	122	90	95	431	1,497	1,623	989
75%	220	118	81	56	76	71	55	61	243	976	1,153	691
90%	148	87	61	38	51	44	36	41	144	663	847	500

6.3 Flood Runoff

Long series of historic data of flood events in the Huong basin are absent. In the major discharge measurement stations at Co Bi (Bo River), Binh Dien (Huu Track) and Duong Hoa (Ta Track) observations were made in the period 1979 - 1985 in Co Bi and Binh Dien, and during only two years (1986 – 1987) in Duong Hoa. The estimate of probable floods on the basis of a frequency analysis of historic data is, therefore, not feasible. On the other hand, long records of rainfall in the Huong basin exist, allowing for a frequency analysis of storm events in the basin. Moreover a number of flood events and corresponding rainfall were registered on an hourly basis, allowing the calibration and verification of rainfall runoff modelling under flood conditions.

Flood modelling with the help of rainfall – runoff modelling has been carried out with the help of the Sacramento model for the land-phase of the runoff generation, while the outflow of this land-phase was routed through the tributaries using the standard Muskingum method.

In addition to the Sacramento modelling, the modelling of the floods in the Huong basin has also been done with the help of the Mike 11 rainfall-runoff simulation module NAM. The auto-calibration option of this modelling package presented quite promising calibration results. Further model running with the parameters found through auto-calibration gave results that are substantially higher than the Sacramento modelling results. For the present study the following rainfall data were available:

Available daily rainfall data Huong basin

Hue	1976 – 2000 (with minor gaps)
Phu Oc	1977, 1980 – 2000 (for gap filling)
Phu Loc	1978 – 1990 (for gap filling)
Nam Dong	1977 – 2000 (with minor gaps)
A Luoi	1976 – 2000 (complete)

On the basis of the length of records and the spatial distribution, it was decided to use the data of Hue, Nam Dong and A Luoi for the analysis of the area rainfall in the respective sub-basins (Bo, Huu Trach, Ta Trach and the lower Huong basin). With Nam Dong series starting at 1977, it was decided to complete the three series for the 24 years period 1977 – 2000.

The Hue data series has been completed with Phu Oc and Phu Loc series. Nam Dong series have been completed using A Luoi data.

For the assessment of the area rainfall on the respective sub-catchments the following area weights have been applied:

Sub-catchment	Rainfall station		
	Hue	Nam Dong	A Luoi
Bo u/s Co Bi	14%	0%	86%
Huu Trach u/s Binh Dien	15%	55%	30%
Huu Trach u/s Tuan	28%	47%	25%
Ta Trach u/s Duong Hoa	0%	100%	0%
Ta Trach u/s Tuan	10%	90%	0%
Lower Huong basin	100%	0%	0%

Frequency analyses were carried out using both the Gumbel and the Log-Normal probability distribution functions. The analyses were carried out for the yearly maximum area rainfall values and for the "early flood" rainfall values (maximum rainfall in period January – August). The respective probability distributions are shown in the Figures B.15 – B.18.

The results (averaged and rounded Gumbel and Log Normal values) are given in the tables below:

One day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	260	365	440	505	600	665
Huu Trach u/s Binh Dien	285	355	400	450	500	550
Ta Trach u/s Duong Hoa	340	425	475	525	590	635
Lower Huong basin	240	345	425	495	585	655

One day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	85	130	165	195	235	270
Huu Trach u/s Binh Dien	85	155	210	260	335	400
Ta Trach u/s Duong Hoa	100	185	260	330	420	495
Lower Huong basin	95	160	210	255	320	365

For the simulation of the flood runoff in the respective sub-basins, a certain hourly distribution of the above daily rainfall values is assumed. From the available hourly rainfall data during flood events it was learned that peak intensities are in the order of 30

–70 mm/hour. From these records it is moreover learned that during excessive rainfall events the high rainfall intensities last some 8 – 10 hours. In the present analysis it is assumed that the daily rainfall is concentrated in 12 hours and that the highest intensities are 30 mm/hour for the moderate storms, increasing to values of 70 mm/hour for the most extreme events.

For the estimate of flood runoff volumes related to storms with longer duration then one day, also the 2, 3, 4 and 5 day probable yearly rainfall has been calculated for the full year and the early season. These rainfalls have been calculated for the areas upstream of the potential dam sites. From the rainfall runoff modelling it is learned that the flood runoff volume can be approximated by using the following runoff factors (is part of the storm volume that is converted directly into runoff):

Sub-basin	Main Flood	Early Flood
Bo sub-basin	0.75	0,50
Huu Trach – Ta Trach sub-basin	0.80	0.55

Two-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	390	565	690	805	965	1085
Huu Trach u/s Binh Dien	400	545	640	725	845	935
Ta Trach u/s Duong Hoa	470	635	745	850	980	1080

Two-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	115	180	225	275	345	400
Huu Trach u/s Binh Dien	115	210	290	375	510	625
Ta Trach u/s Duong Hoa	135	260	360	475	650	805

Three-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	450	690	855	1020	1240	1405
Huu Trach u/s Binh Dien	475	675	810	935	1110	1240
Ta Trach u/s Duong Hoa	550	770	915	1055	1240	1380

Three-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	130	200	250	295	365	420
Huu Trach u/s Binh Dien	130	225	310	400	525	630
Ta Trach u/s Duong Hoa	150	275	380	495	670	815

Four-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	510	800	1000	1205	1470	1680
Huu Trach u/s Binh Dien	545	800	970	1140	1360	1530
Ta Trach u/s Duong Hoa	630	905	1090	1270	1510	1690

Four-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	140	210	260	305	370	420
Huu Trach u/s Binh Dien	135	240	320	405	535	640
Ta Trach u/s Duong Hoa	160	290	400	515	685	825

Five-day maximum year rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	560	885	1110	1340	1645	1880
Huu Trach u/s Binh Dien	585	860	1050	1230	1475	1660
Ta Trach u/s Duong Hoa	670	970	1170	1370	1630	1825

Five-day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Bo u/s Co Bi	155	225	270	320	380	430
Huu Trach u/s Binh Dien	145	250	330	415	540	645
Ta Trach u/s Duong Hoa	170	300	405	525	685	825

The estimated peak discharges and corresponding flood volumes resulting from the one day design storm are as follows:

Main flood at Co Bi

Return Period (years)	10	20	50	100
Peak discharge (m^3/s)	3,900	5,100	6,700	7,800
Flood volume (Mm^3)	200	250	320	370
Runoff Coefficient	0.65	0.69	0.74	0.76

Early flood at Co Bi

Return Period (years)	10	20	50	100 s
Peak discharge (m^3/s)	1,000	1,250	1,600	2,000
Flood volume (Mm^3)	40	60	80	100
Runoff Coefficient	0.35	0.41	0.47	0.51

Main flood at Tuan

Return Period (years)	10	20	50	100
Peak discharge (m^3/s)	9,800	11,400	13,400	15,100
Flood volume (Mm^3)	490	570	660	730
Runoff Coefficient	0.77	0.79	0.81	0.83

Early flood at Tuan

Return Period (years)	10	20	50	100
Peak discharge (m^3/s) Flood volume (Mm^3)	3,100 140	4,400 200	6,400 300	8,400 390
Runoff Coefficient	0.40	0.47	0.55	0.61

7 VU GIA AND THU BON RIVER BASIN

7.1 Basin Characteristics

7.1.1 River Basin

Thu Bon river basin is contained entirely in Vietnam. The river basin are situated between 15°00' to 16°00' north latitude and between 107°00' to 108°30' east longitude. This basin covers Quang Nam province and Da Nang city.

This basin is combined with the Thu Bon and Vu Gia River. These rivers are connecting at downstream of Ai Nghia and flow into the sea at Hoi An and Da Nang.

This basin covers a total catchment area about 11,500 km^2, which included TamKy River basin and some small river basin located connecting coastal area. Major tributaries and its catchement area are shown as follows:

Vu Gia and Thu Bon Basin (Total)	11,510km^2
Major Sub-basins	
Thu Bon (without lower area):	3,590km^2
Vu Gia (without lower area):	5,420km^2
Lower Area (Delta) :	1,370km^2
Tam Ky Basin :	1,130km^2

For the location map of the basin reference is made to Figure B.19.

7.1.2 Climatological Features

Mean annual temperature varies from 24°C to 26°C. Mean annual humidity varies from 80% to 87% and annual evaporation varies from 700mm to 1100mm.

Mean annual rainfall varies from 2,000mm to 4,000mm. In the southern region of basin have biggest rainfall. There are 2 rains peaks year, i.e., small rainfall and heavy rainfall. The heavy rainfall concentrates in October to December. In May and June, rains may cause small floods.

7.2 Natural Runoff

For the assessment of the water availability in the Thu Bon basin, an estimate has been made of the natural runoff of the basin at the confluence of the Thu Bon and Vu Gia tributaries at Ai Nghia. Upstream of this confluence 9,010 km^2, or some 87%, of the entire Tu Bon basin (excluding the Tam Ky basin) is situated. In the flat area downstream of this confluence the runoff conditions are essentially different from the upstream area as a consequence of topographic and land use features. The runoff of this lower part is, therefore, treated separately.

For the estimate of the natural runoff at Ai Nghia, use has been made of historical discharge series at Nong Son in the Thu Bon sub-basin and Thanh My in the Vu Gia sub-basin. Complete simultaneous records of daily discharges in both stations are available since 1984 only. Prior to this year no records are available for Thanh My station. For the present study it is considered appropriate to use the 1984 – 2000 discharge series for the estimate of the natural runoff of the basin. The following discharge data have been collected and processed:

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Nong Son	108.03	15.42	3,130km^2	Thu Bon	1976-2000
Thanh My	107.50	15.46	1,850km^2	Vu Gia	1984-2000

In addition to these discharge data, the following rainfall data have been used for the hydrological analysis:

Station	Longitude	Latitude	Province	Observation Period
Tra My	108.14	15.21	Quang Nam	1977-2000
Son Tan (HiepDuc)	108.05	15.35	Quang Nam	1976-2000
Trao (Hien)	107.38	15.56	Quang Nam	1978-2000
Thanh My	107.50	15.46	Quang Nam	1976-2000
Ai Nghia	108.07	15.53	Quang Nam	1976-2000
DaNang	108.11	16.02	Da Nang	1976-2000

The discharges observed at Nong Son represent the runoff of 3,130 km^2, or some 87%, of the 3,590 km^2 Thu Bon sub-basin. It is, therefore, considered acceptable to estimate the runoff of the entire sub-basin by assuming the ratio between the entire sub-basin area and the observed area to be the same as the ratio between the respective discharges. In this way, the monthly Thu Bon sub-basin discharges have been estimated by multiplying the observed monthly discharges at Nong Son with the factor 1.147.

The discharges observed at Thanh My represent the runoff of 1,850 km^2 of the 5,420 km^2 Vu Gia sub-basin. This corresponds with only 34% of the total sub-basin. Before using the Thanh My discharge series for estimating the Vu Gia sub-basin runoff, the following analyses have been carried out.

a. in order to assess to what extent the observed Thu Bon sub-basin runoff can also be considered representative for the Vu Gia sub-basin, a comparison was made between the area rainfall on the Thu-Bon sub-basin and the area rainfall on the Vu Gia sub-basin.

b. With the same objective, the correlation has been examined between the monthly observed discharges at Nong Son in the Thu Bon sub-basin and the monthly observed discharges at Thanh My in the Vu Gia sub-basin.

Area rainfall on the respective sub-basins has been estimated on the basis of historical rainfall series, assuming the following weights:

Sub-basin	Rainfall station				
	Ai Nghia	Son Tan	Tra My	Thanh My	Trao
Thu Bon	5%	40%	45%	10%	-
Vu Gia	8%	12%	8%	36%	36%
Vu Gia u/s Thanh My	0%	30%	20%	50%	-

The results of these analyses indicate that the area rainfall on the Thu Bon sub-basin is substantially higher than the area rainfall on the Vu Gia sub-basin. From the daily rainfall data for the period 1984 – 2000 it is learned that the average yearly rainfall on the Thu Bon sub-basin amounts to 3,421 mm, as compared to 2,438 mm on the Vu Gia sub-basin. Assuming a similar rainfall-runoff relation for both basins and taking into account the catchment areas of respectively 3,590 km^2 and 5,420 km^2, it can be anticipated that the Vu Gia runoff is less than 10% (7.6%) higher than the Thu Bon runoff, notwithstanding the fact that the Vu Gia sub-basin is 1.5 times as big as the Thu Bon sub-basin. The assumption of a similar runoff-rainfall relation in both sub-basins may even lead to an overestimate of the Vu Gia runoff, since the runoff coefficients tend to increase with increasing rainfall intensities.

Comparing the rainfall on that part of the Vu Gia sub-basin that generates the runoff that is observed at Thanh My with the Vu Gia sub-basin rainfall, it is learned that the average yearly rainfall on the upstream Thanh My area (2,845 mm) is about 17% higher than the Vu Gia sub-basin rainfall. The assumption that the runoff per km^2 at Thanh My is representative for the entire Vu Gia sub-basin, may, therefore, lead to an overestimate of the Vu Gia runoff.

Comparison of the monthly observed discharges at Nong Son (Thu Bon sub-basin) and Thanh My (Vu Gia sub-basin) confirms the substantially higher specific runoff in the Thu-Bon basin as compared to the Vu Gia sub-basin. With a correlation coefficient of R^2=0.9575 the following relation is found for the monthly discharges (in m^3/s):

$$Q_{\text{Than My}} = 0.4075\ Q_{\text{Nong Son}} + 15$$

This indicates that, taking into account the different catchment areas, the discharge per km^2 at Thanh My is of the order of only 70% of the discharge per km^2 at Nong Son. This percentage increases to some 90% when only the dry months (January –September) are taken into account. This can be explained by the fact that during the dry period the runoff is merely determined by base flow, rather than by the direct runoff from the rainfall.

From the results of the above analyses the following is concluded:

1. The use of Thu Bon sub-basin runoff rates for the entire Thu Bon – Vu Gia basin is not acceptable as a consequence of the significant variation of the rainfall between the respective sub-basins.
2. The use of the Thanh My runoff per km^2 for the entire Vu Gia basin will give an overestimate of the natural runoff of this sub-basin.
3. This overestimate will be higher in the wet season than in the dry period.

On the basis of the area rainfall it was found that the year rainfall in the Vu Gia basin upstream of Thanh My is some 17% higher than for the entire Vu Gia basin. Using the Thanh My runoff rate for the entire basin may give a year around runoff overestimate in the order of 15 - 20%. This overestimate will be reflected mainly in the wet season runoff. The overestimate during the dry season could be substantially lower, assuming that the base flow runoff is similar in the entire sub-basin, as appears to be the case when comparing the Thu Bon and Vu Gia runoff under low flow conditions. In this study, the overestimate during the dry season is assumed to be round 5%.

Based on this consideration the series of monthly discharges of the Vu Gia sub-basin at the confluence with the Thu Bon has been derived by applying 95% of the runoff per km^2 at Thanh My for the entire sub-basin. By this approach, the runoff during the flood season is likely to be overestimated. This, however, is not considered of relevance for the elaboration of the water balance of the Thu Bon basin.

The runoff series that has been generated in accordance with above described approach for the entire Thu Bon basin for the period 1984 – 2000 is presented in Table B.7. This runoff includes the runoff of the Thu Bon and Vu Gia sub-basins and the runoff from the 1,370 km^2 lower area, the runoff of which has been estimated on the basis of the net rainfall on that area. The Tam Ky basin has not been included in the Thu Bon basin runoff. The dependable basin runoff has been calculated as follows:

Dependable Monthly Natural Runoff in the whole basin (A=10,460km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	1,492	845	637	515	734	635	524	584	1,141	4,344	5,617	3,953
75%	1,169	682	522	387	523	464	409	428	777	2,768	3,832	2,760
90%	939	562	437	300	385	349	327	323	549	1,845	2,716	1,997

7.3 Flood Runoff

The flood prone area of the Thu Bon basin is situated downstream of the confluence of the Thu Bon and Vu Gia river. At this confluence the sub-catchments of Thu Bon and Vu Gia have an area of 3,590 km^2 and 5,420 km^2 respectively. The discharges of 87% of the Thu Bon sub-catchment are observed at Nong Son. In the Vu Gia sub-catchment observations are available of only 34% of the area, at Thanh My.

For the Nong Son station, data are available for the period 1976 – 2000 (25 years), while observations in Thanh My are restricted to the period 1984 – 2000 (17 years). From the 1976- 2000 discharge series at Nong Son the yearly maximum daily discharges were collected and a frequency analysis has been carried out.

Several probability distribution functions have been assumed for the estimate of the peak discharges with corresponding return periods. The results of the most likely distribution functions are presented below:

Unit: m^3/s

Estimated Peak discharges in m^3/s at Nong Son with corresponding Return Period

Return Period (years)	2	5	10	20	50	100
Log Normal	5,433	7,505	8,888	10,150	11,956	13,276
Pearson-3	5,542	7,667	8,964	10,129	11,564	12,583
Log Pearson	5,324	7,486	9,045		12,844	14,622
Gumbel	5,466	7,526	8,890	10,198	11,892	13,161
Average round values	5,400	7,500	8,900	10,300	12,100	13,400

For the maximum yearly discharges at Thanh My, a similar analysis has been carried out. It is noted that the number of values (17) is not considered adequate for such analysis. However, in the absence of a proper rainfall – runoff model for the entire catchment, it is considered appropriate to make use to the maximum of the available information. The results are presented below:

Estimated Peak discharges in m^3/s at Thanh My with corresponding Return Period,

Unit: m^3/s

Return Period (years)	2	5	10	20	50	100
Log Normal	3,304	4,831	5,894	6,907	8,353	9,447
Pearson-3	3,387	4,987	5,909	6,904	8,044	8,861
Log Pearson	3,175	4,914	6,271	7,449	9,881	11,697
Gumbel	3,373	4,910	5,928	6,902	8,168	9,115
Average round values	3,300	4,900	6,000	7,000	8,000	9,800

Assuming a Creager type of relation between the peak discharges and the catchment area, a first approximation of the peak flows at the confluence of the Vu Gia and the Thu Bon (total catchment area: 9,010 km^2) is as follows:

Approximate peak discharges in m^3/s at the Vu Gia- Thu Bon confluence.

Return Period (years)	2	5	10	20	50	100
Peak Discharge	8,000	10,500	12,500	14,000	17,000	19,000

The concentration time of the basin is estimated of the order of 1 day. It is, therefore, anticipated that intensities corresponding with one day rainfall are indicative for the peak floods.

For both the Thu Bon sub-basin and the Vu Gia sub-basin, the maximum one-day rainfall has been analysed. The following daily rainfall data have been used:

Trao	1978 – 2000 (complete)
Thanh My	1978 - 2000 (complete)
Son Tan	1978 – 2000 (with minor gap)
Tra My	1978 – 2000 (with minor gap)
Ai Nghia	1978 – 2000 (with minor gap)

The Trao and Thanh My data series represent each the rainfall of 40% of the Vu Gia basin. The minor gaps in the Son Tan series were filled with Tra My data, to obtain a complete series that represent the rainfall on 10% of the upper Vu Gia basin and 35% of central part of the Thu Bon basin. Tra My series have been completed with Son Tan data to create a complete series representing the upper 10% of the Vu Gia basin and the upper 50% of the Thu Bon basin. The lower 15% of the Thu Bon basin is represented by Ai Nghia station, the series of which have been completed with Thanh My data.

23 years of areal daily rainfall series have been compiled for both the Vu Gia and the Tu Bon basin, using the above mentioned series and corresponding weights. The results are given in the table below using the log-normal and Gumbel probability distribution functions. These functions gave the best fit.

Maximum yearly one-day area rainfall on the Vu Gia basin

Return period in years	2	5	10	20	50	100
Log-normal	183	255	302	348	408	453
Gumbel	185	255	302	347	405	448

Maximum yearly one-day area rainfall on the Thu Bon basin

Return period in years	2	5	10	20	50	100
Log-normal	215	284	328	370	423	462
Gumbel	215	283	327	370	426	468

Maximum yearly one-day area rainfall on combined Vu Gia - Thu Bon basin

Return period in years	2	5	10	20	50	100
Log-normal	189	246	282	314	359	391
Gumbel	188	244	281	317	363	398

The corresponding volume of one day rainfall on the middle and upper Vu Gia – Thu Bon catchment corresponds with:

Maximum yearly one-day area rainfall volume in Mm^3 on the Vu Gia - Thu Bon basin

Return period in years					
2	5	10	20	50	100
1,700	2,200	2,500	2,800	3,300	3,600

Early floods may occur as a consequence of high rainfall intensities during the period prior to main wet season. Here the early floods are defined as the floods that are a result of storms in the period January – August.

For this period of the year the high flow analysis has been carried out similarly to the analysis for full years. The results of the most likely distribution functions are presented below and some are shown in Figure B.20.

Estimated Early Flood Peak discharges in m^3/s at Nong Song with corresponding Return Period

Return Period (years)	2	5	10	20	50	100
Peak Discharge	700	1,400	2,000	2,600	3,400	4,000

Estimated Early Flood Peak discharges in m^3/s at Thanh My with corresponding Return Period

Return Period (years)	2	5	10	20	50	100
Peak Discharge	400	900	1,400	1,900	2,500	3,100

The conversion of these peak discharges into early flood discharges at the Vu Gia – Thu Bon confluence gives the following approximation.

Approximate early flood peak discharges in m^3/s at the Vu Gia- Thu Bon confluence.

Return Period (years)	2	5	10	20	50	100
Peak Discharge	1,000	2,000	2,800	3,700	4,800	5,800

Early storms have been analysed, and the following maximum one-day precipitation has been found for the entire area upstream of the Vu Gia – Thu Bon confluence:

Maximum yearly early one-day area rainfall on combined Vu Gia - Thu Bon basin

Return period in years	2	5	10	20	50	100
Log-normal	64	99	124	152	187	215
Gumbel	66	103	126	150	180	202

The corresponding volume of one day rainfall on the middle and upper Vu Gia – Thu Bon catchment prior to September corresponds with:

Maximum yearly early one-day area rainfall volume in Mm^3 on the Vu Gia - Thu Bon basin

Return period in years					
2	5	10	20	50	100
600	9,100	1,100	1,400	1,700	1,900

8 TRA KHUC RIVER BASIN

8.1 Basin Characteristics

8.1.1 River Basin

The basin is situated in south central Vietnam between 14°30' to 15°20' north latitude and 108°15' to 109° east longitude.

Tra Khuc river basin covers a total catchment area of 5,200km², which included Ve River basin and some small basin located connecting coastal area.

