

FEASIBILITY STUDY

CHAPTER 3

HYDROLOGICAL ANALYSIS OF PROJECT AREA

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3.1 Introduction

This chapter describes the hydrological analysis for the preliminary design and construction plan of bridge and roads i.e., Route 14A /Route 16A in the Feasibility Study. The basic data for the analysis comprises the water level of rivers and meteorological data including temperature, precipitation, rainy days, humidity, wind velocity, at representative points near each route.

The probability discharge is estimated from the catchment area and rainfall data at each bridge site, and the design high water level and velocity are also determined based on it. In order to confirm its appropriateness, an interview of HWL was undertaken at each bridge site and compared to the calculation results.

Location maps of rivers for Route 14A and Route 16A are shown in Figure 3.1.1 and 3.1.2.

3.2 Outline of Hydrology on Each Route

3.2.1 Route 14A

Route 14A is located in the right bank of Mekong River, which runs to south along the Mekong River with approximately 59 km in total length. The road elevation is around 100m. There are 24 waterways crossing the road and each flows into the Mekong River. As for the catchment area of these rivers, it ranges from 1 km² to 20 km², although most of the rivers have less than 5 km².

The hydrological and meteorological data at Pakse can well represent this area because the plenty and long-term data are available there. The data in detail is compiled in ANNEX F-10.

(1) Water Level of Mekong River at Pakse

As shown in Figure 3.2.1, the water level of Mekong River at the Pakse station becomes the lowest during March and April, in the end of dry season. From May, the beginning of wet season, it start rising and reaches to its highest level in August and September. The largest difference in the water level recorded about 10 meter in August of 1978. (max.=14.63 m in 1978 and min. =4.00m in 1979)

Name of Rivers

No.	River name
1	Thok
2	Maknao
3	Namxan
4	No name
5	No name
6	Gnang
7	No name
8	Imet
9	Kaunam
10	Khao dam
11	Thakhong
12	Thapxang
13	Khone liao
14	Khonken
15	Hong
16	He
17	Dua
18	Sai
19	Phaphin
20	Phabang
21	Sahoua
22	Kok
23	Thateng
24	Manpha

Legend

- Survey Route
- Other National Road

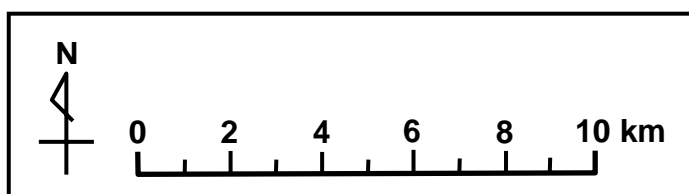
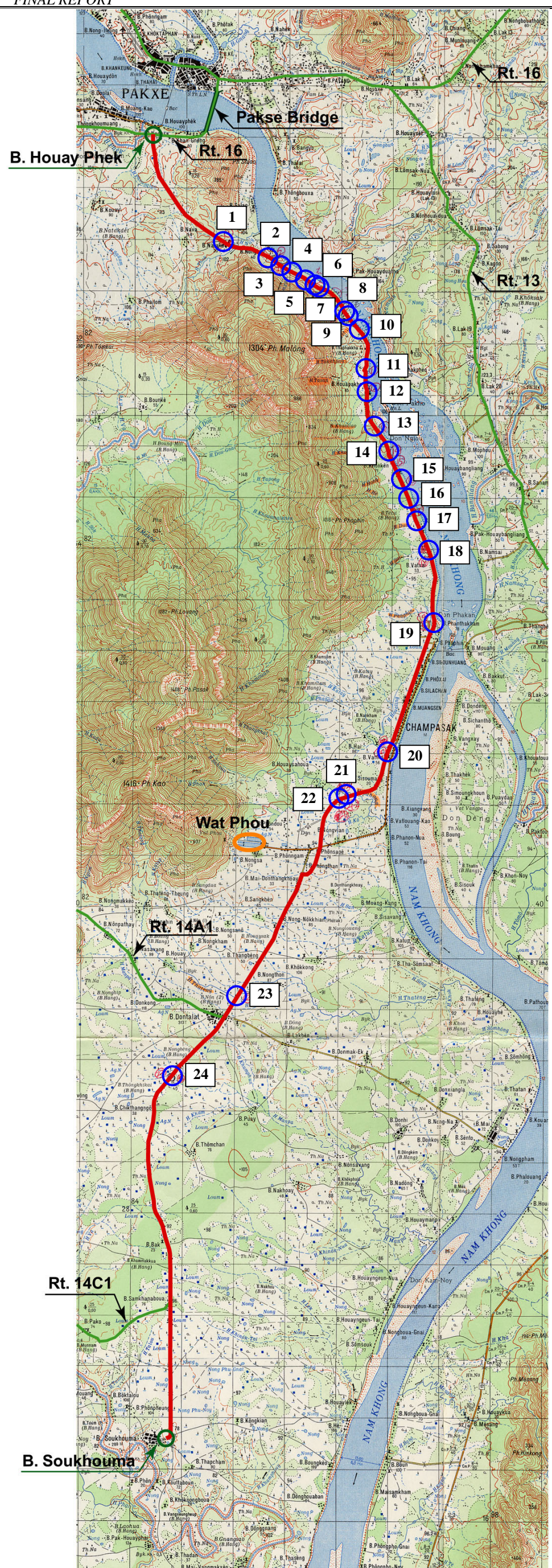
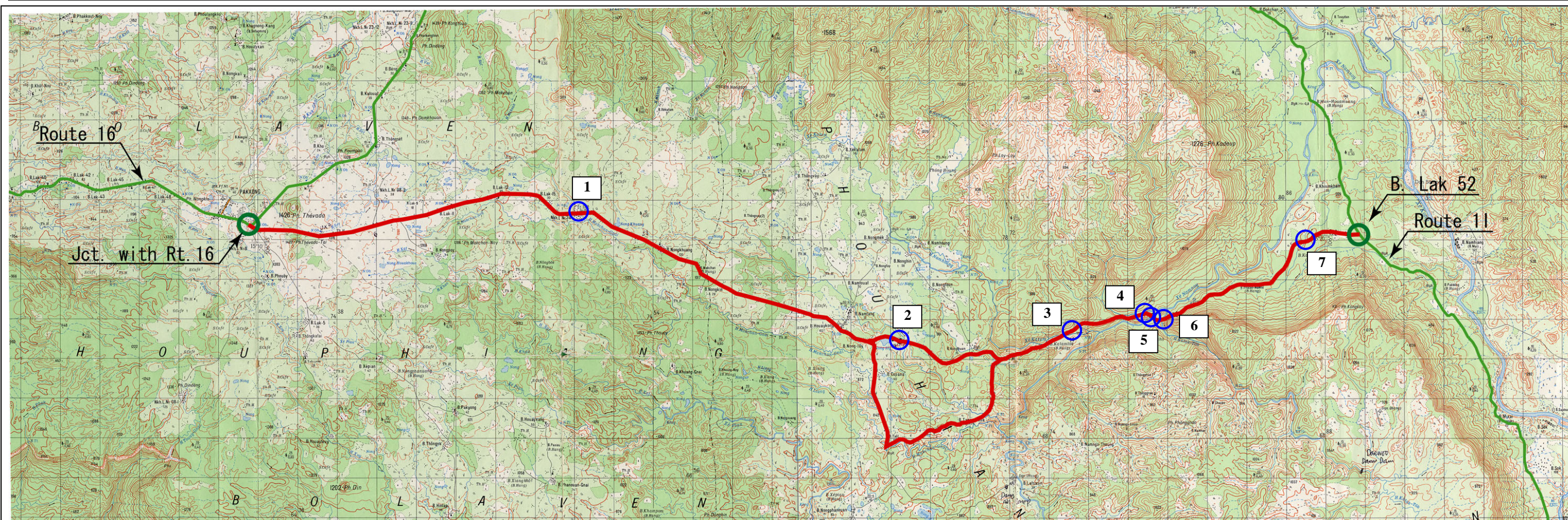


Figure 3.1.1 Location Map of Rivers - Rt. 14A





Name of Rivers

No.	River name
1	Makchan-Gu
2	Namtang
3	Xe Katam
4	Xe Namnoy 1
5	Xe Namnoy 2
6	Ho
7	No name

Legend

- Survey Route
- Other National Road

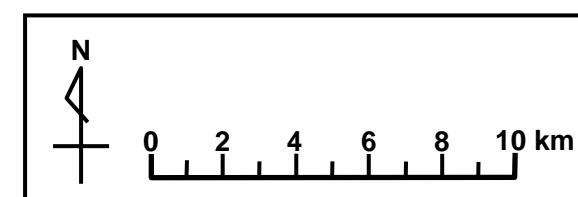


Figure 3.1.2 Location Map of Rivers - Rt. 16A

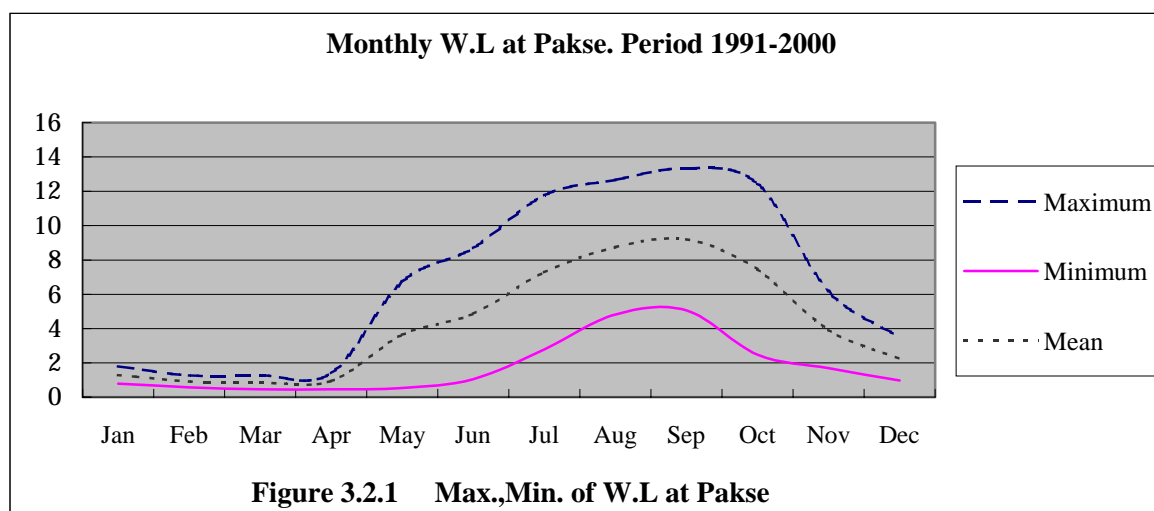
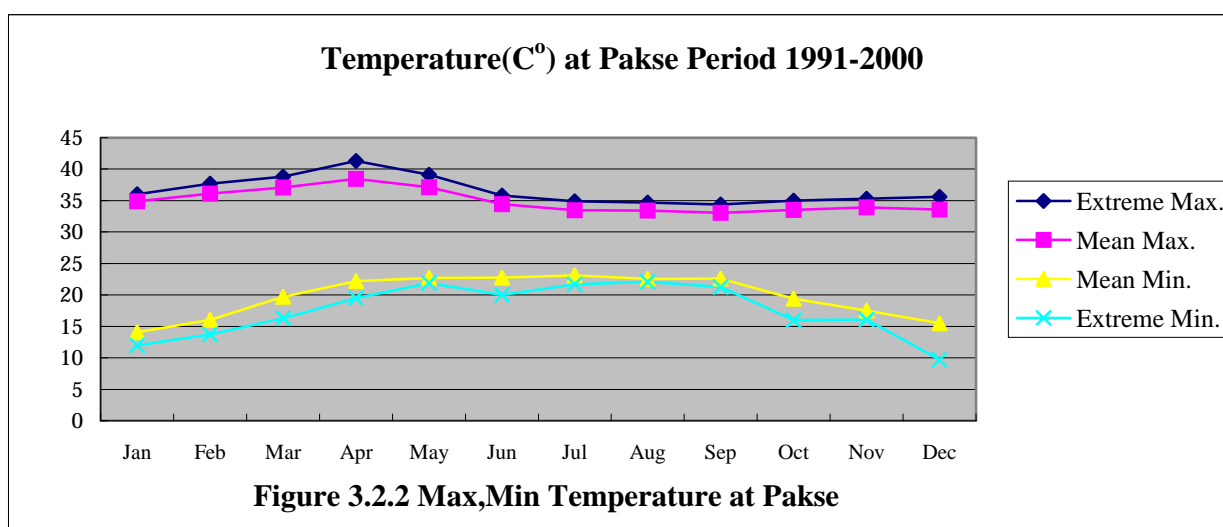