Major tributaries and its catchement area are shown as follows:

Tra Khuc Basin (Total)	5,200km²
Major Sub-basins	
Tra Khuc (without lower area) :	3,030km²
Ve (without lower area) :	820km²
Lower & Coastal area :	840km²

The location map of the basin is presented in Figure B.21.

8.1.2 Climatological Features

Mean annual temperature varies from 20°C to 26°C, annual humidity is about 85% and annual evaporation varies from 680mm to 1,040mm.

Mean annual rainfall varies from 1700mm to 2200mm in plains; 2300mm to 2700mm in low mountains (AnChi, SonHa) and 3200mm to 4000mm in high mountains (TraBong, BaTo, GiaVuc).

The rainy season lasts in 4 month from September to December. Specially, heavy rains usually happen in October and November.

8.2 Natural Runoff

The Tra Khuc basin is composed of a number of sub-basins that each has its own exit to the sea. The main sub-basin is the Tra Khuc itself and the second important one is the Ve sub-basin. Other smaller sub-basins, among them the Tra Cau, enter the common coastal zone of the Tra Khuc basin.

Daily discharge data in the basin are scarce. The following data have been collected and processed:

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Son Giang	108.34	15.02	2,440km²	Tra Khuc	1987-2000
An Chi	108.49	14.59	814km²	Ve	1987-2000

The period of 14 years only is considered short for making a proper assessment of the natural runoff and water availability in the basin. Therefore, efforts have been made to extent the series to a longer period. The following two methods have been investigated:

1. Correlation with rainfall, for which data are available as from 1976,
2. Correlation with the neighbouring catchment area of Thu Bon.

The set of rainfall data that have been collected and processed is as follows:

Station	Longitude	Latitude	Province	Observation Period
Tra Bong	108.32	15.15	Quang Ngai	1976-2000
Quang Ngai	108.47	15.09	Quang Ngai	1976-2000
Ba To	108.45	14.46	Quang Ngai	1976-2000
Gia Vuc	108.34	14.42	Quang Ngai	1977-2000
Son Giang (Son Ha)	108.34	15.02	Quang Ngai	1977-2000

For the catchment area upstream of the Son Giang gauging station (2,440 km^2), monthly area rainfall series were compiled for the period 1976 (June) – 2000 (December). For this compilation the observed daily rainfall data were used of the following stations:

Sub-basin	Rainfall station			
	Gia Vuc	Tra Bon	Quang Ngai	Ba To
TraKhuc u/s SonGiang	55%	35%	6%	4%

Small gaps in the Gia Vuc rainfall series were filled with data of the nearby Ba To station. For the period 1987 – 2000 a multiple regression analysis was carried out to obtain the relation between the monthly area rainfall and the monthly river discharges at Song Giang. This analysis was performed with the following values:

1. the Song Giang monthly discharge (Q_{SQm}) as the dependant variable
2. the monthly area rainfall in the corresponding month (P_m)
3. the monthly area rainfall in the three preceding months (P_{m-1}, P_{m-2} and P_{m-3})

The results of these regression analyses are as follows:

Regression equation	Standard Error of Estimate (m^3/s)	Multiple Correlation Coefficient
Q_{SQm}= +6+0.70 P_m	177	0.912
Q_{SQm}= -26+0.60 P_m+0.21 P_{m-1}	94	0.944
Q_{SQm}= -40+0.62 P_m+0.17 P_{m-1}+ 0.08 P_{m-2}	91	0.949
Q_{SQm}= -49+0.62 P_m+0.17 P_{m-1}+ 0.06 P_{m-2} +0.04P_{m-3}	90	0.95

These relations indicate that on the average the monthly runoff corresponds with 67% of the monthly rainfall plus 18% of rainfall of the preceding month and some 7.5% of the rainfall of the month before the preceding month. The standard error of estimate is considered substantial and the correlation coefficient acceptable. A better correlation and reduction of the standard error can be achieved by carrying out the regression analysis per season instead of per year.

A similar regression analysis was carried out for the Ve basin upstream of An Chi (814 km^2). The catchment rainfall was assessed based on the following data:

ub-basin	Rainfall station		
	Gia Vuc	Quang Ngai	Ba To
Ve u/s AnChi	20%	5%	75%

The multiple regression analysis for the period 1987 – 2000 gave the following results for the An Chi discharges (Q_{ACm}):

Regression equation	Standard Error of Estimate (m^3/s)	Multiple Correlation Coefficient
Q_{ACm}= -7+0.252 P_m	42	0.921
Q_{ACm}= -19+0.216 P_m+0.074 P_{m-1}	33	0.952
Q_{ACm}= -24+0.222 P_m+0.057 P_{m-1}+ 0.032 P_{m-2}	31	0.957
Q_{ACm}=-27+0.225P_m+0.057P_{m-1}+0.025P_{m-2}+0.012P_{m-3}	31	0.958

This regression analysis gives a slightly better result than the analysis of the Song Giang discharges.

From above equations it can be derived that on the average the monthly runoff of the Ve sub-basin corresponds with 71% of the monthly rainfall plus 18% of rainfall of the preceding month and some 9% of the rainfall of the month before the preceding month. The comparison with the discharges observed in the Thu Bon basin has led to the following relations:

Q_{SQm}= 0.705 $Q_{NongSon}$ –1 (with R^2=0.97) and

Q_{ACm}= 0.252 $Q_{NongSon}$ –6.6 (with R^2= 0.88)

Especially for the main Tra Khuc sub-basin, the correlation with Thu Bon basin is considered adequate for being used for the extension of the Tra Khuc runoff series. It has, therefore, been decided to use the relations with the Thu Bon discharges for the extension of the series, rather than the runoff rainfall relations derived from the multiple regression analysis. It is anticipated, however, that in further planning phases a proper rainfall –runoff modelling will generate more accurate results.

With the help of above described methodology, monthly runoff series have been generated for the entire Tra Khuc basin as presented in Table B.8.

The runoff has been composed of:

- Tra Khuc runoff by multiplying the Son Giang discharge with the area proportionality factor of 1.24;
- Ve runoff at An Chi
- Runoff from the smaller basins with total area of 510 km^2, assuming that the runoff

from this area per km^2 corresponds with the combined Thra Khuc – Ve runoff per km^2;

- The runoff from the lower (and coastal) area estimated with the help of the net rainfall on this area.

The dependable monthly runoff of the entire Tra Khuc basin has been calculated as follows:

Dependable Monthly Natural Runoff in the whole basin (A= 5,200km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	740	377	273	200	295	293	231	230	515	2,083	3,169	1,801
75%	573	305	215	150	203	201	170	161	332	1,304	2,141	1,142
90%	454	252	173	116	145	143	129	117	223	856	1,504	758

8.3 Flood Runoff

For the estimate of the probable peak discharges in the Tra Khuc river, use has been made of the historical discharge data of the Son Giang station. Recorded instantaneous maximum discharges were available for only fourteen years. This provides a weak basis for the frequency analysis. The results of the analysis are, nevertheless, summarised below for the maximum yearly floods.

Yearly maximum discharges at Son Giang with corresponding Return Period Unit: m^3/s

	5 years	10 years	20 years	50 years	100 years
Log Normal	8,257	9,967	11,701	13,865	15,578
Pearson 3	8,489	10,098	11,563	13,369	14,664
Gumbel	8,348	10,001	11,588	13,641	15,180
Goodrich	8,606	9,915	11,058	12,277	13,042
Average round values	8,500	10,000	11,500	13,500	15,000

A similar analysis has been carried out with the maximum yearly early flood events (maximum discharge in the period January -August).

Yearly Early maximum discharges at Son Giang with corresponding Return Period Unit: m^3/s

	5 years	10 years	20 years	50 years	100 years
Log Normal	884	1273	1729	2416	3028
Log Pearson	832	1241	1637	2644	3512
Gumbel	1064	1425	1771	2220	2555
Average round values	950	1,300	1,700	2,400	3,000

The frequency distributions are shown in Figure B.22.

For the estimate of flood volumes corresponding with the above mentioned peak discharges, an analysis has been made of the one-day area rainfall in the upper and middle Tra Khuc basin. In view of the size and shape of the basin, it is anticipated that the peak discharges are a result of extreme rainfall intensities with duration less than one day. Since no long series of hourly rainfall data have been made available, use is made of daily rainfall data. For this analysis the following series of historic daily rainfall data have been used:

Rainfall data used for area rainfall analysis in Tra Khuc basin

Gia Vuc	1977 – 2000
Tra Bon	1977 – 2000
Quang Ngai	1977 – 2000
Ba To	1977 – 2000

Small gaps in the Gia Vuc rainfall series were filled with data of the nearby Ba To station.

With the help of the Thiessen method the following area weights have been assessed for the area rainfall on the 2,440 km^2 of the Tra Khuc basin upstream of Son Giang. upper and middle catchment of the Ba basin.

Sub-catchment	Rainfall station			
	Gia Vuc	Tra Bon	Quang Ngai	Ba To
Tra Khuc u/s SonGiang	55%	35%	6%	4%

Using these weights, area rainfall series have been compiled of 24 years of daily rainfall. On these series frequency analyses were carried out using both the Gumbel and the Log-Normal probability distribution functions. The analysis were carried out for the yearly maximum area rainfall values and for the "early flood" rainfall values (maximum rainfall in period January – August).

The results (averaged and round Gumbel and Log Normal values) are given in the table below:

One day maximum area rainfall main flood season in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Tra Khuc basin	230	315	370	425	495	550

One day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Tra Khuc basin	65	100	120	145	175	200

The corresponding rainfall volumes on the upper and middle 3,030 km2 of the Tra Khuc basin are as follows:

Estimated one-day rainfall volumes in Mm^3 on upper and middle Tra Khuc basin

Return period	2 years	5 years	10 years	20 years	50 years	100 years
Main flood season	700	1,000	1,100	1,300	1,500	1,700
Early flood season	200	300	350	450	550	600

The hydrographs and corresponding area rainfall of the 1999 floods are presented in Figure B.23. The direct flood runoff as a consequence of these main storms is of the order of 70% of the storm rainfall volume. It is anticipated that during the early floods this runoff percentage will be lower and could be of the order of 50% or even less.

9 KONE RIVER BASIN

9.1 Basin Characteristics

9.1.1 River Basin

The Kone river basin is situated in the south central Vietnam between 13°30' to 14°30' north latitude and 108°30' to 109°15' east longitude. Almost of catchment is situated Binh Dinh province.

Kone river basin covers a total catchment area of only 3,600km^2, which included Ha Thanh river basin.

Major tributaries and its catchement area are shown as follows:

Kone Basin (Total)	3,640km^2
Major Sub-basins	
Kone (at Binh Thanh) :	2,250km^2
Lower Area (Delta) :	640km^2
Ha Thanh :	630km^2

For the location map of the Kone Basin is presented in Figure B.24.

9.1.2 Climatological Features

Mean annual temperature varies from 20°C to 27°C. Mean monthly humidity varies from 70 to 80 % and annual evaporation varies from 800mm in mountains to 1,200mm in coastal plains.

Mean annual rainfall varies from 1,800mm to 2,100 mm. There are 2 rains peaks, i.e., small rainfall and heavy rainfall. The heavy rainfall concentrates in October to November. Small rains occur in May and June. The dry season starts in January and lasts until August.

9.2 Natural Runoff

Only one discharge measurement station with adequate record length has been identified in the Kone River basin. This station, Cay Muong, has been used as base station for the assessment of the basin runoff.

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Cay Muong	108.52	13.56	1,677km2	Kone	1976-1977 1979-2000

Based on record length and geographical position, the following rainfall stations have been selected for the assessment of the area rainfall in the Kone River basin:

Station	Longitude	Latitude	Province	Observation Period
Binh Tuong (Cay Muong)	108.56	13.55	Binh Dinh	1976-2000
Phu Cat	109.04	14.00	Binh Dinh	1976-2000
Dinh Binh (Binh Quang)	108.48	14.08	Binh Dinh	1979-2000
Vinh Kim	108.46	14.14	Binh Dinh	1982-2000

Daily discharge data of the Cay Muong station have been collected and processed for the period 1976 – 2000. These discharges do not correspond fully with the natural runoff, since the reservoir at Vinh Son has a regulating effect on the runoff. This effect relates to 97 km^2, or 5.8 % of the catchment that is measured at Cay Muong.

The base point of the Kone River basin is not a single geographic position, since the river bifurcates into several branches before it discharges into the Quy Nhon lagoon (Thi Nai Swamp). If, however, this lagoon is considered part of the basin, then the connection between this lagoon and the sea is the base point. Consequently, the Ha Than basin is to be considered as a sub-basin of the Kone River basin.

In the Kone basin a clear distinction can be made between the upper and middle catchment on one side and the lower catchment on the other side. This lower catchment consists essentially of the deltaic zone that has its apex at Binh Thanh just upstream of the Bay Yen weir in the Kone river. This apex is some 30 km upstream of the Kone river mouth.

The natural monthly discharge series derived for the Cay Muong station represents the runoff of the upper 1,677 km^2 of the Kone River basin. This upper area corresponds with 75% of the catchment that drains through Binh Thanh and to 56 % of the total catchment excluding the low-lying delta area. The area of this lower area has been measured at 640 km^2.

To arrive at natural monthly discharges at Binh Thanh and from the entire catchment, the following approach has been used.

With the help of the monthly rainfall data of the selected stations the monthly catchment rainfall has been established for the entire basin. Also for the upper catchment, that is measured at Cay Muong, the monthly area rainfall has been established, using the relevant stations. A comparison between the monthly basin rainfall data and the monthly upper basin rainfall data reveals that the basin rainfall tends to be slightly higher than the upper catchment rainfall. The following relation was found:

$P_{uc} = 0.98\ P_{basin} + 6\ (R^2 = 0.96)$

With:

P_{uc} = monthly rainfall upper catchment in mm
P_{basin} = monthly rainfall basin in mm

From this relation it is concluded that no substantial error is introduced with the assumption that the basin rainfall and the upper catchment rainfall are the same. If, moreover, it is assumed that the rainfall runoff relation of the Nui Mot and Ha Thanh sub-catchments is similar to the rainfall runoff relation of the upper area, then a direct area proportionality factor can be applied to obtain the monthly runoff at Binh Thanh and the monthly runoff from the entire basin excluding the delta area. This approach has been used for this stage of the planning process. The above assumptions will be verified with the help of rainfall runoff modelling in case a comprehensive basin plan is to be elaborated for the Kone basin.

The area factors that have been used to convert the Cay Muong measured discharges to the Binh Thanh and the total middle and basin runoff are respectively 1.34 and 1.79.

The resulting generated series of monthly runoff for the period 1976 – 2000 (with exception of 1978) is presented in the Table B.9. This runoff includes that runoff from the lower area, that have been estimated with the help of the net rainfall on this area. The length of the series is considered sufficient for the purpose of the study, reason why no effort has been made to fill the 1978 gap in the series. The dependable basin runoff has been calculated as follows:

Dependable Monthly Natural Runoff in the whole basin (A= 3,640km^2)

(including HaThanh Basin)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	218	135	108	87	109	122	98	100	162	819	1,107	514
75%	165	106	85	69	83	86	76	72	104	463	659	288
90%	128	84	69	56	65	62	61	53	70	278	413	171

9.3 Flood Runoff

For the estimate of the probable peak discharges in the Kone river, use has been made of the historical discharge data of the Cay Muong station.

Frequency distribution analyses were carried out with the above series of maximum discharges. Figures B.25 show the distribution for different probability functions. It is noted that the availability of only twenty five observed maximum year discharges provides a rather weak basis for the frequency analysis of peak discharges.

From the goodness-of- fit tests it appears that the Log-normal, Pearson 3, Gumbel and Goodrich functions, describes best the frequency distribution. The results are summarised below for the yearly maximum peak discharges at Cay Muong:

Unit: m^3/s

Return period (years)	2	5	10	20	50	100
Log Normal	2,137	3,443	4,401	5,135	6,205	7,005
Pearson 3	2,201	3,653	4,469	5,141	5,977	6,577
Gumbel	2,256	3,621	4,424	5,145	6,078	6,778
Goodrich	2,125	3,779	4,506	5,072	5,760	6,211

Peak discharges at Binh Thanh, the location where the Kone river enters the flood prone lower Kone basin have been estimated as follows.

A Creager type area relation is assumed for the peak discharges. According to this relation, the peak discharge is proportional to the A to the power $A^{-0.05}$, with A is the catchment area. Following this relation, the peak discharge at Binh Thanh (catchment area = 2,350 km^2) is 1.157 times the peak discharge at Cay Muong (catchment area = 1,667 km^2). For the Cay Muong peak discharges the average value of the above estimated probable discharges has been taken. Using this approach, the following probable round peak discharge values have been calculated for Binh Thanh.

Peak discharges in m^3/s at Binh Thanh with corresponding Return Period (years)					
2	5	10	20	50	100
2,500	4,200	5,100	5,900	6,900	7,700

A similar analysis has been carried out with the maximum yearly early flood events. The log-normal function gave by far the best fit, and the following results:

Early flood peak discharges in m^3/s at Binh Thanh with corresponding Return Period			
2	5	10	20
160	310	430	560

For the estimate of volumes of floods that are generated by 1-day peak rainfall on the Kone basin, an analysis has been made of the daily rainfall data from the rainfall stations upstream of the apex of the Kone delta at Binh Thanh. These stations are:

Binh Tuong (Cay Muong)	1976 – 2000
Binh Quang (Dinh Binh)	1979 – 2000
Vinh Kim	1982 – 2000

The Binh Quang and Vinh Kim series show some small gaps that have been filled with Binh Tuong data. Catchment rainfall was calculated for the period 1982 – 2000, assuming equal weight for each station. With the help of these area rainfall series a frequency analysis was carried out of yearly maximum day rainfall. Comparison of the results of this analysis with the maximum rainfall of Binh Tuong (Cay Muong) station over the same period reveals that the Binh Tuong maximum values are essentially the same as the basin values. Since this station has the longest record, it has been decided to use the 1976 – 2000 Binh Tuong data for the estimate of the peak n-day rainfall in the entire basin. The result is as shown below:

Maximum yearly one-day rainfall at Binh Tuong in mm

Return period in years	2	5	10	20	50	100
Log-normal	169	224	259	291	336	368
Gumbel	169	223	259	293	338	371

Maximum yearly two-day rainfall at Binh Tuong in mm

Return period in years	2	5	10	20	50	100
Log-normal	238	318	370	415	483	530
Gumbel	238	317	370	420	485	534

Maximum yearly three-day rainfall at Binh Tuong in mm

Return period in years	2	5	10	20	50	100
Log-normal	270	355	409	458	526	574
Gumbel	269	353	408	458	530	582

These rainfall intensities correspond with the following n-day precipitation volumes in the basin upstream of Binh Thanh (2250 km^2):

Maximum yearly n-day rainfall volume on Kone basin u/s Binh Thanh in Mm^3

Return period	2 years	5 years	10 years	20 years	50 years	100 years
1 day	380	503	583	657	758	831
2 days	535	714	833	939	1,089	1,197
3 days	606	797	919	1,031	1,188	1,301

It is anticipated that the peak discharges that occur at Binh Thanh correspond with one day rainfall intensities, rather than with more day intensities. A typical historic hydrograph and corresponding rainfall is shown in Figure B.26.

Early floods are flood events that occur prior to the start of the rainy season. Here the early floods are defined as the flood events taking place in the period from 1 January to 1 September. One-day rainfall intensities have been assessed for this season in a similar way as for the maximum year values. The results are as follows:

Maximum early (January – September) one-day rainfall at Binh Tuong in mm

Return period in years	2	5	10	20	50	100
Log-normal	73	105	128	150	178	200
Gumbel	75	106	128	149	175	195

The corresponding early storm volume in Mm^3 on the Kone basin upstream of Binh Thanh is estimated as follows:

Return period in years					
2	5	10	20	50	100
170	240	300	350	400	450

10 BA RIVER BASIN

10.1 Basin Characteristics

10.1.1 River Basin

The Ba river basin is situated in the south of central Vietnam between 12°30' to 14°30' north latitude and 108° to 109°20' east longitude. The Ba river basin covers 3 provinces: Gia lai and Dak Lak (Central Highlands) and Phu Yen in south central coast.

Ba river basin covers a total catchment area of 14,000km^2, completely located in Vietnam. Major tributaries in Ba river basin are:

Ba River basin (Total)	14,030km^2
Major Sub-basins	
Ia Ayun :	2,830km^2
Krong H Nang :	1,740km^2
Hinh :	970km^2
Lower Area (Delta) :	440km^2

The location map of the basin is presented in Figure B.27.

10.1.2 Climatological Features

Mean annual temperature ranges from 21 to 24°C, from 25 to 26°C and from 26 to27°C in the upper, middle and lower, respectively. Mean Annual humidity is about 80% and evaporation varies from 1,300mm to 1,500mm.

Mean annual rainfall in the whole basin reaches 1700mm. In the western upper basin (central highlands), the rainy season lasts from May to October, while the dry season lasts from November to April. In the middle and lower basin the rainy season lasts from September to December and dry season lasts from January to August.

10.2 Natural Runoff

For the assessment of the natural runoff at basin level, the measured discharges at Cung Son furnish an excellent starting point. At this location passes the runoff of 88% of the entire Ba catchment and more than 90% of the upper and middle catchment. The following historic information on daily discharge observations has been collected and processed:

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Cung Son	108.59	13.02	12,800km^2	Ba	1977-2000
An Khe	108.39	13.57	1,440km^2	Ba	1978-2000

For the assessment of the area rainfall in the Ba basin the following data have been included in the database:

Station	Longitude	Latitude	Province	Observation Period
M' Drak	108.46	12.45	Dak Lak	1977-2000
Son Hoa (Cung Son)	108.59	13.03	Phu Yen	1976-2000
Tuy Hoa	109.17	13.05	Phu Yen	1977-2000
Cheo Reo (A Yun Pa)	108.27	13.24	Gia Lai	1977-2000
Chu Prong	107.52	13.44	Gia Lai	1978-1995. 1997-2000
An Khe	108.39	13.57	Gia Lai	1977-2000

The discharge record of Cung Son ranges over the period from 1977 onwards. For the conversion of measured discharges at Cung Son into natural runoff, the following upstream developments need to be taken into account:

- The Ia Yun Ha reservoir came into operation in 1990, and regulates the runoff of 1600 km^2, or almost 13% of the catchment u/s Cung Son. Moreover, the water from this reservoir that is used to irrigate 4,500 ha is to be considered as been withdrawn partly from the basins runoff. Corrections of the natural runoff could be estimated on the basis of reservoir operation data and irrigation demands.
- The Song Hinh hydro-electric plant came recently into operation in 2001. The Song Hinh reservoir regulates the runoff of 722 km^2, or about 6% of the catchment u/s Cung Son.