Table 3.2.1 Monthly Water Level of Mekong at Pakse (Period 1991-2000) (m)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	1.73	1.22	1.26	1.40	6.72	8.68	11.76	12.66	13.34	12.45	5.46	3.48
Mean	1.27	0.93	0.91	0.93	3.63	4.86	7.27	9.41	9.56	7.69	3.58	2.31
Min	0.81	0.64	0.55	0.45	0.53	1.04	2.78	6.15	5.77	2.92	1.69	1.14

(1) Temperature

Temperature data for a period of 10 years at Pakse, from 1991 to 2000, were obtained from the meteorological stations. Statistics on temperature are summarized in Figure 3.2.2. The monthly mean maximum and minimum temperature ranges from around 33 to 39 and 14 to 23 respectively. The highest temperature, reaching to 41, was recorded in April, and the extreme lowest was less than 10, in December.



(2) Precipitation

Precipitation data for a period of 10 years, from 1991 to 2000, at the Pakse meteorological station were obtained. Statistics on precipitation are summarized in Table 3.2.2 and Figure 3.2.3. The monthly mean maximum and minimum precipitation are around 370mm in July and 2mm in December and January respectively. The extreme monthly maximum precipitation, reaching to 770mm, is recorded in September.

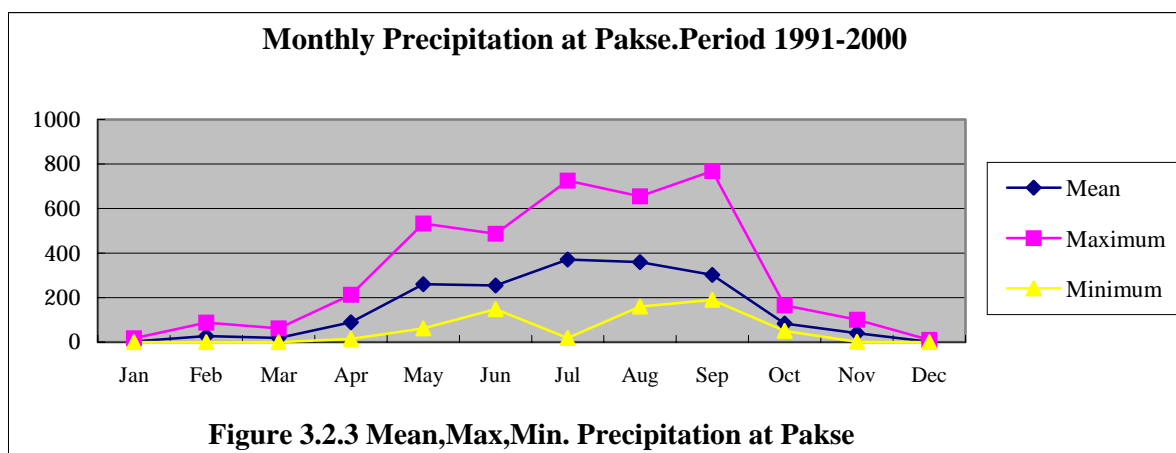


Table 3.2.2 Monthly Precipitation at Pakse (1991 – 2000) (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	16.6	87.8	62.3	212.4	533.5	486.4	725.7	655.7	769.3	165.8	100.0	9.4
Mean	2.5	28.0	18.8	89.7	260.3	253.7	370.2	358.6	301.5	82.8	40.2	2.1
Minimum	0.3	0.1	0.4	14.9	61.1	147.5	18.0	160.1	189.7	50.8	1.0	0.0

(3) Rainy Days

The data of rainy days for a period of 10 years, from 1991 to 2000, at the Pakse meteorological station were obtained. Statistics on rainy days by month are summarized in Table 3.2.3 and Figure 3.2.4. The monthly mean maximum of rainy days are 20 days of over 0 mm rainfall a day in July and August, 6 days of over 20mm rainfall a day in June to October. The monthly mean minimum of rainy days is 0.6 days of over 0 mm rainfall a day and 0.3 days of over 20mm rainfall a day at January respectively. The monthly extreme maximum rainy days are 29 days of over 0 mm rainfall a day in August and 12 days of over 20 mm rainfall a day in May. The monthly minimum rainy days are 0 day in the least and 16 days in the largest of over 0 mm rainfall a day and 3 days of over 20 mm rainfall a day respectively.

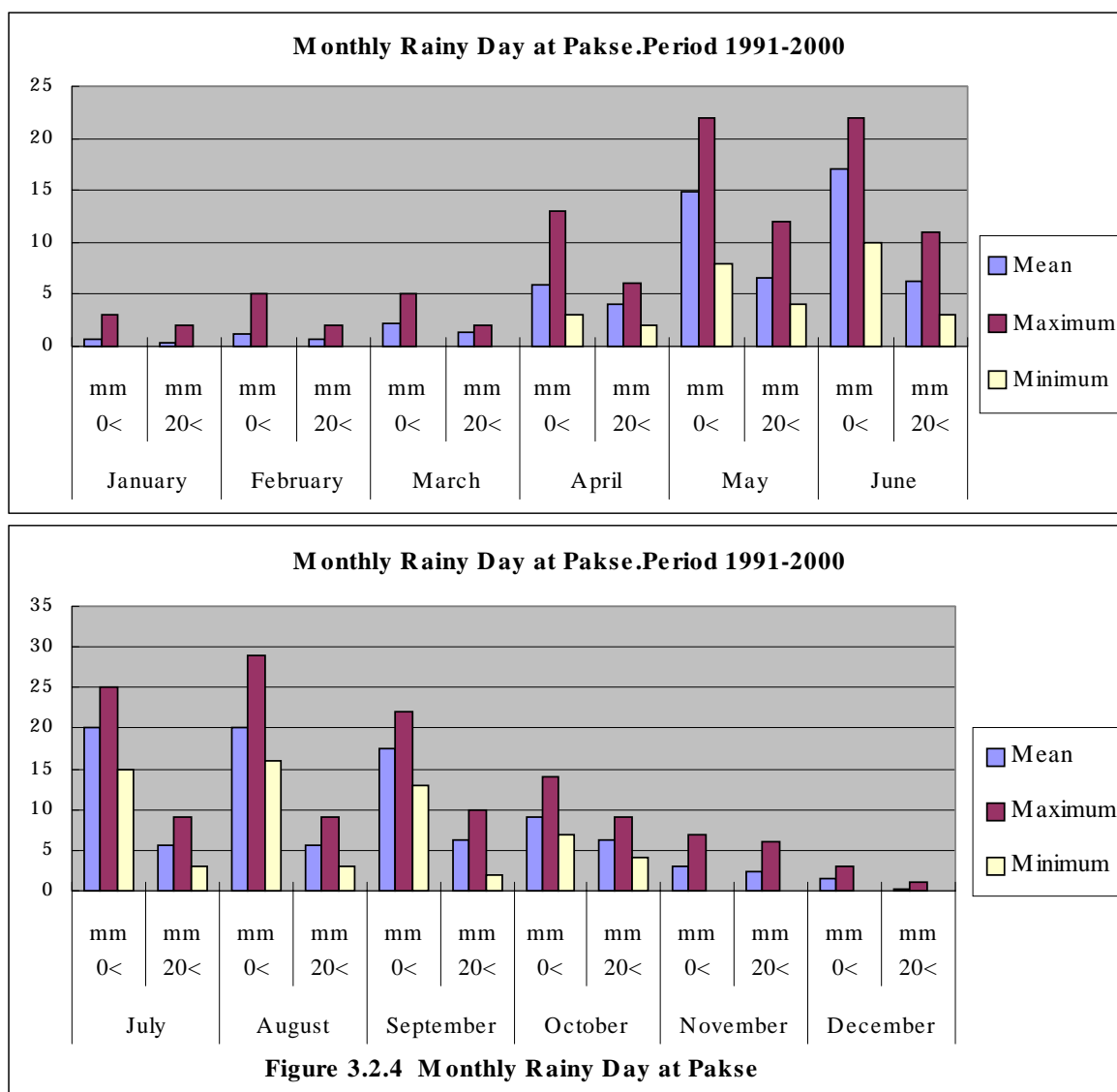


Figure 3.2.4 Monthly Rainy Day at Pakse

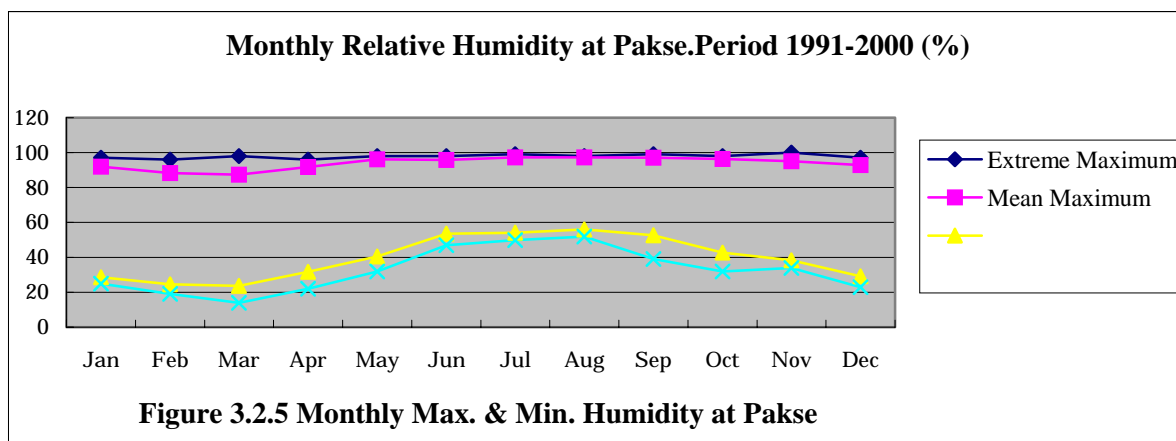
Table 3.2.3 Monthly Rainy Day at Pakse (1991 – 2000)

	January		February		March		April		May		June	
	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<
Maximum	3	2	5	2	5	2	13	6	22	12	22	11
Mean	0.6	0.3	1.1	0.6	2.2	1.3	5.9	4.1	14.9	6.6	17.0	6.3
Minimum	0	0	0	0	0	0	3	2	8	4	10	3

	July		August		September		October		November		December	
	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<
Maximum	25	9	29	9	22	10	14	9	7	6	3	1
Mean	20.0	5.6	20.0	5.6	17.5	6.2	9.1	6.3	3.0	2.4	1.6	0.3
Minimum	15	3	16	3	13	2	7	4	0	0	0	0

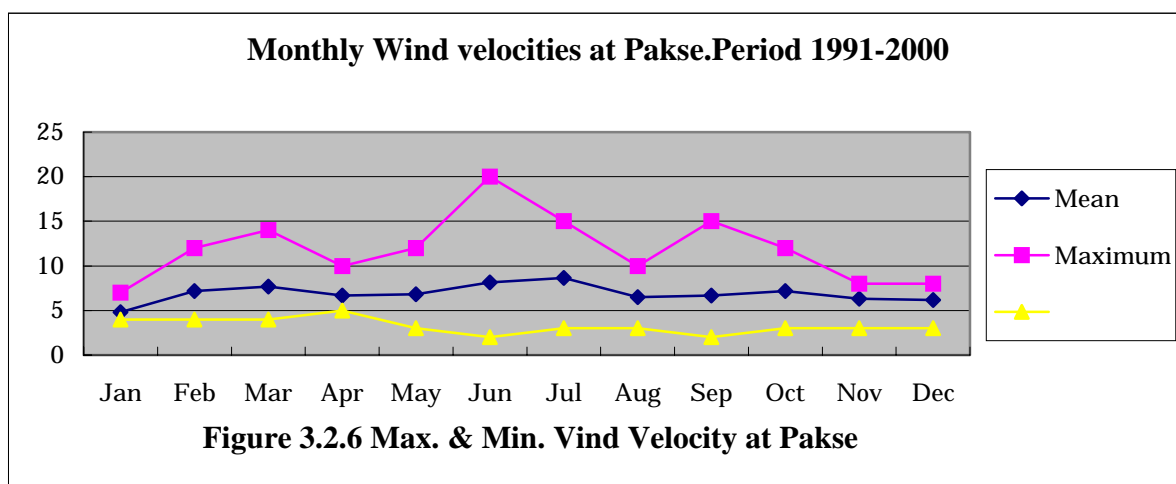
(5) Humidity

The Study Team obtained the humidity data for a period of 10 years, from 1991 to 2000, at the Pakse meteorological station. Statistics on the humidity are summarized in Figure 3.2.5. The monthly mean maximum and minimum ranges from around 88 to 97 % and 25 to 56% respectively. The extreme maximum humidity is 100 % in November and the minimum one is 14 % in March.