The Dong Cam irrigation scheme withdraws water from the river downstream of the Cung Son measurement station and has, therefore, no impact on the measured discharges.

Since the details on the Ia Yun Ha reservoir operation were not available in time for the present analysis, it has been decided to select the runoff series prior to the completion of the reservoir for being used in the water balance analysis. This series of monthly runoff, covering the period 1977 – 1989, is presented in Table B.10. These series have been derived directly from the Cung Son discharge data, using an area multiplication factor of 1.096 to arrive at the natural runoff of the entire middle and upper basin, and adding the runoff of the lower 440 km2 basin area by applying the net rainfall approach. The dependable basin runoff has been calculated as follows:

Dependable Monthly Natural Runoff in the whole basin (A= 14,030km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	397	212	145	111	210	329	355	609	948	1,640	2,246	860
75%	302	168	113	79	140	200	244	388	709	956	1,454	532
90%	236	136	91	58	97	127	173	259	546	588	984	345

10.3 Flood Runoff

For the estimate of the probable peak discharges in the Ba river, use has been made of the historical discharge data of the Cung Son station. For this analysis only 13 years of records of monthly instantaneous peak discharges were available in this study. This provides an extremely weak basis for the frequency analysis. The results of the analysis are, nevertheless, summarised below. The frequency distributions are shown Figure B.28.

Unit: m^3/s

	2 y	5 y	10 y	20 y	50 y	100 y
Log Normal	5,460	9,665	13,029	16,793	22,006	26,477
Pearson 3	5,590	10,480	13,876	17,143	21,350	24,468
Gumbel	6,010	10,655	13,731	16,681	20,499	23,360
Goodrich	5,945	10,584	13,525	16,113	19,441	21,737
Averaged round values	5,800	10,400	13,500	17,000	21,000	24,000 1)

1) Reportedly a 24000 m^3/s flood was observed in 1938, while in 1964 a flood of 21,850 m^3/s was reported.

A similar analysis has been carried out with the maximum yearly early flood events.

Unit: m^3/s

	2 y	5 y	10 y	20 y	50 y	100 y
Log Normal	719	1,136	1,443	1,752	2,195	2,545
Gumbel	753	1,185	1,470	1,744	2,099	2,365
Averaged round values	750	1,150	1,450	1,750	2,150	2,500

For the estimate of flood volumes corresponding with the above mentioned peak discharges, an analysis has been made of the n-day area rainfall in the upper and middle Ba basin. For this analysis the following series of historic daily rainfall data have been used:

Rainfall data used for n-day area rainfall analysis in Ba basin

An Khe	1978 – 2000 (complete)
Chu Prong	1978 – 1995, 1997 – 2000 (4 months gap)
Cheo Reo	1978 – 2000 (2monthas gap)
Ma Drak	1978 – 2000 (1 moth gap)
Son Hoa	1978 – 2000 (complete)

The gaps in the Chu Prong and Cheo Reo series have been filled with An Khe rainfall data. The Ma Drak series has been completed with Son Hoa data.

With the help of the Thiessen method the following area weights have been assessed for the area rainfall on the 12,990 km^2 upper and middle catchment of the Ba basin.

Sub-catchment	Rainfall station				
	An Khe	Chu Prong	Cheo Reo	Ma Dark	Son Hoa
Upper and middle Ba basin	30%	9%	32%	16%	13%

Using these weights, area rainfall series have been compiled of 23 years of daily, 2-days and 3-days rainfall. On these series frequency analyses were carried out using both the Gumbel and the Log-Normal probability distribution functions. The analysis were carried out for the yearly maximum area rainfall values and for the "early flood" rainfall values (maximum rainfall in period January – August)

.The results (averaged and round Gumbel and Log Normal values) are given in the tables below:

One day maximum area rainfall main flood season in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Ba basin	110	155	180	210	250	275

One day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Ba basin	45	60	75	85	100	110

Two day maximum area rainfall main flood season in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Ba basin	150	220	265	310	370	420

Two day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Ba basin	60	80	95	105	125	135

Three day maximum area rainfall main flood season in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Ba basin	165	245	290	340	405	455

Three day maximum "early flood" rainfall in mm

Return Period (years)	2	5	10	20	50	100
Upper and middle Ba basin	70	100	115	130	150	165

The corresponding rainfall volumes on the upper and middle basin are as follows

Estimated yearly n-day rainfall volumes in Mm3 on upper and middle Ba basin

Storm	2 years	5 years	10 years	20 years	50 years	100 years
One-day storm	1,400	2,000	2,300	2,700	3,200	3,600
Two-day storm	1,900	2,800	3,400	4,000	4,800	5,500
Three –day storm	2,100	3,200	3,800	4,400	5,300	5,900

Estimated early n-day rainfall volumes in Mm3 on upper and middle Ba basin

Return period	2 years	5 years	10 years	20 years	50 years	100 years
One-day storm	600	800	1,000	1,100	1,300	1,400
Two-day storm	800	1,000	1,200	1,400	1,600	1,800
Three –day storm	900	1,300	1,500	1,700	1,900	2,100

It is anticipated that the peak discharges at Cung Son are produced by two-day storms. A typical storm and corresponding flood hydrograph is presented in Figure B.29.

11 SESAN RIVER BASIN

11.1 Basin Characteristics

11.1.1 Location

The Sesan River, which originates in the southern highlands of Vietnam and flows into Cambodia, is one of the main tributaries of the Mekong River. The total area of Sesan river basin is 18,570km2. Nearly 40% of the Sesan basin is located in Cambodia. The River basin is situated in the south of central Vietnam between 13°40’ to 15°20’ north latitude and 107°20’ to 108°40’ east longitude. North part of basin lies in the Kon Tum province, and south part of it lies in the Gia Lai Province. Major tributaries in Sesan basin are:

Sesan Basin (Total)	11,530km^2 (within Vietnam)
Major Sub-basins	
Krong Po Ko :	3,450km^2
Dak Bla :	3,410km^2

Location map of the Vietnamese part of the Sesan basin is presented in the Figure B.30.

11.1.2. Climatological Features

Mean annual temperature varies from 18°C to 24°C. Mean monthly humidity may increase from some 70% for March to more than 90% for August.

Mean annual rainfall varies within the range 1300mm to more than 2800mm. The rainy season lasts from May to October. The dry season lasts from December to April.

11.2 Natural Runoff

The Se San basin has been studied extensively in view of the development of the hydropower potential in this basin. Recent studies of, especially, the Sesan 3 project (Feasibility Study by SWECO, 1999) and Sesan 4 (SWECO, 1997 and Halcrow, 1998) present long series of monthly runoff at both sites, covering respectively 68% and 81.5% of the Vietnamese part of the Se San basin. The discharge series have reportedly been prepared by PECC1. The hydrological analyses made in the framework of the power studies are mainly based on daily discharge observations at the following stations:

Station	Longitude	Latitude	Catchment	Tributary	Observation period
Kontum	108.01	14.20	3,056	Dak Bla	1967 – date (with gaps)
Trung Nghia	107.52	14.25	3,320	KrongPoKo	1990 - date
Sa Binh	107.51	14.19	6,732	Sesan	1982 - 1990

Details on the methodology that is used in the preparation of the monthly natural runoff series have not been obtained. For the assessment of the basin rainfall, the following rainfall information has been collected and processed:

Station	Longitude	Latitude	Province	Observation Period
Dac Glei	107.45	15.04	Kon Tum	1977-78.1980-1984. 1986-1995.1997-2000
Dak To	107.50	14.40	Kon Tum	1977-2000
Kon Tum	108.00	14.21	Kon Tum	1976-2000
Pleiku	108.00	13.59	Gia Lai	1976-2000

From the monthly runoff series presented in the above mentioned study, the 1976 –1997 series at the Se San 4 site have been selected for the estimate of the basin runoff at the base point of the basin, i.e. the location where the Sesan river leaves the Vietnamese territory.

The generated monthly runoff series at the base point assumes that the specific discharge of the entire Vietnamese part of the basin corresponds with the runoff per km^2 obtained from the Se San 4 series. The Se San 4 series have, consequently been multiplied by a factor 1.236. The dependable runoff at the base point has been calculated as follows:

Dependable Monthly Natural Runoff (A=11,530km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	572	406	375	356	514	799	1,188	2,017	2,054	1,839	1,333	872
75%	489	343	320	295	404	589	939	1,632	1,621	1,504	1,033	710
90%	425	294	277	250	325	447	760	1,348	1,310	1,254	821	590

11.3 Flood Runoff

To estimate the flood runoff in the Sesan basin, an analysis has been made of the observed peak flows in the basin and of the rainfall intensities. Data on monthly instantaneous peak flows are available for the Kon Tum station in the Dak Bla sub-catchment for the period 1978 – 2000. From this series the following probable discharges have been calculated assuming a Log-normal, Pearson-3 and Gumbel probability distribution respectively:

Probable yearly peak discharges at Kon Tum in the Dak Bla sub-basin in m^3/s

Return Period years	2	5	10	20	50	100
Log-nor.	1,465	2,071	2,482	2,877	3,411	3,815
Pears.3	1,497	2,124	2,510	2,861	3,292	3,600
Gumbel	1,482	2,087	2,487	2,872	3,369	3,742
Round average	1,500	2,100	2,500	2,900	3,400	3,750

The catchment area upstream of the Kon Tum station amounts to 3,056 km^2 . The specific peak discharge at that location, is consequently calculated at some 490 l/s/ km^2 at the once in two year flood, increasing to some 1,200 l/s/ km^2 during the once in 100 years flood.

A similar analysis has been carried out for the floods that occur in the period January -August. Using the same probability distribution, the following results have been obtained:

Probable peak discharges in the period January – August at Kon Tum in the Dak Bla sub-basin in m3/s

Return Period years	2	3	5	10	20
Log-nor.	485	615	774	988	1,214
Pears.3	499	649	815	1,022	1,216
Gumbel	510	652	811	1,010	1,200
Round average	500	650	800	1,000	1,210

The concentration time of the basin is estimated of the order of 1day. It is, therefore, anticipated that intensities corresponding with one day rainfall are indicative for the peak floods. For the Dak Bla sub-basin, the maximum one-day rainfall has been analysed. The following daily rainfall data have been used:

Kon Tum 1976 – 2000 (complete)
Pleiku 1976 – 2000 (with one month gap)

The minor gap in the Pleiku series has been filled with Kon Tum data. The area rainfall on the Dak Bla sub-catchment has been calculated on the basis of the following weights of the respective stations:

Sub-basin	Rainfall station	
	Kon Tum	Pleiku
Dak Bla	75%	25%

Twenty five years daily area rainfall series have been compiled and the following one-day probable rainfall intensities have been calculated assuming a log-normal distribution of the yearly maximum values.

Maximum one day area rainfall on the Dak Bla sub-basin (mm)

Return period in years	2	3	5	10	20
Full year	87	100	113	130	145
January - August	74	87	101	119	137

Figure B.31 shows a typical storm and corresponding flood runoff at Kon Tum. From the hydrograph it can be derived that the direct flood runoff volume corresponds with some 30% of the rainfall volume, assuming that the calculated area rainfall occurs over the full sub-basin area.

It is anticipated that the flood runoff of the Krong Po Ko sub-basin (3,450 km2) has similar characteristics as the flood runoff from the Dak Bla sub-basin (3,410 km2).

12 SREPOK RIVER

12.1 Basin Characteristics

12.1.1 River Basin

Srepok river, which originates in the southern highland of Vietnam and flows into Cambodia, is one of the main tributaries of Mekong river. Vietnamese part of the basin is situated between 12° to 13° north latitude and 107°30’ to 108°45’ east longitude. North part of basin lies in the Dac Lac province, and south part of it lies in the Lam Dong Province.

The catchment area at the boundary with Cambodia is 12,000km^2. Major tributaries in the basin are:

Srepok Basin (total)	12,030km^2 (within Vietnam)
Major Sub-basins	
Ea Krong Ana :	3,860km^2
Ea Krong Kno :	3,910km^2

The location map of the Vietnamese part of Srepok basin is presented in Figure B.32.

12.1.2 Climatological Features

Mean annual temperature varies from 22°C to 24°C and evaporation varies from 1,000mm to 1,600mm.

Mean annual rainfall varies from 1,400 to 2,000mm. The rainy season lasts from May to October. The dry season starts from December and lasts until May or April.

12.2 Natural Runoff

Most of the runoff of the 12,030 km^2 Vietnamese catchment area of the Srepok basin is observed at the Ban Don station, that covers 10,700 km^2 of the basin. All over the basin a number of water management infrastructures are in place like reservoirs, weirs and intake works for irrigation schemes. The impact of this infrastructure on the runoff at Ban Don is difficult to assess. In the present study, it is assumed that this impact is minor and that the observed runoff at Ban Don corresponds broadly with the natural basin runoff.

For the hydrological analysis of the Srepok basin, the following discharge data have been collected and processed:

Station	Longitude	Latitude	Catchment	Tributary	Observation Period
Giang Son	108.11	12.30	3,180km^2	Krong Ana	1977-2000
Ban Don	107.47	12.53	10,700km^2	Srepok	1977-2000
Duc Xuyen	108.59	12.18	3,080km^2	Krong Kno	1978-2000

For the assessment of the area rainfall in the Srepok basin the following data have been included in the database:

Station	Longitude	Latitude	Province	Observation Period
Buon Ho	108.16	12.55	Dak Lak	1977-2000
Cau42 (Krong Buk)	108.22	12.46	Dak Lak	1976-2000
Krong Bong	108.27	12.33	Dak Lak	1977-1990. 1992-1995
Giang Son	108.11	12.30	Dak Lak	1976-2000
Buon Ma Thuot	108.03	12.40	Dak Lak	1977-2000
Cau14	107.56	12.37	Dak Lak	1977-2000
Duc Xuyen	108.59	12.18	Dak Lak	1978-2000
Dak Mil	107.37	12.27	Dak Lak	1977-1993. 1998-2000

The series of observed daily discharges at the Ban Don station has readily been used for the generation of the natural runoff series of the entire Vietnamese part of the Srepok basin for the period 1977 – 2000. It has been assumed that the specific runoff of the catchment area between Ban Don and the Cambodian border corresponds with the specific discharge of the area upstream of this station.

The generated series of monthly natural runoff at the Cambodian border is presented in Table B.12. The dependable runoff at the base point has been calculated as follows:

Dependable Monthly Natural Runoff (A=12,030km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	410	233	187	186	337	538	747	1,032	1,358	1,718	1,199	844
75%	306	185	149	139	242	369	591	794	1,103	1,360	849	564
90%	235	150	122	106	179	263	479	627	915	1,102	622	392

12.3 Flood Runoff

To estimate the flood runoff in the Srepok basin, an analysis has been made of the observed peak flows in the basin and of the rainfall intensities. Data on monthly instantaneous peak flows are available for the Ban Don for the period 1977 – 2000. From this series the following probable discharges have been calculated assuming a Log-normal, Pearson-3 and Gumbel probability distribution respectively:

Probable yearly peak discharges at Ban Don in the Srepok basin m3/s

Return Period years	2	3	5	10	20	50	100
Log-nor.	1,403	1,709	2,049	2,498	2,952	3,538	4,632
Pears.3	1,438	1,764	2,114	2,538	2,929	3,407	3,753
Gumbel	1,431	1,739	2,082	2,513	2,926	3,460	3,861
Round average	1,450	1,750	2,100	2,550	2,950	3,500	4,100

The catchment area upstream of the Ban Don station amounts to 10,700 km^2. The specific peak discharge at that location, is consequently calculated at some 135 l/s/ km^2 at the once in two year flood, increasing to some 400 l/s/ km^2 during the once in 100 years flood.

Observed flood hydrographs (see Figure B.33) show peak discharges as a result of one- and two-day rain storms. These storms have been calculated for the Srepok basin for different return periods. The area rainfall has been estimated on the basis of the average day rainfall in the following stations:

- Buon Ma Thuot;
- Cau 42
- Giang Son and
- Duc Xuyen.

The following probable area rainfall has been calculated, assuming a log-normal probability distribution.

Maximum yearly area rainfall on the Srepok basin (mm)

Return period in years	2	3	5	10	20	50	100
One-day	89	106	125	150	175	205	229
Two-day	117	146	178	222	268	326	373

13 DONG NAI RIVER

13.1 Basin Characteristics

13.1.1 Location

Dong Nai river basin is situated in the south east of Vietnam between 11°20' to 12°20' north latitude and 105°50' to 108°40' east longitude.

The river basin covers a total catchment area about 40,000km^2, which included Saigon and Van Co River Basins. In addition, 15% of catchments located in Cambodia.

The Dong Nai River basin is the largest river in the southern Vietnam. The Dong Nai has its outlet to the South China Sea close to the Ho Chi Minh City. Major tributaries of the Dong Nai River are:

DongNai Basin (Total)	39,580km^2
Major Sub-basins	
DongNai (include LaNga) :	19,070km^2
Be :	7,430km^2
Saigon	4,720km^2
Van Co	8,360km^2

The location map of this basin is presented in Figure B.34.

13.1.2 Climatological Features

Mean annual temperature varies from: 17°C to 28°C and mean annual humidity varies from 77% to 85%.

Mean annual rainfall varies from 1,500mm to 2,800mm. The rainy season lasts from April to November or December. The Dry season lasts from December until March.

13.2 Natural Runoff

In the present study, the Dong Nai basin has been defined as the catchment that is drained through the Dong Nai river and the Saigon river, and that has its base point at the confluence of both rivers at Ho Chi Minh City. The total basin area at that confluence amounts to 29,120 km^2.

In 1996 a Master Plan Study on the Dong Nai River and surrounding basins was completed by Nippon Koei under JICA assignment. In the framework of this study, the series of monthly runoff have been generated for a number of potential dam sites in the basin. The runoff was generated with the help of the Tank model, using 29 years of historical rain fall series (1964 – 1992). The model was calibrated with the help of historical series of daily discharge observations at gauging stations in the different sub-basins.

The two most downstream locations for which the runoff series was generated refer to:

- Hoa An in the Dong Nai river, at this location the entire runoff passes of the 22,594 km^2 middle and upper catchment of the Dong Nai river basin.
- Dau Tieng, in the Saigon river, where the runoff passes of 2,700 km^2 of the upper and middle Saigon sub-basin. For this station runoff series were prepared for the period prior to 1985.

The runoff series that were generated for these locations have been used as basis for the estimate of the entire basin runoff at the base point. The total area covered by these two locations corresponds with 87% of the entire basin.

The runoff of the remaining area has been estimated as follows:

- downstream of Dau Tieng Saigon river is joined by the Thi Thin tributary with a catchment area of 950 km^2, the specific runoff of this area is assumed to be the same as the specific runoff of the Saigon catchment upstream of Dau Tieng;
- the right bank (looking in downstream direction) of the Saigon river downstream of Dau Tieng is considered as lower area, for which the runoff has been estimated on the basis of the net rainfall on that area; the same approach has been used for the basin area downstream of respectively Hoa An and the confluence of Thi Tinh and Saigon river.

The resulting generated series of monthly natural runoff at Ho Chi Minh City is presented in Table B.13 for the period 1964 – 1984. The dependable runoff at the base point has been calculated as follows:

Dependable Monthly Natural Runoff at the confluence of Saigon River (A=29,120km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	777	349	266	319	751	1,982	3,542	4,649	5,472	5,979	3,465	1,617
75%	700	318	245	256	501	1,576	3,022	4,036	4,747	5,254	3,026	1,410
90%	638	292	228	210	348	1,282	2,619	3,554	4,176	4,676	2,679	1,247

13.3 Flood Runoff

Flood runoff in the Dong Nai basin has been addressed by Nippon Koei (1996) in the Master Plan Study on Dong Nai River and Surrounding Basins Water Resources Development. In the National Hydropower Plan Study by SWECO et al, reference is made to design flood estimates prepared by PECC2 for the different hydropower projects, no further analysis on basin flood runoff is presented in the 1999 Phase-1 report of that study. The VWRAP study on Dam Safety Issues, carried out by HASKONING in 2001 and which included the Dau Tieng reservoir in the Saigon basin, concentrates on design discharges for dams, rather than on flood damage mitigation issues.

In the present study, reference is made to the 1996 Nippon Koei Master Plan study. It was therein concluded that insufficient historic data on peak discharges are available for making a frequency analysis of flood events. As a result, the approach of Flood Runoff Modelling was followed, using the Storage Function simulation method. The flood runoff analysis was carried out for several locations, mainly existing or potential dam sites. The most downstream locations that were analysed are:

- Tri An in the Dong Nai river (catchment area: 14,025 km^2)
- Dau Tieng in the Saigon river (catchment area: 2,700 km^2).

The flood runoff analysis was carried out for the 20 and 100 year return period only. For the three locations mentioned above, the following flood discharges were calculated:

Return Period	20 years	100 years
Tri An	6,459 m^3/s	8,265 m^3/s
Dau Tieng	2,351 m^3/s	3,197 m^3/s

Peak discharges at the locations where the Dong Nai and the Saigon enter the lower area at respectively Hoa An and the Saigon- Thi Tinh confluence are not presented. If a Creager type of relation is assumed between the peak discharges, than it could be estimated from these figures that peak flows at Hoa An (catchment area: 22,594 km^2) and the Saigon – Thi Tinh confluence could approximately be as follows:

Return Period	20 years	100 years
Hoa An	8,000 m^3/s	10,000 m^3/s
Saigon Thi Tinh confluence	3,000 m^3/s	4,000 m^3/s

14 CUU LONG RIVER DELTA

14.1 Basin Characteristics

14.1.1 River basin

The lower reaches of the Mekong are known as Cuu Long. Vietnamese part of the Mekong Delta corresponds with the most southern part of the Vietnamese mainland. It spreads between $8^{o}40'$ to 11^{o} north latitude and $104^{o}30'$ to $106^{o}40'$ east longitude.

The catchment of the Mekong River starts in Tibet and totals 795,000km^2. The Cuu Long delta has its apex at Kratie in Cambodia and covers 49,500 km^2, 79% of this area, or some 39,000km^2 is located in the Vietnamese territory. The northern border of the catchment corresponds with the international boundary with Cambodia. The north eastern boundary of the delta basin is not clearly defined. The divide between the Delta area and the Van Co basin is difficult to assess because of manmade canals that connect both systems. In the present study, the west Van Co basin is considered part of the Mekong delta area. The western and south-eastern edge of the delta is formed by respectively the Gulf of Thailand and the South China Sea.