(6) Wind Velocity

The wind velocity data for a period of 10 years, from 1991 to 1996, at the Pakse meteorological station could be obtained. Statistics on the wind velocity are summarized in Figure 3.2.6. According to the statistics, the monthly mean wind velocity ranges from around 5 to 9 m/s. The monthly maximum and minimum wind velocities are 20 m/s in June and 2m/s in September respectively.



(7) Characteristic of Waterways on Route 14A

The major characteristics of waterways, observed by the Study Team, are summarized in Table 3.2.4. The location of each waterway is shown in Figure 3.1.1.

Table 3.2.4 Characteristics of Waterways at the Bridge Site for Route 14A

No	River name	Km Post	Village name	Catchmen Area km ²	River Length km	Hight m	Width	River Bank	Note
1	Thok	5.39	Natakon	9.6	7.00	500	20	Silt & sand	
2	Maknao	7.45	Nonghoy	0.8	1.40	200	10		
3	Namxan	7.95					10		
4	No Name	8.45		0.9	1.30	200	10		
5	No Name	9.05		1.6	1.80	500	10		
6	Gnang	9.38		1.2	1.00	300	15		
7	No Name	9.48		1.1	1.40	300	20		
8	Imet	11.00		4.6	2.70	600	25		
9	Kaunam	11.40					10		
10	Khao dam	12.12					10		
11	Thakhong	13.63	Thaphakkha	4.6	3.30	700	15	Silt & sand	
12	Thapxang	14.54	Houaphakho	3.5	2.30	600	30	Silt & sand	
13	Khone liao	15.82		1.5	2.40	600	20	Silt & sand	
14	Khonken	17.04	Khonken	3.2	2.70	600	30	Silt & sand	
15	Hong	18.32	Khonken	3.4	2.50	600	15	Silt & sand	
16	He	19.00	khonken	3.1	2.70	700	25	Silt & sand	
17	Dua	19.89	Khangnang	0.8	0.80	200	15	Silt & sand	
18	Sai	21.43	Vatxai	6.6	4.20	600	40	Silt & sand	
19	Phaphin	24.35	Champasack	6	4.50	500	15	Silt & sand	
20	Phabang	29.44	Champasack	22.5	8.50	300	40	Silt & sand	
21	Sahoua	32.21	Champasack	20	10.00	900		Silt & sand	
22	Kok	32.61	Champasack	6.4	7.70	300		Silt & sand	
23	Thateng	40.61	Dontalat	11.5	14.70	900	18	Silt & sand	
24	Manpha	45.49	Nongbeng	15	10.00	10	24	Silt & sand	

Source: The Study Team

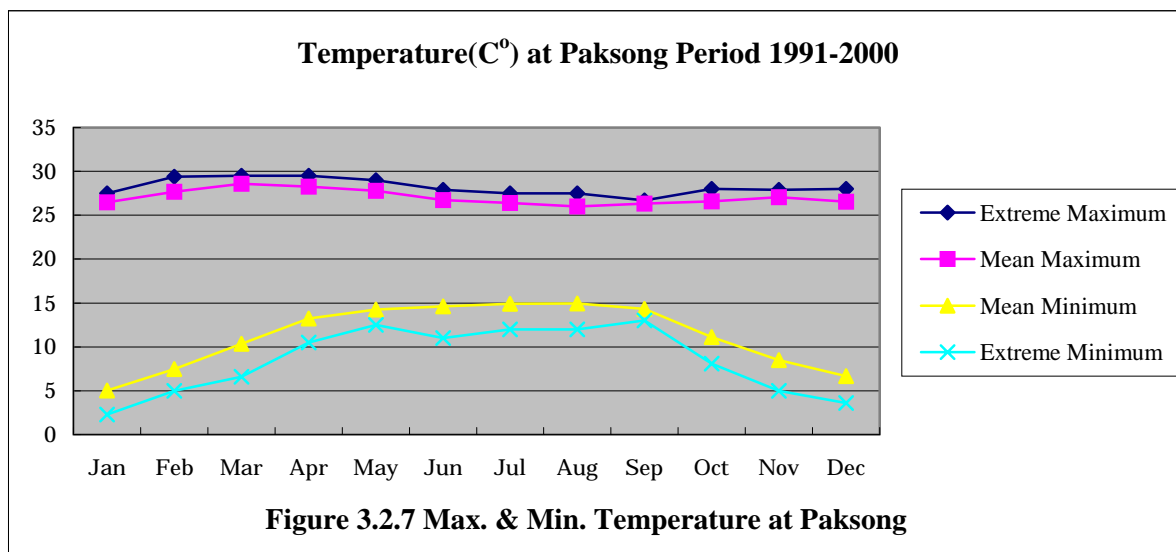
As a result, 24(twenty four) waterways crossing the proposed Route 14A were identified and it is confirmed that all of them flow into the Mekong River. These waterways have relatively small catchment area, ranging from 1 km² to 20 km² and short river length.

3.2.2 Route 16A

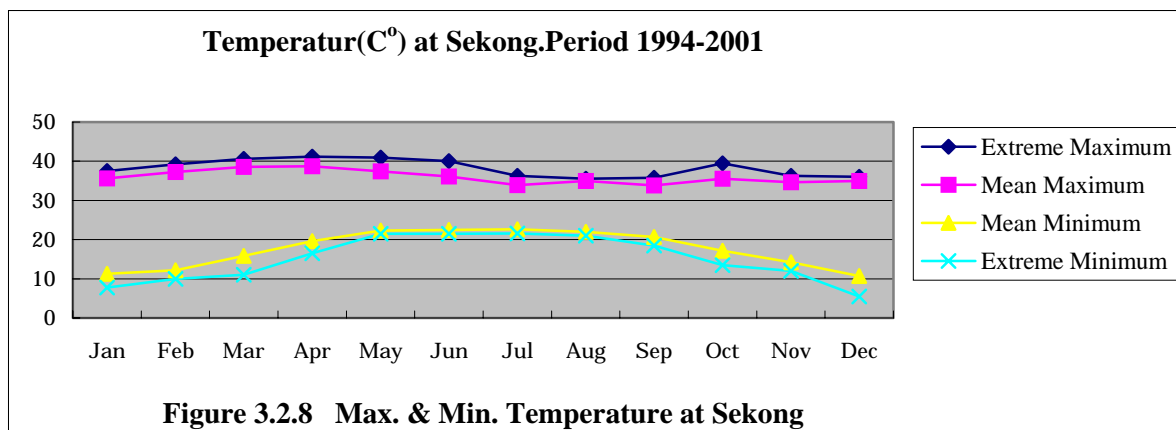
Route 16A is located in Boloven Plateau, about 50 km east from Pakse, and heading for east from Paksong with about 64 km in the total length. The road elevation ranges from about 900m to 1300m at the plateau section. The first 30km section belongs to the watershed of Boloven Plateau. After that, the road goes down along Xe Namnoy, tributary of Sekong River, and crosses rivers at 6 crossing points, and finally reaches to Route 11. The elevation becomes about 140m at the end of the route. Because of its elevation difference, the meteorological data were collected at Paksong and Sekong to grasp this area precisely. The observation data in detail is compiled in ANNEX F-10.

(1) Temperature

The Study Team obtained the temperature data for a period of 10 years, from 1990 to 2000, from the Paksong meteorological station. Statistics on these data are summarized in Figure 3.2.7. The monthly mean maximum and minimum temperature ranges from around 26 to 29 and 5 to 15 respectively. The highest temperature, reaching to 29.5, is recorded in March and April, and the extremely lowest, less than 3, in January.



The temperature data for a period of 8 years, from 1994 to 2001, at the Sekong meteorological station also were obtained. Statistics on these data are summarized in Figure 3.2.8. The monthly mean maximum and minimum temperature ranges from around 34 to 39 and 11 to 22 respectively. The highest temperature, reaching to 41, is recorded in April, and the extremely lowest, less than 6, in December.



(2) Precipitation

The Study Team collected the precipitation data for a period of 10 years, from 1991 to 2000, at the Paksong meteorological station. Statistics on precipitation are summarized in Figure 3.2.9 and Table 3.2.5. The monthly mean maximum and minimum precipitation are around 660mm in August, and 14 mm in January respectively. The extremely monthly maximum precipitation, reaching to 1500 mm, is recorded in July.

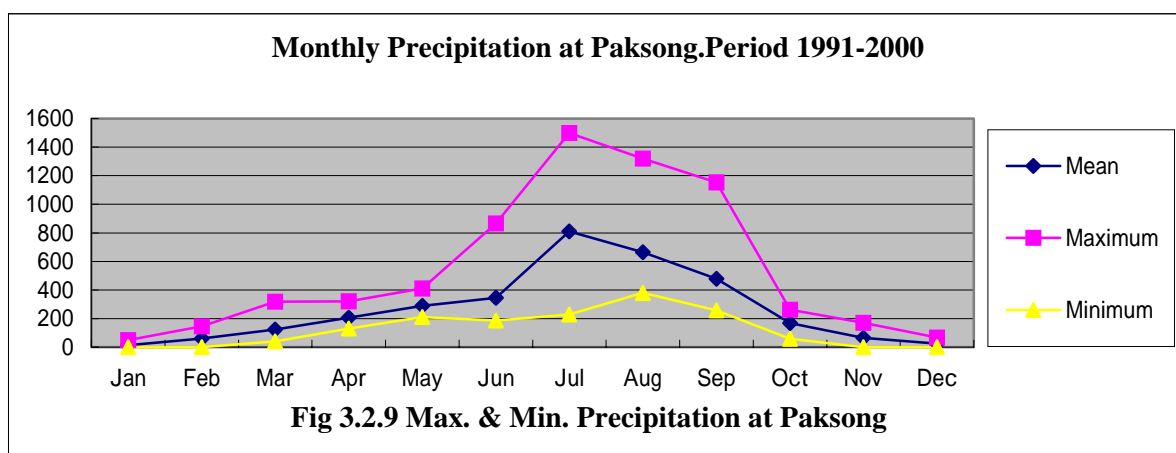


Table 3.2.5 Monthly Precipitation at Paksong (1991 – 2000) (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	50.4	145.9	318.2	319.8	410.5	866.7	1499.8	1318.7	1153.6	262.0	170.1	67.2
Mean	14.0	59.9	122.7	206.6	289.3	346.3	810.2	663.8	477.2	169.4	65.1	25.5
Minimum	0.0	0.3	40.2	130.2	211.2	186.4	229.3	378.2	258.2	57.9	0.2	0.0

The precipitation data for a period of 13 years, from 1989 to 2001, at the Sekong meteorological station also were collected. Statistics on these data are summarized in Figure 3.2.5 and Table 3.2.6. The monthly mean maximum and minimum precipitation are around 300 mm in July and 2 mm in January respectively. The extremely monthly maximum precipitation, slightly over 500 mm, is recorded in July.