When entering the Vietnamese territory, the delta is formed by two branches, the Mekong and the Bassac. In the Vietnamese part of the delta a redistribution of flow takes place from the Mekong to the Bassac river through the Vam Nao. The Bassac maintains its single channel flow throughout to its mouth, while the Mekong river branches out into three estuaries before entering the South China Sea.

Location map of the Vietnamese part of the Cuu Long river basin is presented in the Figure B.35.

14.1.2 Climatological Features

Mean annual temperature is about 27^{o}C and annual humidity varies from 70% to some 80%.

Mean annual rainfall varies from 1400mm to 2400mm. The rainy season lasts from May to November. The Dry season lasts from December to March.

14.2 Natural Runoff

The generation of series of natural runoff of the Mekong basin is impracticable. Numerous discharge regulating infrastructure is in place in the basin. The implementation of a rainfall-runoff model for the entire basin would lack possibilities of calibration if the operation of existing infrastructure would not be taken into account. Such exercise would go far beyond the scope of the present study.

Even the assessment of the actual, regulated, runoff at the base point of the Mekong basin is extremely complicated. Discharge measurements in the Cuu Long main branches, Mekong and Bassac, are not available. Measurement of these discharges is seriously hampered by the tidal fluctuation. The most downstream station outside of the tidal influence is located at Kratie in Cambodia. Daily discharges at this location are available only until 1969. Moreover, the Tongle Sap system, located downstream of Kratie, has a strong regulating effect on the discharges before the Mekong runoff enters the Cuu Long basin.

As a consequence of these complications, only a first estimate of the monthly runoff could be elaborated in the present study. For this estimate, the following methodology has been used:

- monthly discharge data at Kratie have been obtained from the Mekong Delta Master Plan studies, (1990 – 1993, NEDECO);
- the regulating effect of Tonle Sap has been derived from the monthly series of flow to and from Tonle Sap at Prek Kdam, prepared for the period 1960 – 1971 by the Netherlands Delta Team in 1974;
- these two series allow the preparation of the series of monthly runoff at the Vietnam – Cambodia border, corresponding with the inflow into the Cuu Long Delta, for the period 1960 – 1971;
- extension of this series to 25 years (1960 – 1984) has been achieved by averaging the regulating effect of Tonle Sap, assuming that during the years 1972 - 1984 the monthly discharges at Prek Dam correspond with the average of the monthly discharges derived from the 1960 – 1971 values;
- the contribution of the Cuu Long Delta itself to the Mekong basin runoff has been estimated on the basis of the monthly net rainfall on the Cuu Long Delta. For this estimate the series of daily rainfall (1978 – 2000) at Can Tho have been used.

Based on this approach a series of monthly runoff of the Mekong basin at its base point has been estimated for the period 1960 – 1984, as presented in Table B.14. Based on this series the following dependable runoff has been calculated.

Dependable Monthly Natural Runoff (A= 37,870km^2)

unit :million m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	18,046	9,381	7,288	6,296	9,063	27,269	47,577	80,752	87,292	73,335	51,421	32,289
75%	15,895	8,233	6,500	5,636	7,304	20,746	37,718	67,990	76,089	64,509	47,561	29,721
90%	14,179	7,319	5,864	5,102	6,015	16,220	30,603	58,237	67,241	57,477	44,336	27,585

14.3 Flood Runoff

The flood runoff of the Mekong basin enters the Cuu Long Delta along various ways. Prior to entering Vietnam, already a substantial volume of the flood runoff is diverted from the river system to flooded areas in Cambodia. This volume has been estimated at 5 –10% of the river discharge. Moreover, a considerable part of the flood discharge is diverted to the Great Lake through the Tonle Sap.

Efforts have been made in past and are still being made to estimate the peak discharges and flood volumes that eventually enter the Cuu Long Delta, either through the two branches of the river system, or via overland flow. An analysis made of the 1978 flood flows indicate that some 20% of the flood waters enter Vietnam overland.

The order of magnitude of the flood flows can be derived from the peak discharges at Kratie. Series of maximum day discharges are available from this station for the period 1924 – 1969. From these series, the following discharges have been estimated with the help of a number probability functions. The Pearson3 distribution is shown as an example in Figure B.36.

Estimated peak discharges in m^3/s Kratie, based on discharge series 1924 - 1969

Return period			
10 years	20 years	50 years	100 years
61,500	64,500	68,000	70,000

It is noted that the Coefficient of Variation of the yearly peak discharges is remarkably low. With a mean value of peak discharges of 52,657 m^3/s, and a standard deviation of 6,637 m^3/s, the C_v amounts to 0.126 only. It is anticipated that further peak attenuation between Kratie and the Vietnamese border will even reduce this value.

Assuming a diversion of the Mekong flood runoff towards the Great Lake in the order of 15% and a 5 –10% attenuation due to flooding upstream of the Vietnamese border, it can be estimated that flood flows entering Vietnam will be some 20% lower than the Kratie discharges.

Table B.1 Generated Monthly Discharge Series Bang Giang and Ky Cung River Basin

Bang Giang River at International Boundry (A = 4,460km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1960	45	33	60	28	131	215	856	1,045	542	247	111	100	3,413
1961	53	42	92	127	59	540	323	697	551	205	232	133	3,054
1962	119	53	47	49	85	564	547	525	166	131	53	36	2,377
1963	28	27	30	27	36	53	364	423	209	116	172	87	1,572
1964	59	48	56	92	131	426	508	579	337	375	113	66	2,792
1965	42	32	38	205	113	859	535	347	119	108	142	59	2,599
1966	44	32	26	53	58	748	1,064	332	200	123	82	35	2,798
1967	32	31	30	41	179	242	209	707	402	92	57	40	2,062
1968	34	35	44	88	274	720	737	1,712	626	287	144	72	4,774
1969	43	31	31	59	180	457	390	1,137	285	112	88	40	2,854
1970	37	30	29	92	247	453	748	751	486	175	74	63	3,185
1971	40	33	35	33	171	386	960	1,370	479	299	85	54	3,945
1972	39	31	30	33	144	242	243	688	380	206	93	68	2,197
1973	49	37	128	135	677	668	946	697	792	215	77	51	4,471
1974	43	32	33	52	53	523	658	244	424	372	87	61	2,582
Ave(mil m3)	47	35	47	74	169	473	606	750	400	204	107	64	2,978

Ky Cung River at International Boundry (A = 6,790km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1960	98	75	126	58	146	193	1,179	1,430	992	428	183	143	5,050
1961	72	65	108	343	126	470	241	444	776	388	223	149	3,405
1962	127	68	66	76	146	812	868	1,072	317	162	83	61	3,858
1963	47	48	54	56	75	133	897	795	559	224	190	99	3,178
1964	75	65	75	208	223	436	837	614	479	567	131	98	3,807
1965	64	51	70	395	214	1,142	1,128	301	238	118	114	77	3,912
1966	68	52	46	96	69	977	975	463	212	131	74	55	3,217
1967	49	67	51	84	168	214	179	517	663	104	88	70	2,255
1968	53	62	86	227	244	440	712	2,691	854	206	124	77	5,777
1969	113	55	59	119	105	230	312	1,000	316	170	145	62	2,686
1970	62	52	52	211	448	734	770	868	611	244	106	88	4,246
1971	63	56	60	46	222	314	1,978	2,165	460	286	111	84	5,845
1972	61	52	48	59	403	220	217	1,215	646	279	145	91	3,437
1973	77	59	74	245	478	608	1,337	1,187	1,661	318	125	89	6,260
1974	79	58	54	77	116	599	768	319	796	454	102	75	3,497
Ave(mil m3)	74	59	69	153	212	501	826	1,005	639	272	130	88	4,029

BangGiang + KyCung at International Boundary (A=11,250km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1960	143	108	186	85	277	408	2,035	2,475	1,534	676	294	242	8,463
1961	125	107	200	469	185	1,009	565	1,140	1,327	593	455	282	6,458
1962	246	121	113	125	231	1,376	1,416	1,597	484	292	137	98	6,235
1963	75	75	84	83	111	187	1,262	1,217	768	340	362	186	4,750
1964	134	113	131	300	354	861	1,345	1,193	816	942	245	164	6,599
1965	106	83	108	600	327	2,001	1,663	648	357	227	256	135	6,511
1966	112	84	72	149	127	1,724	2,039	795	412	254	156	90	6,015
1967	81	99	82	126	347	456	388	1,224	1,065	196	145	110	4,318
1968	87	98	130	315	518	1,160	1,449	4,403	1,480	493	269	149	10,551
1969	156	87	90	178	285	687	702	2,138	600	282	233	102	5,539
1970	99	82	81	303	695	1,187	1,518	1,619	1,097	419	179	152	7,431
1971	104	89	94	79	394	699	2,938	3,535	939	585	196	138	9,791
1972	100	83	78	91	547	462	461	1,903	1,026	485	238	160	5,634
1973	126	96	202	380	1,155	1,276	2,282	1,884	2,454	533	202	140	10,731
1974	122	90	87	130	170	1,122	1,426	562	1,221	826	189	135	6,079
Ave(mil m3)	121	94	116	228	382	974	1,433	1,756	1,039	476	237	152	7,007

Table B.2 Generated Monthly Discharge Series Red River and Thai Binh River (1/2)

Monthly Discharge at Son Tay (A=144,000km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1957	2,461	1,744	1,993	3,084	3,053	15,889	26,409	15,883	10,368	9,267	4,199	2,946	97,298
1958	2,518	2,637	1,899	1,612	2,258	8,865	21,400	26,730	16,563	8,598	4,406	2,919	100,406
1959	2,453	1,880	3,000	3,318	6,750	14,282	17,677	25,204	15,733	10,231	5,676	3,616	109,821
1960	3,375	2,831	2,376	1,713	2,598	9,046	20,088	25,043	17,159	9,508	5,417	4,794	103,949
1961	3,241	2,806	3,187	3,732	3,669	13,504	12,963	30,052	17,004	14,169	9,124	5,812	119,264
1962	5,303	3,169	2,630	2,773	4,634	17,081	21,133	20,142	11,379	8,464	4,303	2,919	103,930
1963	2,285	1,860	2,073	1,768	2,186	5,599	17,115	20,624	11,483	9,964	12,623	5,384	92,962
1964	3,321	2,531	2,373	2,748	4,794	13,323	27,320	20,945	16,278	15,053	7,595	5,169	121,449
1965	3,535	2,516	2,341	3,396	3,964	14,489	19,713	15,936	9,513	11,544	11,586	5,598	104,131
1966	4,018	2,758	2,116	2,312	2,919	17,392	32,676	24,534	22,213	13,660	7,776	4,848	137,223
1967	3,803	2,758	2,330	2,561	3,964	7,595	13,687	23,275	15,422	10,392	6,895	5,250	97,932
1968	4,152	3,282	3,241	4,355	6,080	12,156	27,320	28,123	20,943	13,847	9,539	4,821	137,859
1969	3,321	2,231	2,001	2,035	3,750	8,268	16,579	39,640	13,530	6,830	5,832	3,107	107,124
1970	2,518	2,231	1,701	2,227	7,366	11,897	33,480	24,588	17,677	8,732	4,743	6,616	123,774
1971	3,348	2,734	2,344	2,773	5,839	15,319	29,195	50,354	24,261	11,785	7,076	4,232	159,259
1972	3,375	2,473	2,103	2,525	4,928	9,590	19,606	20,972	17,418	13,392	8,813	8,008	113,203
1973	4,366	3,387	4,473	3,940	8,062	15,656	25,070	28,123	25,505	11,812	8,165	5,196	143,754
1974	3,884	2,855	2,419	2,592	4,526	11,820	19,552	19,017	19,777	12,508	6,065	3,964	108,978
1975	3,669	2,279	2,025	3,473	6,830	18,377	16,713	14,544	15,733	9,428	6,480	4,071	103,623
1976	3,107	3,332	2,338	2,799	7,687	11,457	15,588	25,472	14,100	8,732	8,243	4,339	107,194
1977	3,455	2,685	2,443	3,084	4,071	5,236	24,186	21,856	10,212	9,428	5,858	3,750	96,264
1978	3,723	2,354	2,392	2,170	8,330	17,574	19,606	21,883	21,721	13,740	5,988	3,937	123,416
1979	3,455	2,951	2,451	2,385	4,152	11,664	16,017	23,168	25,065	8,866	4,692	3,268	108,132
1980	2,839	2,556	1,950	1,903	3,669	5,210	20,275	22,579	17,470	8,357	4,432	3,294	94,534
1981	3,080	2,364	2,164	4,069	9,053	15,111	21,240	26,248	17,937	12,428	10,316	5,464	129,474
1982	4,232	3,338	2,705	3,551	2,812	7,258	13,740	26,248	17,340	13,338	6,998	5,330	106,892
1983	4,178	3,242	3,991	2,696	3,910	6,299	9,107	21,722	18,118	13,499	11,223	5,437	103,422
1984	4,446	2,957	2,215	2,260	6,616	14,334	20,061	15,642	13,738	12,187	5,910	3,268	103,632
1985	2,547	1,928	1,995	2,366	3,910	11,094	16,124	18,668	22,395	9,187	10,679	5,839	106,734
1986	3,589	2,298	1,958	4,458	9,428	15,319	27,320	24,079	18,040	14,410	7,413	4,526	132,838
Ave(mil m3)	3,453	2,632	2,441	2,823	5,060	12,023	20,699	24,043	17,137	11,112	7,269	4,591	113,282

Monthly Discharge at Hoa Binh (A=51,800km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1957	1,053	728	868	1,306	964	7,880	12,749	7,500	4,329	4,446	1,799	1,200	44,821
1958	1,010	958	680	575	702	3,940	11,464	14,945	6,817	4,018	2,206	1,548	48,863
1959	1,205	806	1,221	1,213	2,678	7,854	9,133	15,213	7,724	5,437	2,825	1,845	57,156
1960	1,489	1,165	868	645	1,085	5,495	10,714	12,347	8,476	3,723	2,136	2,129	50,272
1961	1,412	1,205	1,061	1,120	1,221	6,687	7,633	17,463	7,957	5,866	3,603	2,569	57,797
1962	2,303	1,466	1,146	1,042	2,140	9,850	12,803	12,026	5,832	3,964	2,175	1,444	56,191
1963	1,104	810	865	671	873	2,955	8,785	10,231	5,702	4,553	5,106	2,239	43,896
1964	1,505	1,042	937	897	2,030	5,806	16,713	11,089	8,372	5,785	3,188	2,231	59,597
1965	1,519	1,055	892	995	1,219	6,636	10,821	9,053	4,614	5,866	5,495	2,786	50,949
1966	1,969	1,231	972	874	1,077	8,683	16,740	13,258	10,316	6,187	3,214	2,041	66,562
1967	1,503	1,040	854	941	1,253	3,084	8,223	13,499	6,661	4,071	3,136	2,092	46,359
1968	1,722	1,263	1,074	1,555	2,325	4,899	13,553	11,946	8,942	6,241	4,147	2,046	59,713
1969	1,409	943	790	723	1,508	4,277	9,133	20,275	5,625	3,134	2,281	1,320	51,419
1970	1,093	803	651	741	3,321	5,314	18,133	11,383	7,595	3,830	2,159	3,375	58,398
1971	1,599	1,243	1,010	1,265	2,319	7,413	12,669	22,579	9,668	4,419	2,722	1,690	68,597
1972	1,337	955	812	977	1,637	4,562	11,919	10,312	7,232	6,000	3,992	3,616	53,348
1973	1,738	1,306	1,446	1,586	3,509	7,569	11,490	13,071	9,279	4,419	3,447	1,931	60,793
1974	1,436	960	879	972	1,661	5,573	11,089	10,821	11,249	5,571	2,696	1,792	54,697
1975	1,543	936	766	1,239	2,443	7,750	8,571	7,419	7,724	4,312	3,110	1,958	47,772
1976	1,495	1,501	1,053	1,081	3,080	5,780	9,562	13,713	7,154	4,285	3,629	2,170	54,502
1977	1,570	1,110	956	1,203	1,446	3,344	13,553	10,767	5,132	4,580	2,877	1,867	48,405
1978	1,813	1,098	919	744	3,053	7,309	8,571	9,830	7,620	3,937	1,957	1,355	48,208
1979	1,101	878	729	666	983	3,577	7,339	11,597	12,079	4,232	1,910	1,382	46,473
1980	1,020	784	659	604	1,015	2,076	8,785	10,714	7,050	3,910	1,869	1,414	39,901
1981	1,181	839	790	925	3,455	6,998	10,794	13,312	9,020	5,544	5,288	2,670	60,818
1982	1,647	1,207	1,002	1,301	1,085	3,836	8,410	13,151	7,724	5,785	3,136	2,210	50,495
1983	1,666	1,176	1,374	892	1,178	2,618	4,553	11,919	10,290	5,651	5,314	2,598	49,229
1984	2,028	1,268	1,018	980	3,214	7,750	13,205	7,446	7,465	6,696	2,696	1,623	55,387
1985	1,213	922	820	1,001	1,773	5,962	9,214	10,151	10,135	3,910	4,614	2,303	52,017
1986	1,781	1,055	879	1,467	3,509	5,936	13,928	9,508	7,335	5,464	2,825	1,722	55,409
Ave(mil m3)	1,482	1,059	933	1,007	1,925	5,714	11,008	12,218	7,837	4,861	3,185	2,039	53,268

Table B.2 Generated Monthly Discharge Series Red River and Thai Binh River (2/2)

Monthly Discharge at Yen Bai (A=48,000km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1957	766	576	718	1,008	908	3,421	4,821	4,071	2,748	3,134	1,164	828	24,162
1958	675	823	520	446	458	1,680	3,857	5,276	3,862	2,298	1,138	779	21,811
1959	645	523	962	850	1,645	2,100	2,973	5,089	3,629	2,946	1,607	956	23,924
1960	860	679	546	435	726	1,776	4,125	5,384	3,499	2,341	1,229	1,178	22,778
1961	787	820	854	1,026	884	2,903	2,403	6,455	5,106	3,884	2,320	1,567	29,009
1962	1,355	888	688	780	1,125	3,473	3,830	4,044	2,722	2,309	1,260	790	23,265
1963	664	559	667	524	603	1,296	3,134	4,044	2,582	2,660	2,644	1,259	20,634
1964	841	639	600	710	1,125	2,403	3,777	3,964	3,370	3,696	1,794	1,275	24,193
1965	903	668	608	796	879	2,773	2,786	2,973	2,042	2,786	2,473	1,594	21,279
1966	1,039	629	496	555	916	3,240	4,821	5,571	5,521	4,339	1,897	1,141	30,165
1967	948	704	619	664	755	1,672	2,017	4,232	3,421	2,611	1,711	1,283	20,637
1968	1,034	854	771	1,143	1,074	1,905	3,884	6,616	5,780	3,937	2,338	1,205	30,542
1969	900	595	533	570	742	1,319	2,678	6,776	3,110	2,041	1,602	916	21,784
1970	779	668	530	715	1,856	2,903	6,107	5,357	4,018	2,389	1,680	2,595	29,597
1971	1,211	977	779	946	1,529	3,110	7,366	12,401	5,210	3,616	2,291	1,369	40,806
1972	1,074	787	651	1,006	868	1,846	3,080	4,285	3,525	2,670	2,193	1,875	23,859
1973	1,031	837	1,061	886	1,259	2,004	4,285	5,544	5,676	2,622	2,468	1,275	28,949
1974	865	578	538	591	876	2,929	2,973	3,964	3,551	2,486	1,467	962	21,780
1975	1,034	658	560	845	1,176	3,499	3,187	3,616	3,551	2,365	1,908	1,109	23,507
1976	822	900	664	861	1,760	1,962	2,574	4,553	2,851	1,966	1,825	1,055	21,793
1977	865	714	624	832	846	1,029	3,777	3,723	2,644	2,095	1,332	943	19,423
1978	945	602	541	500	1,637	3,551	3,910	5,759	5,728	3,750	1,467	970	29,360
1979	814	685	536	542	905	1,711	1,998	4,205	4,303	2,003	967	769	19,437
1980	568	474	378	399	763	1,047	3,509	3,830	4,303	2,403	1,128	865	19,665
1981	742	525	442	560	1,444	2,022	2,333	3,161	2,227	1,856	1,786	1,307	18,403
1982	731	588	455	643	533	1,312	2,322	5,009	3,862	2,866	1,586	1,104	21,010
1983	1,010	791	1,173	604	729	1,135	1,497	3,696	3,421	3,830	3,344	1,489	22,720
1984	1,120	672	554	638	1,733	3,655	3,964	3,214	2,903	2,732	1,159	790	23,133
1985	632	527	536	648	927	2,696	2,625	3,535	4,743	2,411	2,592	1,296	23,168
1986	841	583	530	1,021	1,655	2,333	4,393	4,500	4,588	4,955	1,864	1,165	28,428
Ave(mil m3)	883	684	638	725	1,078	2,290	3,500	4,828	3,817	2,867	1,808	1,190	24,307