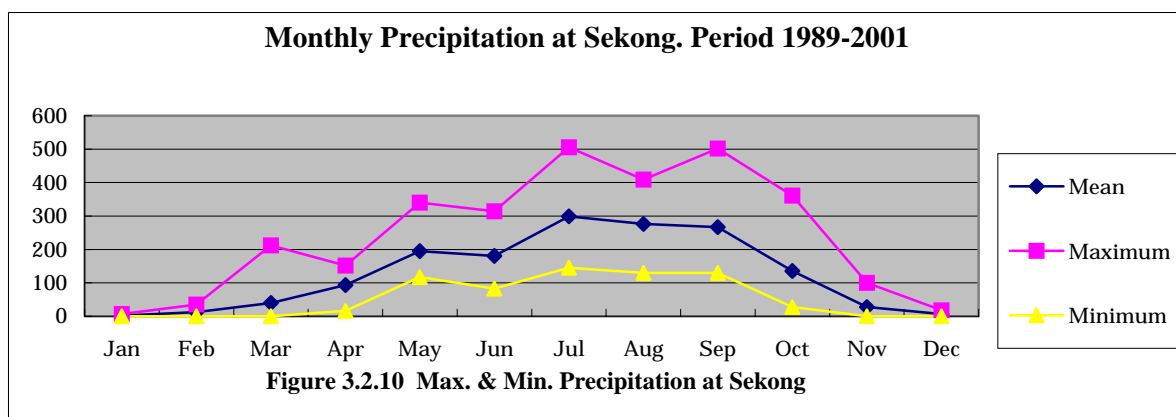


Table 3.2.6 Monthly Precipitation at Sekong (1989 – 2001) (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	6.8	35.8	212.5	152.0	340.3	314.0	505.0	409.3	501.3	361.5	100.1	18.0
Mean	1.9	12.2	40.3	94.0	195.3	180.8	299.4	276.5	266.5	136.0	28.0	7.1
Minimum	0.0	0.0	0.0	16.6	117.2	83.3	145.0	130.1	130.3	27.6	0.0	0.0

(3) Rainy days

The rainfall data for a period of 10 years, from 1991 to 2000, at Paksong meteorological station were obtained for the study. Statistics on the rainy days are summarized in Figure 3.2.11 and Table 3.2.7. The monthly mean maximum of rainy days are 17 days of over 0 mm rainfall a day in May and July, 12 days of over 20 mm rainfall a day in August. The monthly mean minimum of rainy days are 2.5 days of over 0 mm rainfall a day and 0.1 days of over 20 mm rainfall a day in January respectively. On the one hand, the monthly maximum rainy days are 22 days of over 0 mm a day in May and 19 days of over 20 mm rainfall in July. The monthly minimum rainy days are 0 day at smallest and at the largest are 14 days of over 0 mm rainfall a day in July, 8 days of over 20 mm rainfall a day in August respectively.

The Study Team collected a number of rainy days per month for a period of 11 years, from 1991 to 2001, at Sekong meteorological station. Statistics on the rainy days are summarized in Figure 3.2.11 and Table 3.2.8. The maximum monthly mean of the rainy days are 21 days of over 0 mm a day in July, 3 days of over 20 mm over in July, August and September. The minimum monthly mean of rainy days are 1.5 and 0 days of over 0 mm a day in January

respectively. The monthly maximum rainy days are 29 days of over 0 mm a day in June and 7 days of over 20 mm in July and September. The monthly minimum rainy days are 0 day at the smallest and 6 days at the largest of over 0 mm a day in June, 0 days of over 20 mm a day respectively.

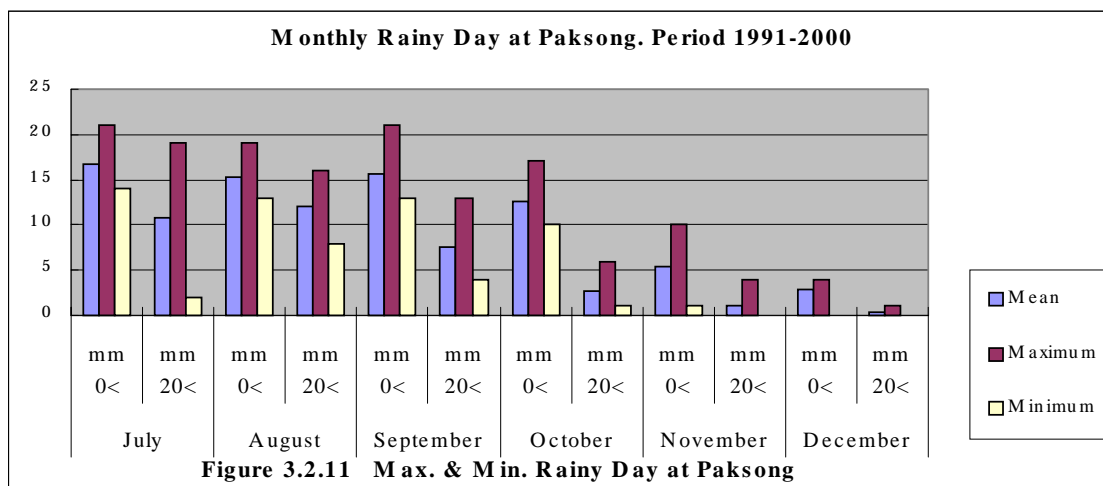
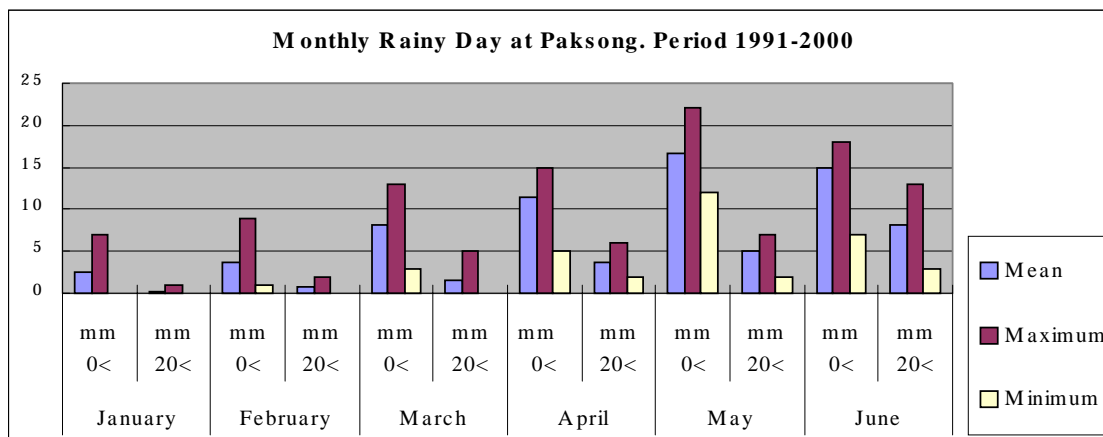


Figure 3.2.11 Max. & Min. Rainy Day at Paksong

Table 3.2.7 Monthly Rainy day at Paksong (1991 – 2000)

	January		February		March		April		May		June	
	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<
Maximum	7	1	9	2	13	5	15	6	22	7	18	13
Mean	2.5	0.1	3.7	0.7	8.2	1.5	11.4	3.7	16.7	5.1	14.9	8.2
Minimum	0	0	1	0	3	0	5	2	12	2	7	3