Monthly Discharge at Vu Quang (A=29,600km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1957	675	532	573	982	1,446	4,873	7,473	3,455	2,618	1,671	1,166	846	26,312
1958	654	750	536	495	937	2,491	5,276	7,017	4,925	2,314	1,231	822	27,449
1959	691	561	956	1,156	2,786	4,458	6,107	6,776	4,380	2,167	1,345	1,004	32,388
1960	887	739	779	485	1,079	2,447	6,321	5,919	5,184	2,461	1,457	1,283	29,041
1961	860	723	1,224	1,446	1,420	4,562	3,375	8,089	4,147	3,375	2,825	1,661	33,706
1962	1,505	854	726	874	1,334	4,484	5,973	5,651	2,722	1,902	1,122	817	27,963
1963	648	617	702	648	822	1,672	4,339	4,821	2,320	2,282	3,732	1,540	24,143
1964	862	694	704	933	1,596	5,262	6,134	6,107	3,421	4,259	2,037	1,358	33,368
1965	945	641	667	1,374	1,760	3,966	5,464	3,482	1,941	2,786	3,110	1,283	27,419
1966	1,004	728	568	765	911	4,795	9,937	4,768	3,888	2,346	1,700	1,098	32,508
1967	769	614	570	695	1,730	2,312	3,134	5,250	3,603	2,443	1,322	1,074	23,516
1968	870	767	830	1,283	1,870	4,458	8,357	7,419	5,262	3,134	2,478	1,331	38,059
1969	916	612	587	710	1,270	2,696	4,473	10,606	4,121	2,370	2,141	1,192	31,694
1970	879	781	645	918	2,255	3,525	8,491	6,455	5,028	2,266	1,257	1,275	33,775
1971	846	706	595	907	2,033	4,795	7,794	14,570	7,128	3,509	1,778	1,409	46,071
1972	892	749	640	687	1,888	2,538	3,937	4,821	4,484	3,161	1,446	1,082	26,325
1973	1,039	1,016	1,642	1,226	3,214	5,054	6,589	7,258	6,636	3,616	1,757	1,409	40,457
1974	1,347	1,164	844	778	1,821	3,396	5,973	3,803	4,847	3,589	1,470	1,184	30,215
1975	996	692	828	1,348	3,777	7,569	5,518	3,991	3,681	2,384	1,591	1,133	33,506
1976	903	1,017	887	874	3,080	3,214	3,964	5,464	3,473	2,095	1,952	919	27,840
1977	937	885	745	863	1,709	889	5,812	4,928	2,317	2,582	1,231	691	23,590
1978	737	464	680	687	3,134	6,506	5,571	5,276	5,910	4,446	2,532	1,567	37,511
1979	1,513	1,340	1,144	1,115	2,044	6,299	6,991	7,500	7,076	2,579	1,752	1,074	40,426
1980	1,465	1,273	758	692	1,607	2,193	6,241	7,500	4,743	1,955	1,190	967	30,583
1981	1,195	1,110	1,398	2,366	4,018	4,069	5,410	6,669	5,106	4,044	2,773	1,711	39,872
1982	1,524	1,304	1,211	1,363	1,173	3,214	4,500	7,741	5,262	3,964	2,773	1,982	36,011
1983	1,497	1,323	1,454	1,078	1,942	2,773	3,000	7,982	5,936	3,643	3,266	1,827	35,721
1984	1,444	1,123	817	982	2,124	5,651	7,098	6,241	4,795	4,232	2,317	1,377	38,199
1985	1,350	1,159	1,476	1,405	1,553	2,877	4,259	5,330	7,387	2,370	2,722	1,628	33,516
1986	1,063	919	750	1,747	3,402	5,936	9,026	7,794	5,288	3,428	2,045	1,553	42,952
Ave(mil m3)	1,030	862	864	1,029	1,991	3,966	5,884	6,423	4,588	2,912	1,984	1,270	32,805

Table B.3 Generated Monthly Discharge Series Ma River

Ma River at confluence of Buoi River (A=19,820km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1981	419	300	310	381	649	1,261	1,731	2,330	1,876	1,790	844	578	12,469
1982	485	362	344	394	399	829	1,437	4,156	2,910	1,811	882	628	14,638
1983	542	406	426	349	456	436	785	1,578	1,869	2,101	824	565	10,337
1984	485	359	307	300	592	1,216	1,961	1,791	1,142	1,350	995	539	11,038
1985	482	379	339	470	542	912	1,074	2,135	3,201	1,436	904	608	12,482
1986	462	328	318	352	962	1,357	1,736	1,587	1,485	972	610	490	10,659
1987	405	330	319	297	350	399	771	1,976	1,736	935	573	441	8,534
1988	395	301	291	291	467	338	790	1,516	1,091	2,111	650	429	8,670
1989	229	176	202	184	350	800	722	803	800	1,442	499	323	6,531
1990	269	228	301	228	436	1,057	1,533	1,113	1,031	1,057	531	336	8,121
1991	284	214	216	221	258	889	1,136	1,250	639	428	319	293	6,149
1992	264	208	184	155	224	423	932	620	872	462	294	260	4,898
1993	217	167	177	182	344	280	535	886	1,047	490	307	259	4,891
1994	201	159	196	228	412	751	2,038	1,864	1,692	967	507	420	9,436
1995	403	288	268	224	298	1,319	2,101	3,817	2,746	960	602	424	13,452
1996	388	299	343	285	548	769	2,617	5,035	3,625	1,642	1,537	703	17,791
1997	531	390	457	562	449	671	2,764	3,297	3,458	1,638	746	558	15,522
1998	424	330	305	340	441	803	1,308	947	1,340	614	379	310	7,541
1999	262	185	182	229	462	1,656	1,337	2,251	2,199	934	686	515	10,899
2000	396	345	349	306	712	1,149	2,277	2,061	2,822	1,292	647	501	12,854
Ave(mil m3)	377	288	292	299	468	866	1,479	2,051	1,879	1,222	667	459	10,346

Chu River at Bai Thuong (A=7,460km2) including Am River

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1981	189	141	146	183	210	388	736	604	602	1,190	453	263	5,105
1982	176	123	110	125	140	392	406	715	1,398	1,194	467	285	5,531
1983	240	161	155	111	140	148	204	374	441	983	312	183	3,452
1984	144	115	100	102	116	349	455	512	479	827	529	234	3,963
1985	188	141	133	141	231	520	336	640	1,289	926	474	304	5,322
1986	202	142	121	147	476	436	470	501	673	587	313	207	4,275
1987	180	135	123	126	171	226	325	1,070	598	473	289	195	3,910
1988	135	103	84	73	214	175	226	457	262	2,107	384	211	4,431
1989	160	117	129	99	303	692	720	604	729	1,888	505	288	6,234
1990	230	186	269	174	319	547	794	824	1,089	1,284	547	286	6,548
1991	231	164	158	157	167	438	564	1,049	520	311	214	186	4,158
1992	173	123	102	84	126	315	415	383	845	339	181	151	3,236
1993	116	84	81	100	306	180	333	636	867	334	177	141	3,356
1994	106	84	114	159	391	414	882	1,525	1,726	769	359	281	6,809
1995	198	143	137	110	239	436	575	1,108	1,619	454	268	203	5,491
1996	169	134	154	124	241	440	737	1,405	1,791	741	1,022	370	7,327
1997	264	189	189	291	212	328	852	933	1,157	918	374	267	5,975
1998	198	140	122	134	191	265	256	305	600	264	150	132	2,758
1999	91	66	61	92	353	668	318	603	672	560	464	277	4,227
2000	186	141	140	150	432	516	540	579	1,176	561	301	218	4,939
Ave(mil m3)	179	132	131	134	249	394	507	741	927	835	389	234	4,852

Ma River Basin (A=31,060km2)

(million m3)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1981	608	441	456	572	859	1,649	2,466	3,090	2,612	4,876	1,297	841	19,768
1982	662	485	454	519	604	2,051	1,843	4,871	7,118	4,998	1,722	913	26,240
1983	782	617	581	460	597	584	988	2,218	2,513	5,228	1,136	749	16,454
1984	628	475	407	402	708	2,173	2,482	2,355	2,787	2,747	1,577	773	17,514
1985	670	520	472	611	772	1,545	1,663	3,296	6,347	2,572	1,614	911	20,994
1986	664	470	438	499	1,438	1,913	2,354	2,648	3,236	2,123	965	697	17,445
1987	585	464	442	423	529	625	1,097	3,910	2,983	1,563	862	637	14,120
1988	530	404	375	364	681	514	1,016	1,973	1,818	5,191	1,034	640	14,539
1989	389	294	331	283	801	2,884	2,285	1,736	1,759	4,531	1,003	611	16,907
1990	499	414	570	402	755	1,604	2,327	2,496	3,197	4,175	1,726	622	18,788
1991	515	378	374	379	426	1,327	1,700	2,717	1,159	739	533	479	10,725
1992	437	331	286	239	350	737	2,572	1,087	3,412	801	475	411	11,138
1993	334	251	258	282	676	461	868	1,651	2,747	825	484	400	9,235
1994	307	244	311	387	1,408	1,964	4,443	4,458	6,130	2,496	865	700	23,713
1995	601	431	405	334	537	1,991	2,808	5,919	4,795	1,414	870	627	20,734
1996	558	433	497	409	788	1,208	3,882	7,683	7,045	2,551	3,825	1,073	29,952
1997	796	579	646	1,162	661	1,271	3,979	5,428	4,911	3,209	1,120	825	24,589
1998	622	470	427	474	785	1,132	1,563	1,415	2,313	877	530	442	11,051
1999	353	251	243	386	1,177	2,324	1,655	3,073	3,016	3,815	1,524	793	18,612
2000	582	486	488	456	1,144	1,665	2,817	2,932	5,405	1,975	948	719	19,617
Ave	556	422	423	452	785	1,481	2,240	3,248	3,765	2,835	1,206	693	18,107

Table B.4 Generated Monthly Discharge Series Ca River Basin (1/2)

Ca River at Do Luong (A=21,130km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	438	369	303	307	497	682	828	1,756	958	907	1,131	469	8,644
1977	390	277	252	337	417	281	769	1,086	1,811	662	437	345	7,065
1978	292	216	211	308	405	930	1,087	2,890	6,314	4,703	1,445	806	19,608
1979	591	418	360	356	558	1,432	911	1,790	1,832	859	473	350	9,933
1980	286	242	202	223	443	776	1,495	1,522	6,316	2,813	790	551	15,659
1981	431	286	275	417	503	1,207	2,114	1,851	1,697	3,324	1,261	686	14,051
1982	543	406	337	433	478	1,400	1,211	2,384	4,760	4,118	1,538	929	18,535
1983	756	532	580	395	513	492	782	1,403	1,604	3,233	1,218	624	12,132
1984	462	360	304	291	682	831	1,115	1,870	1,195	2,868	1,493	673	12,143
1985	525	400	357	334	396	1,056	1,015	1,771	3,132	1,951	1,121	722	12,780
1986	478	352	322	338	1,587	1,325	1,292	1,408	1,918	1,909	901	556	12,388
1987	393	297	288	289	385	693	800	2,803	2,054	1,375	792	492	10,662
1988	361	293	278	236	457	382	442	1,053	815	5,573	1,154	714	11,758
1989	428	313	309	267	1,037	2,240	2,043	2,585	2,747	4,909	1,507	758	19,144
1990	558	423	604	349	539	1,376	2,503	2,250	2,762	3,912	1,676	824	17,775
1991	572	425	396	383	400	930	1,304	3,642	1,708	1,617	760	585	12,719
1992	570	394	319	208	329	764	1,386	1,230	1,628	1,277	482	370	8,956
1993	263	183	173	215	647	519	1,498	1,234	2,049	860	430	313	8,385
1994	250	230	247	270	635	972	2,075	4,410	4,201	1,987	975	754	17,006
1995	541	395	375	323	575	990	1,325	2,789	4,517	1,590	828	586	14,833
1996	421	345	355	334	520	648	1,075	3,276	5,825	2,475	2,745	1,041	19,061
1997	716	531	492	682	615	813	2,201	2,785	3,056	2,131	927	635	15,585
1998	460	368	349	366	411	535	843	755	993	528	334	308	6,250
1999	259	205	204	308	874	1,317	857	1,519	1,712	1,610	1,173	571	10,610
2000	385	302	311	289	1,002	1,597	1,615	1,448	2,815	1,283	695	474	12,217
Ave(mil m3)	455	342	328	330	596	967	1,303	2,060	2,737	2,339	1,051	605	13,116

At the confluence of Ngan Sau River and Ngan Pho River (A=3,210km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	210	194	199	152	261	196	139	165	186	739	1,692	304	4,437
1977	285	201	175	229	197	85	67	169	448	535	572	265	3,229
1978	245	186	270	221	381	204	230	829	4,056	1,489	553	409	9,072
1979	314	213	176	199	365	368	185	1,077	2,234	502	245	185	6,063
1980	166	143	131	155	213	287	171	176	1,884	1,863	553	383	6,126
1981	276	182	162	130	474	259	351	194	1,476	1,363	1,038	332	6,238
1982	241	207	216	222	233	340	322	466	750	677	357	288	4,318
1983	267	223	245	217	237	229	270	346	365	569	318	251	3,536
1984	231	207	212	204	258	270	311	403	315	525	351	257	3,543
1985	239	206	218	210	223	298	298	391	551	413	306	263	3,615
1986	233	201	214	210	368	331	332	346	403	408	279	242	3,567
1987	222	194	210	204	222	253	272	517	420	342	266	235	3,356
1988	219	199	208	198	230	216	228	303	268	855	310	262	3,496
1989	227	196	212	201	301	442	424	490	504	774	353	267	4,392
1990	243	209	248	211	240	337	480	449	506	652	373	275	4,225
1991	244	209	223	216	223	282	334	619	377	372	262	246	3,607
1992	244	211	213	194	215	262	344	325	368	330	228	220	3,153
1993	207	180	196	195	253	232	357	325	419	279	221	213	3,078
1994	205	186	205	202	252	287	428	713	682	417	288	266	4,131
1995	241	206	220	208	245	290	336	515	721	369	270	246	3,866
1996	226	205	218	210	238	248	306	574	880	477	504	302	4,388
1997	310	249	207	256	193	115	136	250	618	1,020	261	170	3,786
1998	126	121	108	94	108	84	80	96	661	349	244	253	2,324
1999	176	118	119	191	425	169	96	92	110	1,054	830	243	3,623
2000	185	156	200	180	369	508	286	704	1,040	1,103	540	451	5,721
Ave(mil m3)	231	192	200	196	269	264	271	421	810	699	449	273	4,276

Table B.4 Generated Monthly Discharge Series Ca River Basin (2/2)

Giang River (A=1,090km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	29	25	22	21	34	39	43	86	51	74	126	35	586
1977	30	21	19	25	28	16	37	56	101	54	45	27	461
1978	24	18	22	24	35	51	59	167	464	277	90	54	1,284
1979	41	28	24	25	41	81	49	128	182	61	32	24	716
1980	20	17	15	17	29	48	75	76	367	209	60	42	976
1981	32	21	20	24	44	66	110	92	142	210	103	46	909
1982	35	27	25	29	32	78	69	128	247	215	85	54	1,023
1983	46	34	37	27	34	32	47	78	88	170	69	39	702
1984	31	25	23	22	42	49	64	102	68	152	83	42	702
1985	34	27	26	24	28	61	59	97	165	106	64	44	734
1986	32	25	24	25	88	74	73	79	104	104	53	36	714
1987	28	22	22	22	27	42	48	149	111	77	47	33	628
1988	26	22	22	19	31	27	30	61	49	288	66	44	683
1989	29	23	23	21	60	120	110	138	146	254	83	46	1,054
1990	36	28	38	25	35	77	134	121	146	204	92	49	985
1991	37	28	28	27	28	54	73	191	93	89	46	37	731
1992	36	27	24	18	24	46	77	70	89	72	32	26	542
1993	21	16	17	18	40	34	83	70	111	51	29	24	513
1994	20	19	20	21	40	56	112	229	219	108	57	46	947
1995	35	27	27	24	37	57	74	148	235	88	49	37	837
1996	29	25	26	24	34	40	62	172	300	132	145	60	1,050
1997	46	35	31	42	36	42	105	136	165	141	53	36	867
1998	26	22	21	21	23	28	41	38	74	39	26	25	384
1999	19	14	14	22	58	67	43	72	82	119	90	36	637
2000	26	20	23	21	61	94	85	96	173	107	55	41	803
Ave(mil m3)	31	24	24	24	39	55	71	111	159	136	67	39	779

Ca River Basin (A=29,850km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	678	632	524	479	792	917	1,011	2,007	1,195	2,527	4,725	807	16,294
1977	706	500	446	592	642	382	874	1,554	2,851	1,936	1,392	715	12,589
1978	606	500	503	553	821	1,185	1,473	4,478	17,170	7,650	2,344	1,270	38,551
1979	946	659	560	580	984	2,177	1,145	4,085	5,504	1,422	750	559	19,372
1980	472	402	348	395	685	1,110	1,741	2,367	9,822	5,597	1,496	976	25,413
1981	739	489	456	571	1,195	1,531	3,167	2,136	6,052	7,575	2,732	1,064	27,708
1982	818	739	734	684	743	1,818	1,602	2,977	6,788	8,345	4,852	1,271	31,370
1983	1,069	824	862	640	784	754	1,099	1,827	2,173	9,855	1,604	913	22,403
1984	724	592	539	517	1,028	1,151	1,489	2,374	3,242	6,384	2,922	971	21,932
1985	798	670	601	568	646	2,320	1,373	2,259	7,015	3,714	3,596	1,029	24,589
1986	743	578	560	573	2,593	1,730	1,697	1,943	2,695	5,498	1,444	1,054	21,107
1987	643	513	520	515	634	989	1,120	4,408	3,728	2,404	1,384	759	17,618
1988	606	513	509	453	718	625	700	1,416	2,233	9,710	1,529	1,019	20,031
1989	684	532	545	489	1,653	2,802	2,819	4,740	3,669	12,584	2,953	1,221	34,690
1990	864	744	890	586	814	1,789	3,920	3,744	4,650	8,526	2,588	1,148	30,264
1991	853	662	646	625	651	1,266	1,711	4,725	3,137	7,235	1,273	1,724	24,508
1992	876	652	556	420	568	1,184	1,807	1,625	3,124	4,907	741	616	17,075
1993	491	380	385	428	941	785	1,939	2,185	4,336	1,505	681	550	14,604
1994	476	435	472	493	1,056	1,490	2,736	5,715	6,721	2,749	2,118	1,705	26,165
1995	927	628	622	555	856	1,337	1,736	3,913	7,441	2,868	1,487	869	23,238
1996	676	633	599	568	792	937	1,443	4,022	9,971	4,447	5,149	1,402	30,639
1997	1,299	888	847	1,285	845	970	2,442	3,195	4,173	4,351	1,242	840	22,376
1998	612	511	478	480	542	647	965	889	3,431	1,659	967	614	11,796
1999	519	337	337	521	1,980	1,553	995	1,683	1,904	6,370	2,418	851	19,469
2000	596	478	534	490	1,432	2,199	1,986	2,248	5,277	2,989	1,507	967	20,703
Ave(mil m3)	737	580	563	562	976	1,346	1,720	2,901	5,132	5,312	2,156	997	22,980

Table B.5 Generated Monthly Discharge Series Thach Han River Basin

Quang Tri River (A = 1,390km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	273	154	107	69	49	29	24	38	107	324	407	180	1,760
1978	118	62	50	33	83	62	77	226	466	363	362	293	2,195
1979	137	76	52	32	29	101	97	208	294	287	240	162	1,716
1980	89	51	34	22	68	117	119	62	444	875	656	316	2,853
1981	213	109	75	56	99	170	129	74	120	487	843	389	2,763
1982	182	102	70	43	35	23	47	23	213	216	252	161	1,365
1983	85	48	33	21	16	41	69	37	32	319	670	214	1,583
1984	128	74	49	32	41	106	76	271	142	438	468	266	2,092
1985	127	73	51	32	27	91	67	47	131	554	550	369	2,119
1986	163	90	62	38	65	40	25	59	59	365	320	290	1,576
1987	144	82	55	41	42	28	25	107	271	171	268	179	1,414
1988	92	53	35	21	25	13	9	29	95	477	297	255	1,400
1989	163	78	59	39	140	187	155	182	118	235	189	182	1,728
1990	85	51	41	25	42	80	52	87	435	1,279	834	325	3,336
1991	177	100	73	44	32	23	16	66	74	408	274	334	1,620
1992	146	83	56	33	26	28	76	185	168	577	589	280	2,248
1993	164	87	63	39	34	26	16	14	75	378	363	864	2,122
1994	259	143	101	67	44	54	43	35	202	186	242	330	1,707
1995	161	90	61	38	32	22	20	46	281	1,077	852	389	3,069
1996	200	118	76	54	49	69	71	59	471	839	1,156	555	3,718
1997	223	123	86	114	69	42	28	84	208	368	261	234	1,840
1998	104	59	41	26	26	19	18	41	214	407	740	505	2,199
1999	274	150	99	77	154	98	63	93	76	341	1,422	543	3,390
2000	212	125	83	66	84	57	64	47	186	443	471	323	2,160
Ave(mil m3)	163	91	63	44	54	64	58	88	203	476	530	331	2,165

Cam Lo + Others (A = 790km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	156	88	61	39	28	16	13	22	61	185	232	103	1,003
1978	67	36	28	19	47	35	44	129	265	207	206	167	1,251
1979	78	43	30	18	16	57	55	119	168	164	137	92	978
1980	51	29	19	12	39	67	68	35	253	499	374	180	1,626
1981	121	62	43	32	56	97	73	42	68	278	480	222	1,575
1982	104	58	40	24	20	13	27	13	121	123	143	92	778
1983	49	27	19	12	9	23	40	21	18	182	382	122	902
1984	73	42	28	18	23	61	43	154	81	250	267	152	1,192
1985	72	42	29	18	15	52	38	27	74	316	314	210	1,208
1986	93	52	35	22	37	23	14	34	34	208	182	165	898
1987	82	47	32	23	24	16	14	61	154	98	153	102	806
1988	52	30	20	12	14	8	5	17	54	272	169	145	798
1989	93	45	34	22	80	107	88	104	67	134	108	104	985
1990	48	29	23	14	24	46	29	49	248	729	475	185	1,902
1991	101	57	42	25	18	13	9	37	42	233	156	190	923
1992	83	47	32	19	15	16	43	106	96	329	336	160	1,281
1993	94	50	36	22	20	15	9	8	43	215	207	492	1,210
1994	148	81	58	38	25	31	25	20	115	106	138	188	973
1995	92	52	35	22	18	12	11	26	160	614	486	222	1,749
1996	114	68	43	31	28	39	41	34	268	478	659	317	2,119
1997	127	70	49	65	39	24	16	48	119	210	149	133	1,049
1998	59	33	23	15	15	11	10	24	122	232	422	288	1,254
1999	156	85	56	44	88	56	36	53	43	195	811	310	1,932
2000	121	71	47	38	48	32	37	27	106	252	268	184	1,231
Ave(mil m3)	93	52	36	25	31	36	33	50	116	271	302	188	1,234

Thach Han River Basin (A=2,550km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	429	242	167	108	76	45	37	60	197	730	738	287	3,117
1978	186	98	78	52	130	97	121	411	962	796	620	503	4,054
1979	215	120	82	50	45	176	153	374	688	451	459	257	3,072
1980	140	80	53	34	133	196	188	97	1,175	1,581	1,108	599	5,382
1981	334	171	118	88	155	267	202	116	292	1,069	1,626	634	5,073
1982	286	161	110	67	54	36	73	35	402	459	798	252	2,734
1983	134	75	52	33	24	64	109	57	52	927	1,120	339	2,987
1984	201	116	76	50	64	167	138	432	254	839	918	437	3,692
1985	200	114	81	50	43	142	106	74	276	1,213	1,024	616	3,937
1986	256	142	97	60	101	62	39	93	93	812	603	534	2,892
1987	247	129	87	64	67	44	39	247	505	356	563	281	2,629
1988	144	83	55	32	39	21	15	46	222	861	483	467	2,468
1989	256	123	93	61	263	294	243	308	209	476	363	308	2,997
1990	134	83	64	40	66	126	81	203	809	2,401	1,398	521	5,927
1991	277	157	115	69	50	36	25	107	120	950	468	528	2,902
1992	229	130	87	52	41	45	119	309	338	1,403	949	513	4,215
1993	258	137	98	61	54	41	25	36	125	816	609	1,459	3,719
1994	407	224	159	105	68	85	68	55	504	377	482	594	3,128
1995	253	142	96	60	50	34	31	73	567	1,993	1,485	648	5,432
1996	315	186	119	85	108	108	112	93	830	1,545	1,992	964	6,456
1997	349	194	135	179	108	66	44	132	417	654	416	499	3,194
1998	163	92	64	40	44	30	28	65	540	720	1,470	852	4,108
1999	442	235	155	121	265	153	98	147	120	755	2,582	920	5,993
2000	336	196	130	104	132	89	101	74	353	824	840	538	3,717
Ave(mil m3)	258	143	99	69	91	101	91	152	419	959	963	565	3,909

Table B.6 Generated Monthly Discharge Series Huong River Basin

Huong River at Tuan (Huu Trach + Ta Trach A=1,460km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	32	41	51	21	12	6	6	27	157	419	510	198	1,479
1978	191	68	41	27	85	54	40	20	13	141	393	393	1,464
1979	141	80	41	29	80	322	214	192	209	355	580	252	2,494
1980	115	57	39	34	25	46	40	33	589	942	1,280	531	3,730
1981	281	122	79	82	170	107	84	49	92	1,049	1,251	687	4,053
1982	288	130	84	73	49	57	45	44	301	162	315	241	1,789
1983	168	68	42	27	19	174	154	103	78	958	1,133	416	3,338
1984	213	128	72	50	93	153	110	155	131	720	936	481	3,241
1985	229	122	86	70	68	119	69	42	179	576	946	748	3,254
1986	301	144	138	59	139	74	55	83	60	1,029	537	510	3,128
1987	178	88	63	39	31	38	25	141	296	197	632	408	2,137
1988	151	92	52	32	37	26	18	28	101	1,007	698	467	2,709
1989	260	117	79	57	310	204	148	121	93	196	201	174	1,961
1990	112	53	37	25	80	37	28	67	328	1,242	1,305	526	3,840
1991	251	151	106	174	107	65	47	64	66	587	369	328	2,314
1992	210	82	49	31	39	109	86	100	129	1,220	699	374	3,127
1993	185	85	60	40	41	30	29	25	47	783	612	800	2,736
1994	294	130	91	54	67	65	38	25	234	325	380	643	2,347
1995	218	152	73	41	37	30	32	31	172	1,429	1,157	704	4,075
1996	286	203	102	81	149	102	76	41	474	1,255	1,457	984	5,210
1997	421	200	119	126	95	68	53	49	311	490	461	503	2,897
1998	165	88	54	41	72	66	65	37	326	451	1,323	985	3,673
1999	557	236	172	163	205	127	72	51	93	516	1,934	1,376	5,500
2000	513	280	157	146	113	125	93	270	245	1,237	1,073	794	5,046
Ave(mil m3)	240	121	79	63	88	92	68	75	197	720	841	563	3,148

Bo River at Co Bi (A=720km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	6	5	5	11	22	10	7	14	64	224	322	118	808
1978	76	28	29	20	32	27	30	24	254	196	240	259	1,214
1979	90	41	26	19	43	116	54	57	107	175	229	135	1,093
1980	59	27	19	16	48	89	48	35	232	530	579	277	1,959
1981	167	69	44	63	54	45	34	19	41	451	613	348	1,948
1982	143	63	41	42	35	23	17	14	147	128	214	90	955
1983	50	22	15	12	10	37	43	28	28	376	429	167	1,215
1984	74	37	30	34	53	84	74	136	73	274	432	210	1,512
1985	85	43	38	32	48	70	43	22	67	277	480	326	1,531
1986	130	56	38	43	68	32	20	28	25	366	241	239	1,286
1987	106	53	51	31	40	24	13	44	172	116	298	148	1,094
1988	74	39	23	14	31	17	17	13	45	339	249	202	1,063
1989	116	43	35	22	114	94	95	61	61	115	174	126	1,055
1990	51	30	19	18	30	17	34	56	159	814	624	284	2,136
1991	123	79	63	82	66	37	25	24	20	263	194	269	1,246
1992	109	45	28	18	26	36	42	39	79	538	379	236	1,573
1993	100	47	32	21	45	28	23	19	54	254	210	382	1,214
1994	121	58	36	54	54	51	30	21	175	153	204	394	1,350
1995	137	82	40	36	32	34	24	34	121	761	541	341	2,184
1996	139	120	54	44	70	111	62	39	245	678	760	552	2,874
1997	218	101	69	104	59	38	29	21	134	293	211	214	1,492
1998	67	35	26	33	42	24	21	49	167	232	784	472	1,951
1999	256	143	95	102	122	71	42	42	40	311	1,252	599	3,073
2000	225	126	70	100	102	87	72	80	75	441	451	344	2,172
Ave(mil m3)	113	58	39	40	52	50	37	38	108	346	421	281	1,583

Huong River Basin (A=3,300km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	37	69	140	32	34	16	13	41	378	1,335	1,020	481	3,597
1978	406	95	70	47	117	81	69	44	1,343	954	1,187	942	5,357
1979	247	121	67	49	123	810	268	249	836	661	1,232	445	5,107
1980	174	85	57	50	73	135	88	68	1,996	2,437	2,560	963	8,686
1981	520	191	123	146	225	151	118	68	296	3,047	2,592	1,407	8,882
1982	463	193	126	114	84	80	62	57	640	433	1,226	417	3,895
1983	273	90	58	38	29	422	197	131	106	2,880	2,160	620	7,002
1984	287	178	102	84	146	237	420	292	295	1,607	2,305	955	6,909
1985	329	164	124	102	115	189	111	65	367	1,835	2,330	1,543	7,275
1986	451	223	176	103	207	106	75	110	413	2,199	1,152	1,119	6,335
1987	284	141	114	70	71	62	39	184	640	406	1,614	636	4,260
1988	225	131	76	46	68	43	35	42	290	1,961	1,292	824	5,032
1989	522	159	115	79	558	298	243	181	154	544	624	329	3,807
1990	176	83	55	43	111	54	62	184	771	3,122	2,502	855	8,016
1991	396	288	169	302	173	103	73	88	86	1,586	635	798	4,696
1992	401	126	77	48	65	195	128	139	312	3,024	1,314	824	6,653
1993	284	132	91	62	86	59	52	44	101	1,846	1,293	1,551	5,600
1994	441	188	127	108	121	116	68	47	589	779	965	1,596	5,145
1995	354	234	113	77	69	64	56	65	576	3,209	2,470	1,341	8,627
1996	425	357	156	125	219	213	137	80	1,496	2,676	3,057	1,875	10,815
1997	745	315	189	231	154	106	81	70	882	1,490	910	1,182	6,355
1998	245	123	80	74	192	91	86	86	1,144	897	3,433	1,913	8,363
1999	1,057	437	424	274	327	198	114	93	147	1,129	4,176	2,792	11,166
2000	1,032	406	226	246	215	212	165	532	501	2,647	2,053	1,730	9,967
Ave(mil m3)	407	189	127	106	149	168	115	123	598	1,779	1,838	1,131	6,731

Table B.7 Generated Monthly Discharge Series Vu Gia - Thu Bon River Basin

Thu Bon River at Ai Nghia (A=3,590km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1984	555	356	211	177	298	384	181	126	160	1,555	2,581	1,858	8,439
1985	664	332	217	194	345	229	139	138	313	1,122	3,497	2,473	9,663
1986	782	382	273	171	440	237	139	177	132	2,467	1,475	3,351	10,026
1987	764	426	453	233	185	282	146	167	697	261	2,331	850	6,796
1988	592	358	279	197	313	284	262	145	349	2,814	1,819	1,160	8,571
1989	1,161	443	351	196	596	399	331	368	483	595	1,239	847	7,009
1990	436	300	257	182	299	229	200	231	328	3,845	3,498	1,096	10,900
1991	545	420	435	505	418	221	222	243	305	1,957	1,419	1,880	8,570
1992	741	338	215	145	165	210	136	325	412	3,388	2,391	1,362	9,829
1993	605	289	235	188	203	192	187	104	192	1,880	1,719	3,337	9,131
1994	654	296	289	183	210	194	123	135	779	1,269	1,373	1,541	7,045
1995	555	360	225	127	124	158	203	277	497	3,443	3,784	2,349	12,103
1996	779	579	315	234	594	428	272	167	510	4,207	6,529	3,313	17,930
1997	748	352	234	229	339	271	274	144	1,571	943	2,117	876	8,097
1998	331	190	126	85	126	81	106	96	486	1,157	6,053	2,992	11,830
1999	1,476	735	565	536	767	599	322	246	284	1,668	5,501	4,784	17,482
2000	1,043	708	366	445	623	485	392	685	362	3,036	4,525	2,697	15,367
Ave(mil m3)	731	404	297	237	356	287	214	222	462	2,095	3,050	2,163	10,517

Vu Gia River at Ai Nghia (A=5,420km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1984	617	437	311	295	339	494	256	310	348	2,020	2,726	1,534	9,687
1985	740	408	300	293	395	655	331	259	626	1,292	2,264	2,061	9,622
1986	803	407	314	238	448	281	254	304	220	2,261	1,452	2,451	9,434
1987	799	470	386	257	230	267	187	391	774	390	1,773	915	6,839
1988	637	428	346	252	353	348	408	263	411	3,301	2,074	1,390	10,210
1989	1,119	466	385	248	692	454	452	412	491	598	898	731	6,946
1990	375	265	243	185	432	269	237	340	640	5,223	4,166	1,489	13,866
1991	668	431	393	376	378	319	328	392	395	1,777	1,153	1,567	8,176
1992	701	368	284	201	279	328	254	670	605	3,651	2,649	1,310	11,300
1993	719	390	321	254	285	244	274	216	375	1,305	1,409	3,232	9,026
1994	830	400	358	321	334	284	329	345	1,099	1,074	1,578	1,560	8,514
1995	645	444	303	204	237	194	268	318	611	3,687	3,980	2,272	13,163
1996	976	666	398	334	593	610	447	382	1,045	4,582	6,533	4,342	20,908
1997	1,302	667	497	475	530	310	307	283	1,683	1,084	1,639	784	9,561
1998	404	266	209	172	218	152	164	212	546	1,239	6,298	2,972	12,851
1999	1,611	853	727	618	1,032	1,052	642	592	476	2,065	5,678	4,192	19,537
2000	1,277	919	488	656	887	740	791	1,299	810	3,281	4,792	3,246	19,185
Ave(mil m3)	837	487	368	316	451	412	349	411	656	2,284	3,004	2,121	11,696

Monthly Runoff Thach Vu Gia -Thu Bon River Basin 10,380km2

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1984	1,172	793	522	472	636	878	437	435	560	4,509	6,024	3,550	19,989
1985	1,403	740	516	488	740	992	470	397	971	3,057	6,400	4,845	21,021
1986	1,585	789	587	409	995	519	393	558	352	5,902	3,075	6,338	21,501
1987	1,562	897	840	490	415	550	332	616	1,671	810	4,965	1,768	14,917
1988	1,228	786	625	449	666	632	669	408	986	7,117	3,998	2,725	20,289
1989	2,289	909	736	445	1,689	854	783	817	974	1,438	2,292	1,726	14,951
1990	811	565	500	366	732	497	444	597	1,223	9,763	8,217	2,585	26,302
1991	1,213	851	827	1,111	796	540	550	754	761	4,603	2,667	3,513	18,186
1992	1,453	706	500	346	444	589	390	994	1,067	8,748	5,215	2,738	23,189
1993	1,323	679	556	442	489	437	461	320	604	4,295	3,284	6,853	19,743
1994	1,485	696	647	504	545	484	452	480	2,407	2,965	3,211	3,434	17,307
1995	1,201	804	528	331	360	352	471	595	1,671	8,433	8,814	4,657	28,217
1996	1,756	1,245	713	568	1,187	1,038	720	550	2,067	9,623	14,013	7,771	41,251
1997	2,058	1,019	731	704	870	581	581	427	3,903	2,674	4,163	1,807	19,517
1998	779	455	335	257	344	233	270	308	1,639	2,794	13,080	6,162	26,656
1999	3,301	1,599	1,292	1,154	1,798	1,651	963	838	793	4,618	12,921	10,127	41,053
2000	2,517	1,627	854	1,102	1,509	1,225	1,182	2,203	1,207	7,379	9,762	6,489	37,056
Ave(mil m3)	1,596	892	665	567	836	709	563	665	1,344	5,219	6,594	4,535	24,185

Table B.8 Generated Monthly Discharge Series Tra Khuc River Basin (1/2)

TraKhuc River at the apex of delta (A=3,030km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	463	267	168	111	145	113	127	93	124	1,057	2,088	618	5,374
1977	493	297	270	146	114	68	77	119	249	624	2,169	537	5,162
1978	798	245	235	151	420	212	284	187	687	833	1,620	1,355	7,026
1979	424	209	139	106	232	660	249	199	159	888	1,504	803	5,572
1980	358	228	146	119	199	319	258	258	698	1,840	2,937	661	8,022
1981	440	283	182	145	281	305	228	141	219	2,902	3,601	1,957	10,682
1982	493	239	153	160	107	188	127	107	493	329	572	286	3,253
1983	244	128	97	62	89	147	125	245	199	1,539	2,560	731	6,166
1984	420	269	158	132	224	290	136	93	119	1,184	1,966	1,415	6,406
1985	503	251	162	146	261	172	104	102	236	853	2,665	1,884	7,340
1986	594	289	206	128	333	178	103	132	98	1,879	1,122	2,554	7,617
1987	498	268	253	157	138	201	134	138	371	189	2,079	729	5,153
1988	504	301	224	178	255	257	329	167	304	2,096	1,624	876	7,116
1989	700	293	289	177	311	314	318	313	452	386	718	520	4,792
1990	322	206	171	120	192	200	204	186	215	2,540	2,198	817	7,371
1991	420	297	262	269	242	205	168	226	276	1,323	999	1,256	5,943
1992	553	284	183	118	134	222	119	294	351	2,892	1,716	807	7,673
1993	427	239	206	148	171	180	170	95	212	1,363	1,503	2,642	7,355
1994	556	247	216	165	189	163	123	113	654	855	861	876	5,017
1995	371	279	168	105	99	97	121	157	342	2,537	2,912	1,590	8,776
1996	635	412	231	164	385	352	267	168	354	2,482	5,767	2,876	14,094
1997	572	261	177	153	263	205	209	134	966	568	1,477	679	5,664
1998	284	167	125	89	100	85	115	120	212	1,199	4,820	2,631	9,944
1999	1,160	550	427	348	662	490	299	250	335	1,891	3,616	4,187	14,213
2000	778	523	270	300	415	471	369	607	402	1,695	3,431	2,115	11,376
Ave(mil m3)	520	281	205	156	238	244	190	186	349	1,438	2,261	1,416	7,484

Monthly Discharge Ve River at the apex of delta (A=820km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	118	62	32	16	25	17	20	10	20	290	590	163	1,362
1977	126	71	62	26	16	3	5	18	56	164	614	139	1,301
1978	215	56	51	27	105	45	66	37	183	225	454	377	1,843
1979	106	46	23	14	51	176	55	41	30	241	421	216	1,420
1980	87	50	26	18	41	76	58	58	187	518	837	175	2,132
1981	111	67	36	26	65	72	49	24	47	826	1,030	552	2,905
1982	126	54	28	30	14	38	20	14	127	79	150	66	747
1983	54	22	11	2	9	26	19	54	41	430	728	196	1,593
1984	105	62	29	22	48	68	23	10	18	327	555	394	1,662
1985	129	58	30	26	59	34	13	13	52	231	758	530	1,934
1986	156	69	43	21	80	35	13	21	12	529	310	725	2,014
1987	103	65	77	32	19	44	26	14	76	36	956	241	1,689
1988	133	62	41	34	30	36	21	8	51	402	309	128	1,256
1989	200	59	110	52	57	48	57	67	138	102	204	117	1,211
1990	72	58	33	23	52	58	27	27	51	674	519	219	1,812
1991	100	64	80	68	51	36	26	26	31	261	229	341	1,314
1992	136	69	55	35	17	39	18	71	56	857	506	215	2,072
1993	102	54	33	13	18	26	11	7	25	447	536	791	2,063
1994	123	63	103	68	21	26	20	16	130	182	227	227	1,204
1995	93	42	30	13	32	15	12	13	86	798	791	478	2,404
1996	154	115	50	34	75	46	36	25	73	671	1,563	932	3,773
1997	157	68	40	44	61	51	74	46	209	132	519	278	1,678
1998	94	43	24	23	37	24	28	25	61	465	1,250	1,008	3,081
1999	384	161	115	87	104	79	56	60	76	494	873	1,728	4,217
2000	398	157	60	47	67	72	43	89	54	299	837	600	2,723
Ave(mil m3)	143	68	49	32	46	48	32	32	76	387	631	433	1,976

Table B.8 Generated Monthly Discharge Series Tra Khuc River Basin (2/2)

Monthly Discharge Other small basins (A=510km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	77	43	26	17	23	17	20	14	19	178	355	103	892
1977	82	49	44	23	17	9	11	18	40	104	369	90	856
1978	134	40	38	24	70	34	46	30	115	140	275	229	1,175
1979	70	34	21	16	37	111	40	32	25	150	255	135	926
1980	59	37	23	18	32	52	42	42	117	312	500	111	1,345
1981	73	46	29	23	46	50	37	22	35	494	613	332	1,800
1982	82	39	24	25	16	30	20	16	82	54	96	47	530
1983	39	20	14	8	13	23	19	40	32	261	436	123	1,028
1984	70	44	25	20	36	47	21	14	18	200	334	240	1,069
1985	84	41	26	23	42	27	15	15	38	144	453	320	1,228
1986	99	47	33	20	55	28	15	20	15	319	190	434	1,276
1987	80	44	44	25	21	32	21	20	59	30	402	128	906
1988	84	48	35	28	38	39	46	23	47	331	256	133	1,109
1989	119	47	53	30	49	48	50	50	78	65	122	84	795
1990	52	35	27	19	32	34	31	28	35	426	360	137	1,217
1991	69	48	45	45	39	32	26	33	41	210	163	212	961
1992	91	47	31	20	20	35	18	48	54	497	294	135	1,291
1993	70	39	32	21	25	27	24	13	31	240	270	455	1,248
1994	90	41	42	31	28	25	19	17	104	137	144	146	824
1995	61	43	26	16	17	15	18	23	57	442	490	274	1,481
1996	105	70	37	26	61	53	40	26	57	418	971	504	2,367
1997	97	44	29	26	43	34	37	24	156	93	264	127	973
1998	50	28	20	15	18	14	19	19	36	220	804	482	1,725
1999	205	94	72	58	101	75	47	41	54	316	595	784	2,441
2000	156	90	44	46	64	72	54	92	60	264	565	360	1,868
Ave(mil m3)	88	46	34	25	38	39	29	29	56	242	383	245	1,253

Monthly Runoff Tra Khuc Basin (A=5,200km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	711	372	227	143	193	147	167	117	163	1,862	3,530	975	8,606
1977	701	418	375	195	147	80	93	165	632	1,325	3,461	782	8,375
1978	1,525	341	324	202	607	292	396	253	1,333	1,406	2,561	2,057	11,297
1979	600	289	183	136	494	1,142	344	353	214	1,619	2,480	1,215	9,069
1980	505	315	195	156	272	447	357	358	1,181	3,444	4,717	1,034	12,981
1981	663	396	246	194	391	447	314	187	411	5,101	5,787	3,105	17,242
1982	749	332	205	215	138	256	167	137	845	560	915	463	4,981
1983	337	170	123	71	112	196	163	339	272	2,893	4,114	1,157	9,948
1984	600	375	212	174	309	405	179	126	222	1,947	3,455	2,296	10,302
1985	737	349	218	194	362	333	132	131	503	1,531	4,807	2,855	12,153
1986	849	405	282	168	639	242	131	192	126	3,445	1,708	4,122	12,309
1987	681	376	374	213	177	277	207	176	641	341	4,392	1,145	9,000
1988	745	416	300	241	323	332	396	199	568	3,132	2,310	1,219	10,181
1989	1,053	399	453	259	543	410	441	494	751	611	1,114	789	7,314
1990	473	300	232	162	276	292	261	241	312	4,168	3,650	1,283	11,649
1991	589	409	460	397	332	272	220	303	427	2,252	1,423	1,906	8,990
1992	887	399	269	174	171	310	155	413	550	5,080	2,809	1,182	12,399
1993	598	331	270	183	214	233	206	115	308	2,450	2,763	4,099	11,771
1994	768	351	361	264	237	213	162	147	1,197	1,567	1,310	1,338	7,915
1995	525	364	224	133	148	127	151	192	691	4,704	4,666	2,462	14,388
1996	922	630	318	224	574	450	343	219	829	4,127	9,436	4,465	22,538
1997	876	372	245	223	367	289	341	248	1,908	992	2,378	1,208	9,448
1998	503	237	169	127	156	123	161	164	635	2,573	7,955	4,613	17,416
1999	1,901	807	632	677	867	644	402	351	520	3,246	5,673	7,652	23,370
2000	1,515	770	374	393	546	615	485	1,165	516	2,939	5,211	3,392	17,922
Ave(mil m3)	801	397	291	221	344	343	255	271	630	2,533	3,705	2,272	12,062

Table B.9 Generated Monthly Discharge Series Kone River Basin

Kone River without Lower Area (Delta) (A=3,000km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	163	126	86	64	84	70	90	83	186	528	837	251	2,568
1977	165	112	103	50	37	25	29	43	454	271	1,526	181	2,995
1978													
1979	168	81	59	47	65	206	79	43	83	600	785	330	2,546
1980	147	105	78	61	134	173	117	204	426	1,451	2,533	424	5,853
1981	208	116	65	58	106	156	121	71	63	1,853	2,344	1,111	6,271
1982	310	187	143	139	93	136	75	54	112	122	141	78	1,590
1983	57	30	23	13	30	42	41	196	124	1,030	1,380	367	3,334
1984	225	148	91	84	117	202	71	41	49	585	1,615	939	4,167
1985	261	141	88	71	99	66	49	27	85	486	1,140	803	3,315
1986	230	147	112	64	132	63	50	104	68	706	444	1,413	3,534
1987	255	117	102	56	48	67	33	45	127	61	1,756	368	3,034
1988	192	109	80	54	50	50	84	35	99	1,232	821	300	3,107
1989	211	107	110	71	101	109	177	158	454	267	293	195	2,252
1990	102	59	45	37	133	280	118	108	96	1,698	1,372	367	4,416
1991	180	122	102	95	70	67	74	53	95	771	407	406	2,442
1992	198	102	71	55	50	92	53	88	91	1,790	791	266	3,647
1993	160	79	62	44	57	51	46	30	81	704	689	1,317	3,318
1994	269	116	99	68	95	96	68	74	294	596	274	349	2,400
1995	172	132	85	60	72	96	108	107	236	1,153	1,354	682	4,255
1996	325	197	121	96	192	154	114	68	163	683	2,856	1,890	6,859
1997	361	170	128	111	149	113	86	50	124	159	670	231	2,351
1998	113	64	46	60	72	57	60	76	147	895	2,747	1,726	6,063
1999	574	268	222	163	243	254	202	120	134	1,015	1,897	2,578	7,671
2000	420	272	153	141	156	207	165	252	161	701	1,458	872	4,959
Ave(mil m3)	228	129	95	73	99	118	88	89	165	807	1,255	727	3,873

Kone Basin (A=3,640km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	176	142	103	83	102	89	107	106	245	692	1,045	245	3,136
1977	178	128	120	70	57	46	50	64	692	366	1,745	178	3,694
1978													
1979	181	99	79	67	84	216	97	63	86	790	837	318	2,918
1980	161	121	96	80	149	185	133	214	409	1,822	2,593	407	6,371
1981	218	132	84	77	123	169	136	89	67	2,327	2,799	1,126	7,350
1982	315	199	158	153	111	151	93	74	115	188	220	82	1,858
1983	76	51	45	35	51	63	62	207	162	1,409	1,548	365	4,075
1984	234	162	109	102	133	272	90	61	54	783	1,916	917	4,833
1985	268	155	106	90	116	85	69	49	169	663	1,536	816	4,121
1986	239	162	129	83	147	82	70	121	71	981	457	1,558	4,101
1987	263	133	119	76	68	86	54	65	127	66	2,263	354	3,672
1988	204	125	98	74	70	70	102	56	109	1,617	928	290	3,744
1989	221	124	175	89	118	126	189	224	434	271	283	191	2,446
1990	119	78	65	58	148	407	134	125	99	2,168	1,478	400	5,278
1991	192	138	119	112	89	86	92	73	115	982	437	396	2,830
1992	209	119	90	74	70	109	73	106	94	2,112	820	258	4,134
1993	173	97	82	64	76	70	66	51	132	1,012	799	1,391	4,014
1994	276	132	116	87	112	114	87	93	302	700	266	400	2,685
1995	185	147	103	80	91	113	125	123	229	1,440	1,406	669	4,710
1996	328	208	137	113	203	167	131	188	516	1,436	2,896	1,785	8,109
1997	362	183	143	127	163	129	104	70	207	277	774	237	2,776
1998	129	83	66	80	91	76	79	94	160	1,102	3,196	1,834	6,991
1999	563	275	231	176	252	262	212	136	134	1,326	2,205	2,651	8,425
2000	422	279	167	156	222	217	178	260	159	956	1,523	838	5,378
Ave(mil m3)	237	145	114	92	119	141	106	113	204	1,062	1,415	738	4,485

Table B.10 Generated Monthly Discharge Series Ba River Basin

Ba River without Lower Area (Delta) (A=13,590km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	321	179	146	83	94	72	146	185	2,048	841	2,189	395	6,701
1978	299	156	113	96	195	142	537	780	1,238	1,271	2,041	673	7,540
1979	328	182	132	114	175	1,044	983	1,474	599	2,195	1,883	739	9,848
1980	310	197	120	70	759	765	522	477	1,339	1,842	4,075	815	11,292
1981	395	229	119	145	215	719	365	893	734	4,178	6,074	2,466	16,533
1982	591	310	220	218	152	418	530	297	815	468	414	200	4,631
1983	146	81	53	30	110	306	160	662	530	3,883	2,256	828	9,045
1984	393	268	166	162	323	511	343	1,315	1,080	2,094	3,173	1,401	11,229
1985	636	255	180	231	221	365	502	516	962	1,265	1,804	1,242	8,179
1986	391	220	162	88	281	129	202	1,423	1,186	1,405	1,131	3,313	9,932
1987	625	297	229	142	124	197	186	468	503	243	2,933	833	6,779
1988	415	232	155	98	124	361	308	205	581	4,171	3,342	680	10,673
1989	709	297	192	144	581	413	580	951	1,251	1,605	990	503	8,216
Ave(mil m3)	428	223	153	125	258	419	413	742	990	1,959	2,485	1,084	9,277

Ba Basin (A=14,030km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	321	179	146	83	94	72	146	185	2,365	917	2,305	430	7,243
1978	299	156	113	96	195	142	537	780	1,238	1,307	2,132	673	7,667
1979	328	182	132	114	175	1,044	983	1,474	599	2,318	2,071	757	10,177
1980	310	197	120	70	768	765	522	477	1,421	2,180	4,269	831	11,931
1981	395	229	119	145	215	719	365	893	819	4,661	6,352	2,578	17,492
1982	591	310	220	218	152	418	530	297	815	538	482	200	4,770
1983	146	81	53	30	110	306	160	662	530	4,158	2,560	828	9,624
1984	393	268	166	162	323	511	343	1,315	1,130	2,245	3,296	1,401	11,553
1985	636	255	180	231	221	365	502	516	1,007	1,364	2,144	1,305	8,725
1986	391	220	162	88	281	129	202	1,423	1,207	1,560	1,210	3,500	10,374
1987	625	297	229	142	124	197	186	468	503	257	3,363	833	7,223
1988	415	232	155	98	124	361	308	205	641	4,387	3,612	680	11,219
1989	709	297	192	144	581	413	580	951	1,279	1,814	1,046	503	8,507
Ave(mil m3)	428	223	153	125	259	419	413	742	1,042	2,131	2,680	1,117	9,731

Table B.11 Generated Monthly Discharge Series Sesan River Basin

Sesan River at the International Boundry (A=11,530km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1976	440	281	252	227	376	621	1,065	1,932	2,113	1,350	858	699	10,215
1977	408	301	282	267	274	302	576	971	1,751	964	1,000	463	7,558
1978	340	198	238	242	319	529	912	2,412	2,587	1,708	1,109	783	11,378
1979	538	352	289	282	601	1,613	2,169	3,810	2,143	2,178	1,315	847	16,137
1980	614	421	345	314	740	1,005	1,477	1,332	2,335	2,391	2,539	1,124	14,638
1981	701	452	442	437	558	2,051	1,444	2,534	1,317	2,544	2,401	1,355	16,236
1982	710	494	443	436	424	1,080	1,872	1,614	2,661	1,311	876	619	12,541
1983	499	382	331	249	376	587	845	1,679	1,227	2,521	1,653	837	11,187
1984	659	465	437	532	584	1,413	954	2,991	2,725	2,002	1,725	1,000	15,486
1985	693	478	454	471	515	1,507	1,346	2,606	2,027	1,487	1,047	766	13,398
1986	662	511	513	476	1,192	835	1,477	2,199	2,471	2,013	1,278	1,195	14,822
1987	656	478	413	372	427	623	1,116	1,784	1,727	912	906	596	10,012
1988	489	386	373	332	610	1,003	922	1,406	847	2,408	1,137	781	10,694
1989	619	460	486	466	968	972	1,528	2,665	2,428	1,592	923	716	13,824
1990	450	374	330	309	564	976	949	1,404	1,776	2,692	1,691	885	12,402
1991	660	450	431	333	366	679	1,236	2,643	2,469	2,527	1,149	862	13,804
1992	627	465	449	419	541	723	911	2,121	2,017	2,073	1,439	829	12,614
1993	544	402	389	375	463	426	741	1,868	1,664	1,624	1,031	1,127	10,656
1994	450	310	272	303	416	677	2,540	2,337	4,217	1,797	1,015	922	15,255
1995	528	372	320	246	338	451	907	1,397	1,377	1,574	1,657	893	10,059
1996	632	479	403	429	615	686	1,433	2,276	3,590	2,340	3,877	2,114	18,874
1997	1,018	700	600	634	812	753	1,385	2,563	2,466	2,151	1,226	768	15,077
Ave(mil m3)	588	419	386	371	549	887	1,264	2,116	2,179	1,916	1,448	917	13,039

Table B.12 Generated Monthly Discharge Series Srepok River Basin

Srepok River at the International Boundry (A=12,030km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1977	283	180	146	105	120	138	432	420	1,499	1,158	654	337	5,470
1978	229	146	135	125	302	324	768	1,135	1,709	1,960	1,341	621	8,795
1979	341	198	171	164	270	665	1,088	1,395	777	1,394	1,027	798	8,287
1980	364	243	189	164	364	576	600	761	1,893	1,878	1,930	848	9,810
1981	432	282	210	196	372	890	695	1,795	1,046	2,617	2,723	1,550	12,807
1982	693	387	328	323	365	733	829	696	1,895	1,107	638	407	8,401
1983	273	175	139	101	184	307	344	851	794	2,147	1,227	570	7,112
1984	350	227	158	181	397	644	695	1,532	1,601	1,978	1,011	791	9,565
1985	394	237	202	299	441	490	723	782	1,139	1,156	634	813	7,308
1986	356	217	179	138	226	274	540	1,472	1,167	1,273	733	1,093	7,669
1987	437	240	207	149	194	465	1,012	828	1,552	990	781	701	7,556
1988	367	232	166	169	397	502	593	722	1,002	2,225	1,767	784	8,925
1989	418	230	229	236	550	762	950	1,350	1,676	1,533	718	436	9,088
1990	269	156	131	148	233	1,382	1,032	1,636	2,251	1,615	1,870	985	11,708
1991	458	252	242	204	276	352	503	736	1,156	1,370	554	341	6,446
1992	226	124	100	148	292	894	964	1,870	1,809	2,121	1,895	686	11,130
1993	367	224	208	173	324	424	710	839	1,068	3,262	981	2,204	10,785
1994	757	366	267	279	426	698	1,100	955	1,385	1,286	804	533	8,857
1995	312	187	146	124	203	310	647	641	1,311	1,746	956	749	7,331
1996	567	273	168	207	754	994	1,115	1,240	1,681	2,470	2,710	2,130	14,309
1997	1,054	426	291	401	519	499	1,042	1,609	1,732	1,535	1,011	454	10,574
1998	223	133	96	80	218	252	398	670	690	1,488	3,166	2,775	10,190
1999	1,012	424	330	406	1,224	1,475	979	1,472	1,353	1,473	2,038	2,064	14,249
2000	710	389	313	381	579	894	1,196	1,213	1,892	4,192	1,715	1,798	15,273
Ave(mil m3)	454	248	198	204	385	623	790	1,109	1,420	1,832	1,370	1,019	9,652

Table B.13 Generated Monthly Discharge Series Dongnai River Basin

Dong Nai River at Hoa An (A=22,594km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1964	660	285	156	220	1,582	2,020	2,908	4,199	4,347	4,763	3,452	1,549	26,141
1965	687	254	169	236	2,217	1,928	2,365	2,447	3,454	3,747	2,507	1,350	21,360
1966	575	230	253	341	455	1,528	2,317	4,518	3,674	4,063	3,460	2,164	23,578
1967	873	346	223	328	1,359	2,128	4,782	5,075	5,513	7,116	4,555	1,723	34,022
1968	742	275	195	241	366	1,393	3,778	4,228	4,160	5,435	3,308	1,574	25,695
1969	743	326	207	166	495	717	2,149	3,691	5,054	5,492	3,032	1,117	23,189
1970	519	221	203	187	428	1,981	3,834	3,131	3,190	5,710	4,396	1,960	25,761
1971	866	356	249	327	1,146	1,830	2,660	3,478	4,794	5,501	3,009	1,536	25,753
1972	666	272	202	215	366	1,264	1,933	3,075	5,254	6,293	3,450	1,867	24,856
1973	753	315	221	212	507	1,192	1,466	3,174	4,777	4,320	2,207	1,072	20,216
1974	526	244	210	195	1,347	1,529	2,500	3,587	3,693	6,023	3,750	1,310	24,916
1975	631	282	236	511	368	1,113	3,343	4,174	6,058	3,827	2,247	1,246	24,034
1976	597	294	228	207	315	1,786	3,700	4,190	5,626	4,665	2,604	1,102	25,314
1977	527	239	212	196	198	430	3,332	4,879	3,268	2,892	1,731	818	18,721
1978	398	201	194	235	421	1,283	2,813	5,048	7,398	6,576	3,462	1,457	29,485
1979	647	274	235	373	1,175	2,200	4,199	5,141	3,226	4,839	2,841	1,342	26,492
1980	658	308	231	210	586	1,915	2,383	2,177	5,669	4,973	2,582	1,319	23,012
1981	677	422	240	284	736	3,490	3,242	4,587	3,953	4,568	2,296	1,017	25,513
1982	491	250	266	573	565	698	2,342	4,657	5,299	4,975	2,986	1,342	24,443
1983	537	248	246	588	250	905	2,897	3,289	5,542	6,213	3,366	1,388	25,470
1984	632	284	230	353	1,049	1,708	2,793	5,553	4,722	4,836	1,837	897	24,894
Ave(mil m3)	638	282	219	295	759	1,573	2,940	4,014	4,699	5,087	3,004	1,388	24,898

Saigon River u/s of DauTieng +ThiThinh basin (A=3,650km2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1964	120	51	35	31	32	58	413	505	394	544	528	261	2,971
1965	143	59	37	33	35	53	94	146	286	260	465	270	1,881
1966	152	70	41	35	218	426	268	188	288	433	315	185	2,618
1967	122	59	40	38	38	90	316	465	365	529	444	292	2,798
1968	162	81	47	37	103	108	440	453	529	714	387	213	3,273
1969	119	52	41	38	40	44	162	376	428	774	645	286	3,006
1970	155	67	45	40	42	41	84	252	380	447	356	191	2,101
1971	113	53	43	40	42	135	408	428	322	609	677	414	3,285
1972	218	114	60	43	51	161	402	447	513	633	490	260	3,392
1973	160	82	51	43	45	55	116	129	251	801	614	426	2,773
1974	208	99	57	44	45	45	62	151	360	456	322	209	2,058
1975	137	69	49	44	125	235	231	349	265	608	678	340	3,131
1976	182	85	53	46	47	48	249	394	668	427	191	133	2,522
1977	81	47	47	46	47	52	83	220	589	674	401	213	2,500
1978	115	55	49	46	47	46	156	233	467	528	526	273	2,539
1979	156	73	52	48	85	108	214	349	594	704	405	229	3,016
1980	138	69	52	48	51	106	342	387	376	503	289	187	2,548
1981	117	58	51	49	59	243	565	541	573	625	633	324	3,838
1982	183	88	58	50	61	95	199	366	345	522	385	241	2,593
1983	152	76	56	51	53	85	175	291	646	777	541	283	3,186
1984	160	78	56	51	53	54	196	395	490	587	476	267	2,862
Ave(mil m3)	147	71	49	43	63	109	246	336	435	579	465	262	2,804

Dong Nai Basin (A=29,120km2)

(million m3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1964	780	336	191	251	1,614	2,403	4,030	5,380	4,898	5,406	4,249	1,810	31,349
1965	830	312	207	269	2,340	2,347	2,639	3,117	4,310	4,289	2,972	1,620	25,253
1966	727	299	294	376	985	2,706	3,053	5,681	4,421	4,958	3,933	2,350	29,783
1967	996	405	263	366	1,840	2,288	5,844	5,585	6,365	8,419	5,002	2,015	39,387
1968	905	356	242	278	734	1,931	4,307	4,819	6,003	6,592	3,694	1,786	31,646
1969	862	378	247	204	536	1,453	2,757	4,751	6,073	6,734	3,678	1,403	29,075
1970	674	288	247	228	469	2,589	3,993	3,830	4,044	6,820	4,752	2,152	30,085
1971	979	409	292	367	1,369	2,308	3,477	4,393	5,265	6,467	3,687	1,950	30,964
1972	884	386	262	257	417	2,069	2,567	3,522	6,449	7,011	3,959	2,127	29,909
1973	913	397	273	256	552	1,721	2,297	3,543	5,441	5,526	2,821	1,498	25,238
1974	734	343	267	240	1,392	1,574	2,702	3,752	4,214	7,082	4,073	1,519	27,893
1975	768	350	286	556	493	1,839	3,995	4,908	6,825	4,822	2,925	1,587	29,353
1976	778	379	281	253	363	2,324	4,371	4,969	6,797	5,480	2,795	1,235	30,024
1977	608	286	259	242	245	779	4,140	5,899	4,470	3,815	2,578	1,031	24,351
1978	512	255	244	280	587	1,917	3,281	5,662	8,716	8,111	4,076	1,730	35,371
1979	804	347	287	420	1,260	2,494	4,673	5,556	3,835	5,961	3,245	1,571	30,452
1980	796	377	284	258	813	2,714	3,103	3,032	6,397	5,667	2,952	1,506	27,898
1981	794	480	292	333	796	4,057	4,813	5,383	4,547	5,508	2,929	1,341	31,273
1982	673	337	324	623	626	1,379	3,013	5,403	6,196	5,923	3,585	1,583	29,665
1983	688	324	303	639	303	1,174	3,737	4,496	6,567	7,194	4,023	1,671	31,120
1984	792	361	286	404	1,102	1,872	3,682	5,998	5,673	6,046	2,313	1,164	29,694
Ave(mil m3)	786	353	268	338	897	2,092	3,642	4,747	5,596	6,087	3,535	1,650	29,990

Table B.14 Generated Monthly Discharge Series Cuu Long River Delta

Cuu Long (Mekong) at the boundary with Cambodia

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1960	14,404	7,292	5,308	3,719	3,380	9,955	32,126	96,788	79,403	83,952	52,228	34,896	423,450
1961	21,129	10,876	7,597	5,112	9,101	33,917	59,890	106,069	112,851	113,483	63,589	41,304	584,919
1962	26,098	14,822	9,828	5,816	8,288	32,690	53,135	79,962	84,176	74,707	53,311	33,293	476,126
1963	19,291	9,650	7,652	5,765	4,947	22,154	49,123	95,201	90,241	76,259	55,212	35,977	471,473
1964	19,907	10,040	7,688	6,474	12,073	21,395	42,273	60,315	80,614	85,164	60,726	39,136	445,804
1965	22,310	11,502	8,222	6,386	8,071	39,950	55,802	60,541	77,078	61,656	48,578	30,846	430,943
1966	18,984	10,623	8,916	7,681	16,234	29,784	63,355	85,759	125,105	77,934	54,444	38,159	536,977
1967	24,001	12,528	9,591	7,318	10,681	21,301	35,604	60,466	69,629	62,963	42,795	30,262	387,138
1968	17,414	9,658	6,772	5,214	9,653	16,138	33,236	65,290	88,643	64,276	43,808	26,279	386,382
1969	10,759	6,404	5,864	5,979	5,758	30,992	60,103	84,270	54,906	57,451	45,968	26,549	395,004
1970	14,342	6,757	5,129	5,377	10,051	29,529	66,072	108,598	102,139	71,330	44,486	34,517	498,325
1971	20,776	10,080	6,140	6,911	8,696	26,053	82,548	92,782	91,501	73,357	50,465	33,099	502,408
1972	20,498	11,017	8,722	7,990	9,081	25,942	40,802	105,250	74,741	72,460	53,200	39,680	469,383
1973	23,858	12,318	9,709	7,056	12,850	28,261	40,699	58,401	97,823	60,081	45,922	32,171	429,150
1974	16,683	8,564	6,626	7,010	8,925	25,126	23,662	83,624	85,135	47,428	44,302	29,476	386,561
1975	16,742	8,699	6,414	5,708	7,840	29,359	43,616	77,825	94,842	65,614	52,320	29,364	438,344
1976	15,960	9,010	7,156	6,818	10,320	18,895	29,147	80,619	46,841	61,838	55,013	33,269	374,885
1977	15,687	7,432	7,052	7,334	7,219	4,714	20,432	41,533	66,566	44,335	43,045	27,936	293,283
1978	17,269	8,448	6,816	6,012	9,407	29,799	56,389	132,572	97,551	87,355	47,838	28,804	528,260
1979	16,525	8,765	7,156	6,499	12,910	32,552	48,357	70,545	65,830	52,771	37,903	28,022	387,836
1980	15,204	7,705	6,291	5,882	7,891	19,595	40,922	64,757	106,081	67,894	53,012	30,700	425,934
1981	16,991	8,893	7,657	7,103	11,812	54,890	82,405	99,116	67,424	57,512	45,013	34,683	493,498
1982	18,705	9,957	7,874	7,671	8,111	14,354	28,312	62,692	74,943	79,764	48,216	30,556	391,155
1983	16,986	8,634	7,855	6,927	7,181	11,894	18,163	50,026	68,064	64,141	58,058	35,045	352,974
1984	18,510	9,346	6,795	5,638	10,090	21,689	54,761	95,326	80,278	54,435	48,499	29,385	434,751
Ave(mil m3)	18,361	9,561	7,393	6,376	9,223	25,237	46,437	80,733	83,296	68,726	49,918	32,536	437,799

Monthly Runoff Cuu Long Delta

(million m3)

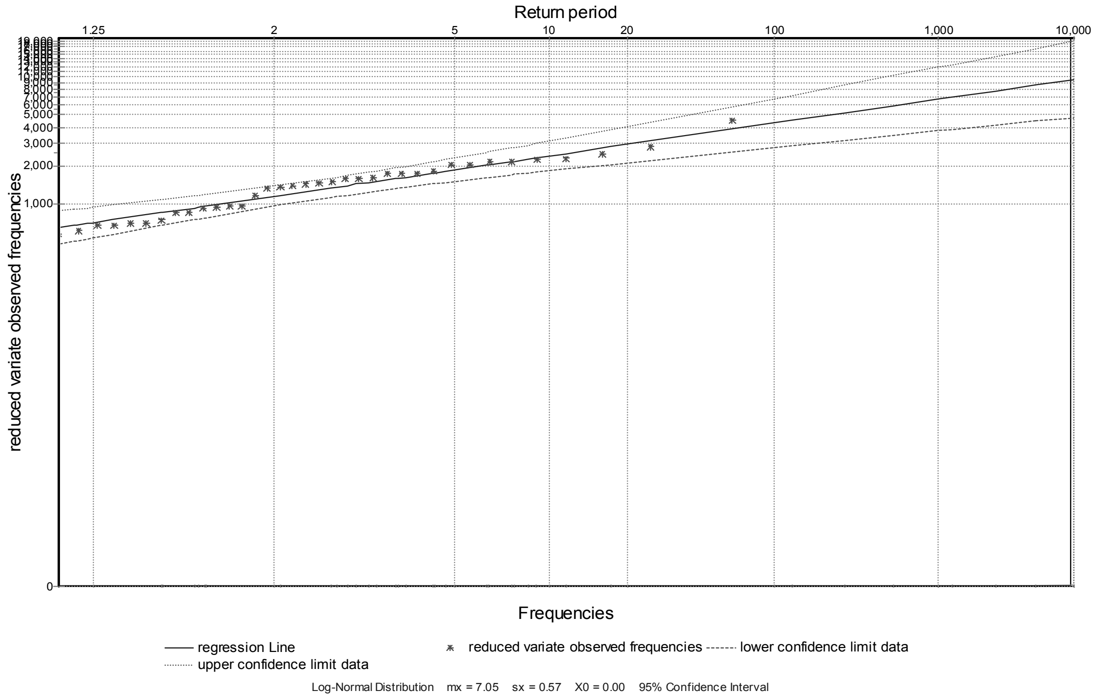
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
1960	14,404	7,292	5,308	3,719	3,494	13,401	36,027	98,833	85,349	90,201	54,197	34,896	447,119
1961	21,129	10,876	7,597	5,112	9,215	37,363	63,790	108,114	118,797	119,731	65,558	41,304	608,588
1962	26,098	14,822	9,828	5,816	8,402	36,136	57,036	82,007	90,122	80,955	55,281	33,293	499,795
1963	19,291	9,650	7,652	5,765	5,061	25,600	53,024	97,246	96,187	82,507	57,181	35,977	495,141
1964	19,907	10,040	7,688	6,474	12,186	24,841	46,174	62,360	86,559	91,413	62,695	39,136	469,473
1965	22,310	11,502	8,222	6,386	8,184	43,397	59,703	62,586	83,024	67,904	50,548	30,846	454,612
1966	18,984	10,623	8,916	7,681	16,348	33,230	67,256	87,804	131,050	84,182	56,413	38,159	560,646
1967	24,001	12,528	9,591	7,318	10,795	24,747	39,504	62,511	75,574	69,212	44,764	30,262	410,807
1968	17,414	9,658	6,772	5,214	9,767	19,584	37,137	67,335	94,589	70,525	45,777	26,279	410,051
1969	10,759	6,404	5,864	5,979	5,871	34,438	64,004	86,315	60,852	63,699	47,937	26,549	418,673
1970	14,342	6,757	5,129	5,377	10,165	32,975	69,972	110,643	108,084	77,578	46,456	34,517	521,994
1971	20,776	10,080	6,140	6,911	8,810	29,499	86,448	94,827	97,447	79,606	52,435	33,099	526,076
1972	20,498	11,017	8,722	7,990	9,195	29,388	44,703	107,295	80,687	78,709	55,169	39,680	493,052
1973	23,858	12,318	9,709	7,056	12,963	31,707	44,600	60,446	103,769	66,329	47,892	32,171	452,819
1974	16,683	8,564	6,626	7,010	9,039	28,572	27,563	85,669	91,081	53,677	46,272	29,476	410,230
1975	16,742	8,699	6,414	5,708	7,954	32,805	47,517	79,870	100,788	71,863	54,289	29,364	462,013
1976	15,960	9,010	7,156	6,818	10,434	22,341	33,048	82,664	52,786	68,086	56,982	33,269	398,554
1977	15,687	7,432	7,052	7,334	7,333	8,160	24,332	43,578	72,512	50,583	45,015	27,936	316,952
1978	17,269	8,448	6,816	6,012	9,612	38,218	61,540	135,711	106,234	88,484	50,856	28,804	558,003
1979	16,525	8,765	7,156	6,499	12,910	32,775	56,575	74,260	69,194	54,233	39,864	28,022	406,780
1980	15,204	7,705	6,291	5,882	10,391	29,097	40,922	66,454	108,558	76,335	55,106	30,700	452,644
1981	16,991	8,893	7,657	7,103	13,895	61,839	82,405	101,426	72,215	64,647	47,067	34,683	518,820
1982	18,705	9,957	7,874	7,671	8,111	15,690	37,306	70,058	80,662	87,285	48,216	30,556	422,091
1983	16,986	8,634	7,855	6,927	7,181	16,715	23,359	56,979	76,081	71,768	59,694	35,045	387,224
1984	18,510	9,346	6,795	5,638	10,090	30,744	54,761	98,946	84,777	57,658	48,499	29,385	455,148
Ave(mil m3)	18,361	9,561	7,393	6,376	9,496	29,331	50,348	83,357	89,079	74,687	51,767	32,536	462,292

The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

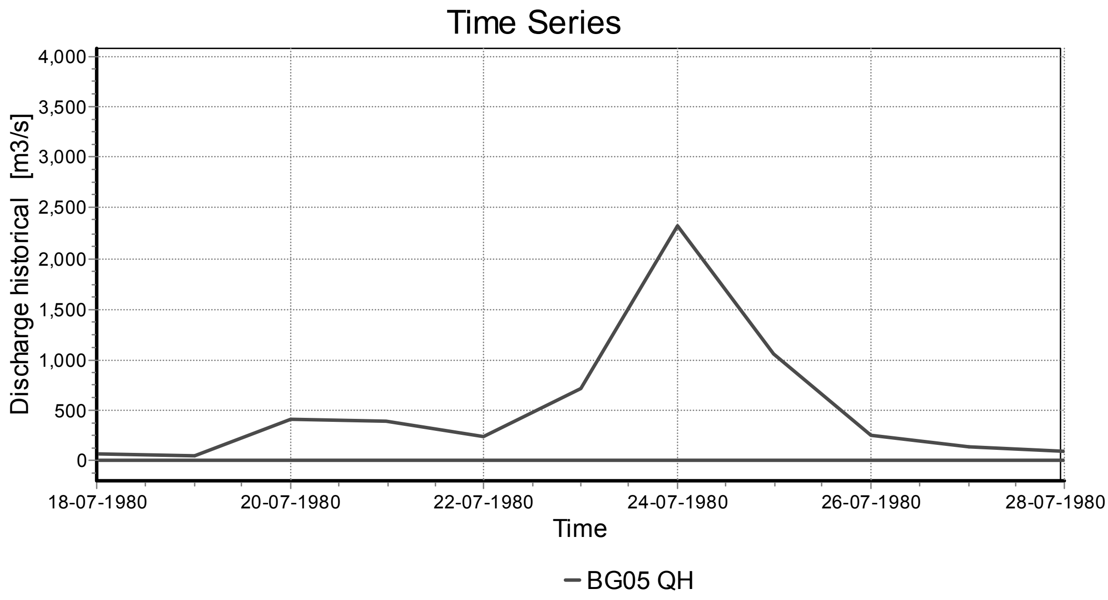
Figure B.1
Location Map
Bang Giang and Ky Cung River Basin

Log-normal Distribution (Yearly maximum discharges)

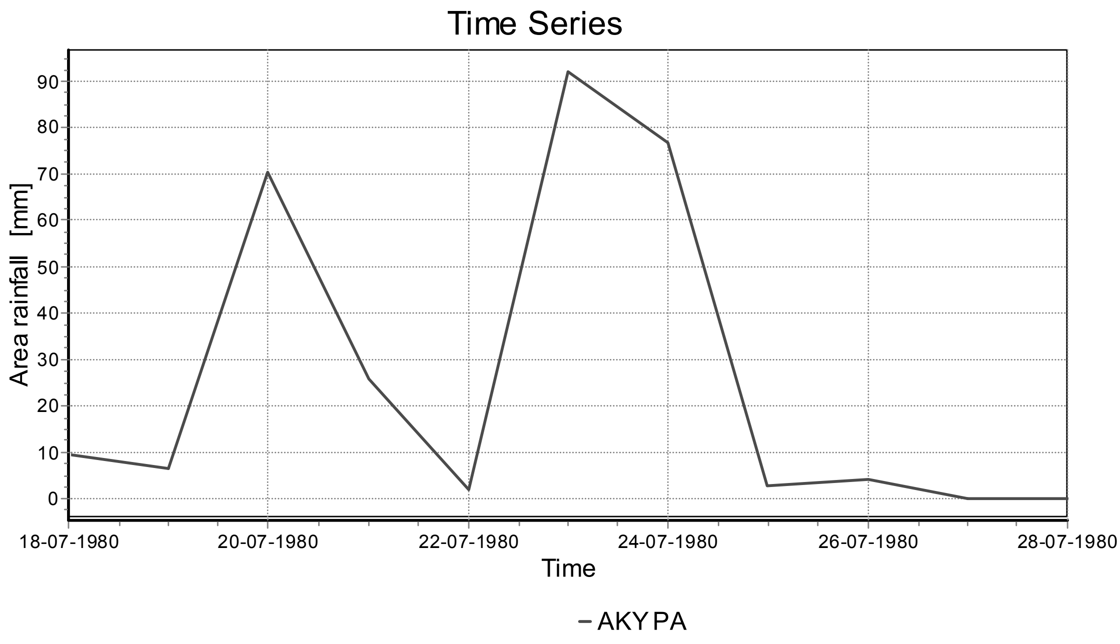


The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam	**Figure B.2**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Frequency Distributions Ky Cung River at Lang Son**

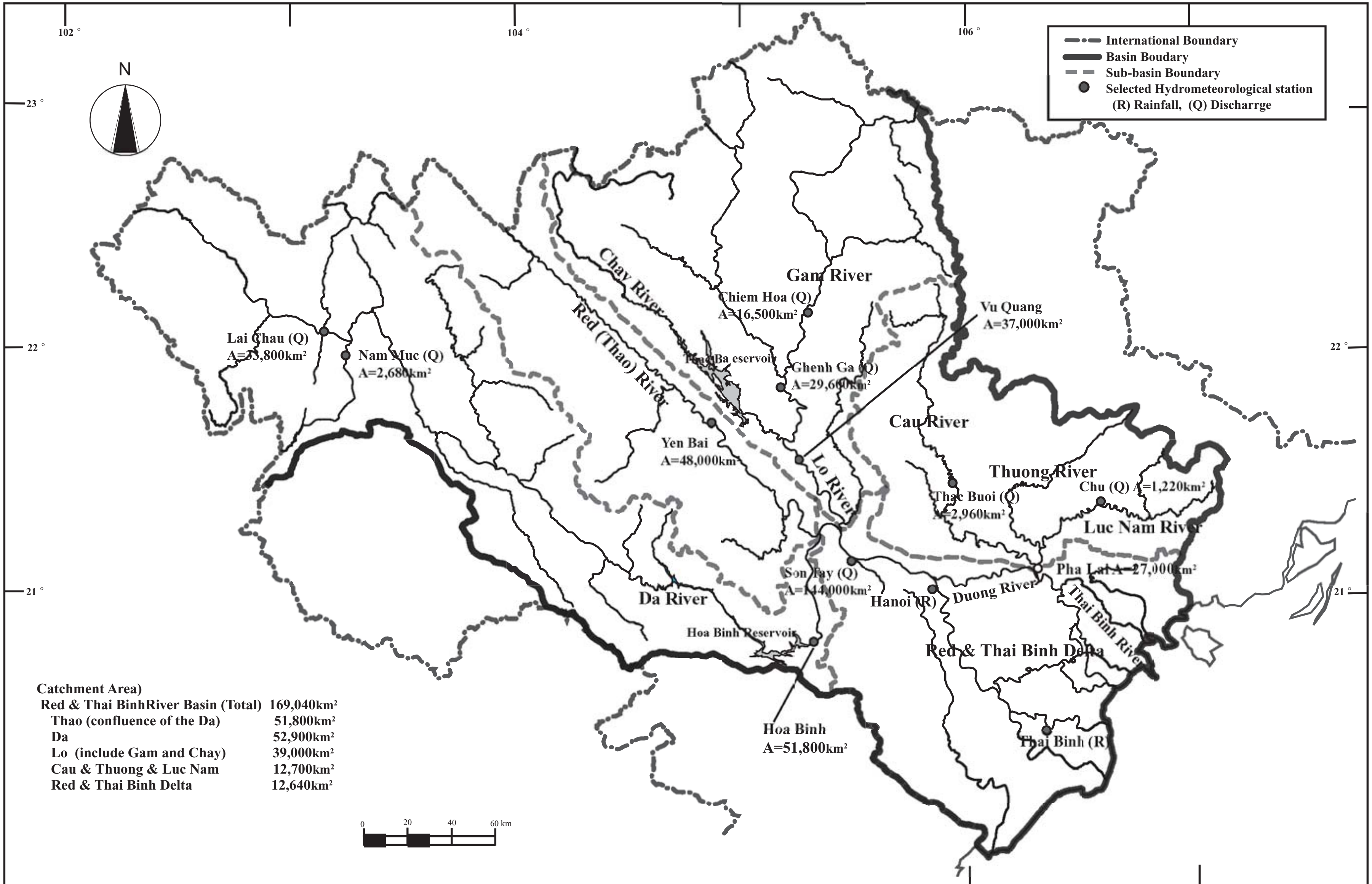
1980 Flood at Lang Son (instantaneous peak discharge: 2,800 m3/s)



Ky Cung Basin Area Rainfall (upstream Lang Son)



The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam	**Figure B.3** **Typical Flood** **Ky Cung River at Lang Son**
JAPAN INTERNATIONAL COOPERATION AGENCY	



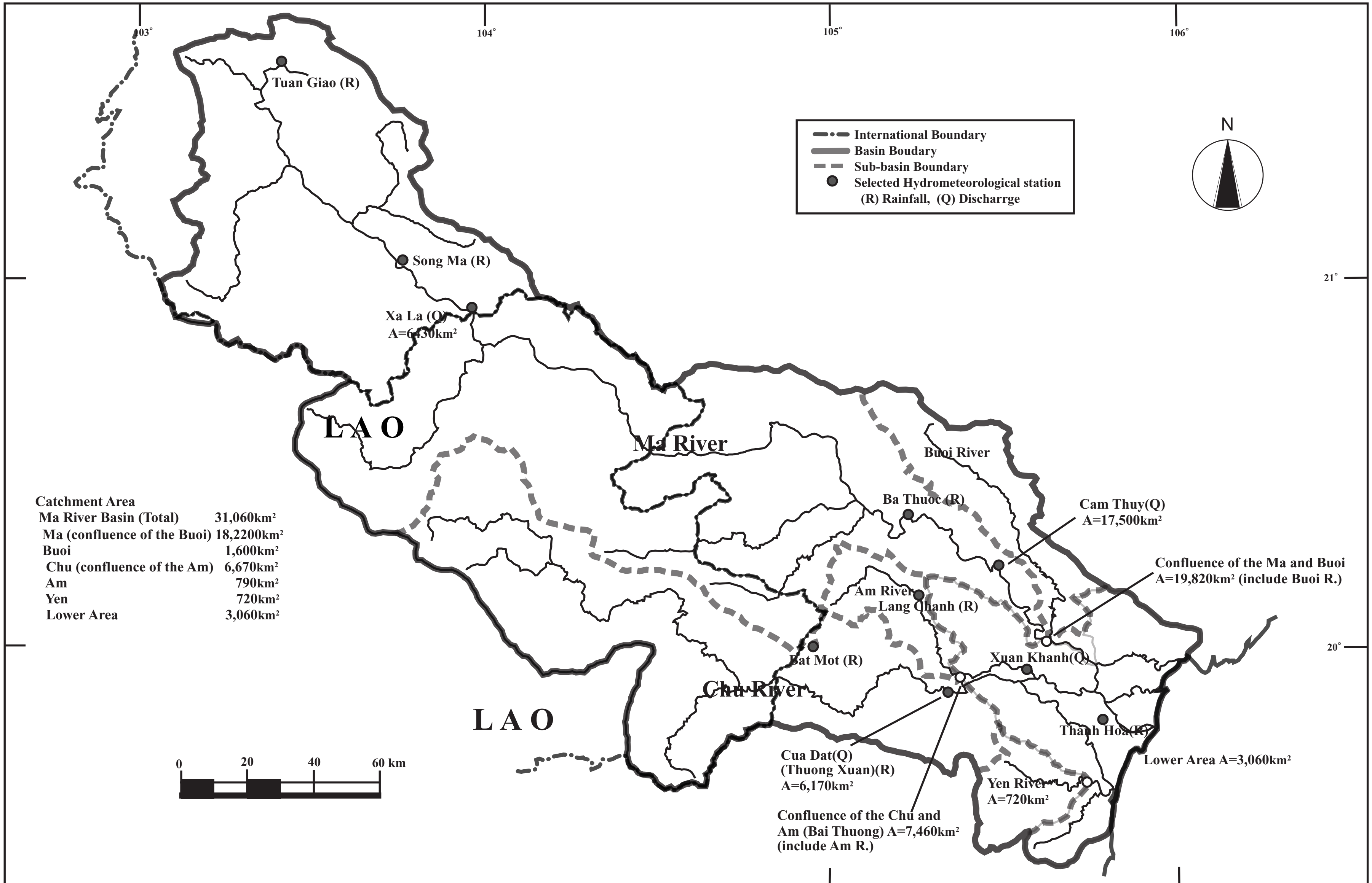
Catchment Area)

Red & Thai BinhRiver Basin (Total)	169,040km²
Thao (confluence of the Da)	51,800km²
Da	52,900km²
Lo (include Gam and Chay)	39,000km²
Cau & Thuong & Luc Nam	12,700km²
Red & Thai Binh Delta	12,640km²

The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam

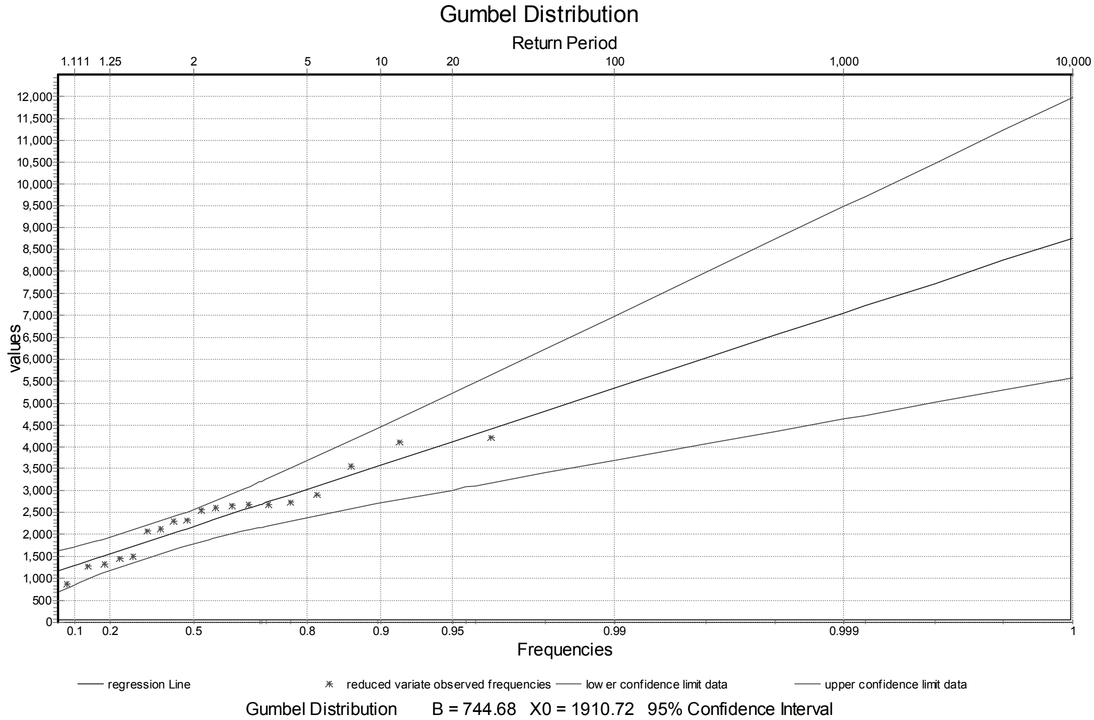
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure B.4
Location Map Red and Thai Binh River Basin

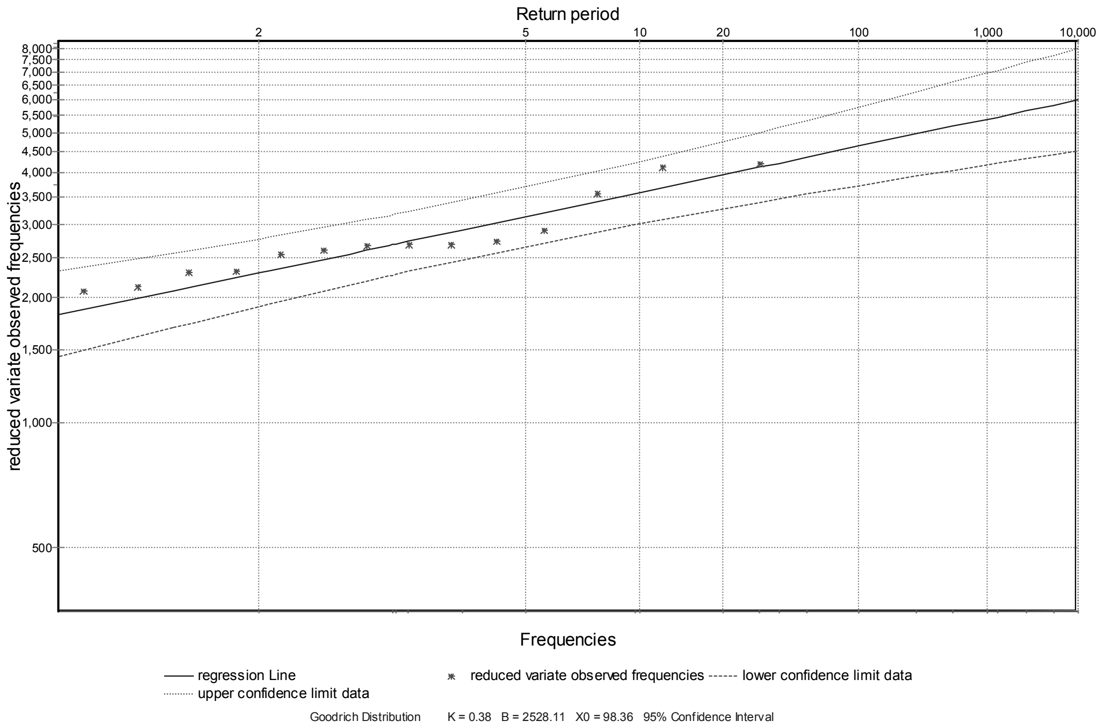


The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam	Figure B.5 Location Map Ma River Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	

Gumbel Distribution (Yearly maximum discharges)



Goodrich Distributions (Yearly maximum discharges)



The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam	**Figure B.6**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Frequency Distributions Chu River at Cua Dat**