	July		August		September		October		November		December	
	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<
Maximum	21	19	19	16	21	13	17	6	10	4	4	1
Mean	16.7	10.8	15.3	12.0	15.7	7.6	12.6	2.7	5.4	1.0	2.8	0.3
Minimum	14	2	13	8	13	4	10	1	1	0	0	0

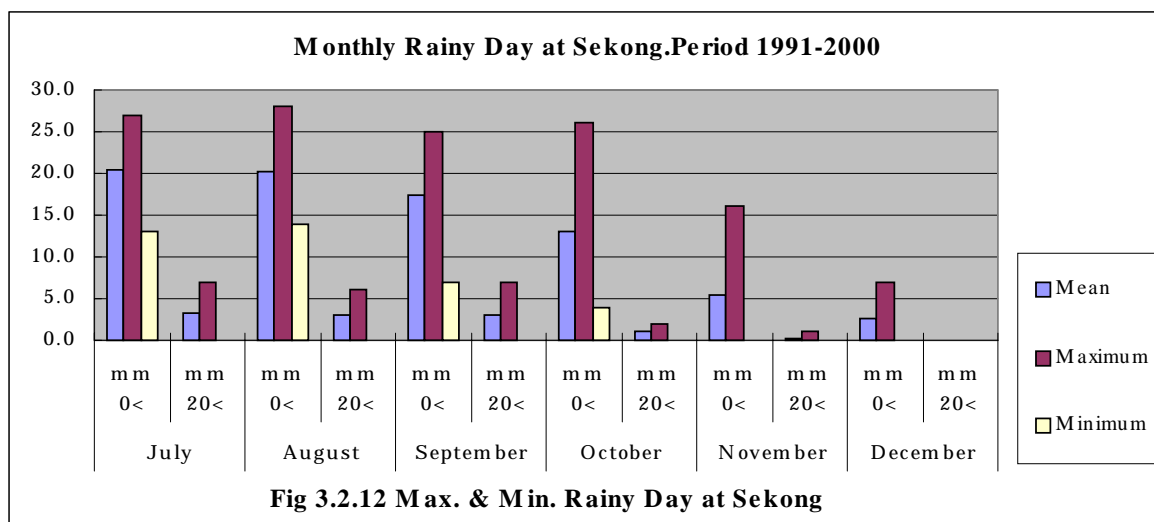
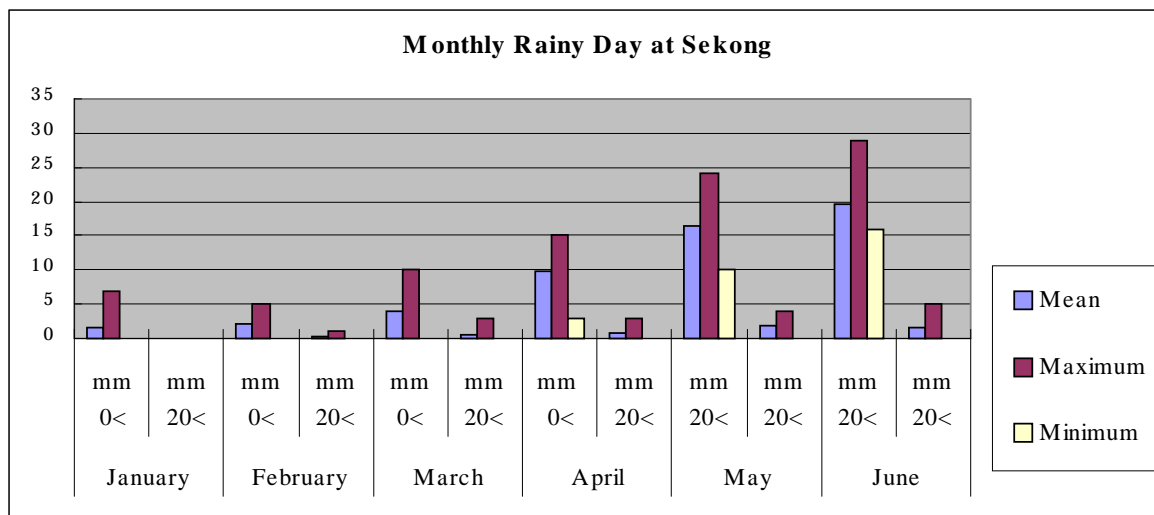


Fig 3.2.12 Max. & Min. Rainy Day at Sekong

Table 3.2.8 Monthly Rainy day at Sekong (1991 – 2001)

	January		February		March		April		May		June	
	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 20<	mm 20<	mm 20<	mm 20<
Maximum	7	0	5	1	10	3	15	3	24	4	29	5
Mean	1.6	0.0	2.1	0.2	4.0	0.5	9.7	0.8	16.5	1.9	19.7	1.5
Minimum	0	0	0	0	0	0	3	0	10	0	16	0

	July		August		September		October		November		December	
	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<	mm 0<	mm 20<
Maximum	27	7	28	6	25	7	26	2	16	1	7	0
Mean	20.5	3.2	20.2	3.0	17.3	3.1	13.0	1.0	5.5	0.2	2.6	0
Minimum	13	0	14	0	7	0	4	0	0	0	0	0

(4) Characteristic of Each River for the Route 16A

The characteristics of each river, observed by the Study Team, are summarized in Table 3.2.9. The location of each river is indicated in Figure 3.1.2.

Table 3.2.9 Characteristics of Each River at the Bridge Site for Route 16A

No	River name	Km Post	Village name	Catchmen Area km2	River Length km	Hight	Width	River Bank	Note
1	Makchan-Gu	17.575	B. Chansavan	33.0	13.0	200	24.0	Rock	
2	Namtang	35.550		56.0	21.0	310	30.0	Soil	
3	Xe Katam	45.997		296.0	52.0	1100	50.0	Big stone	
4	Xe Namnoy-1	51.655		1170.0			59.5	Boulder	
5	Xe Namnoy-2	51.845					24.5	Boulder	
6	Huay Ho	52.175		71.0	19.0	660	24.5	Boulder	With out Dam basin
7	No Name	61.473	Ban Lak56	4.2	6.0	700		Box C.	

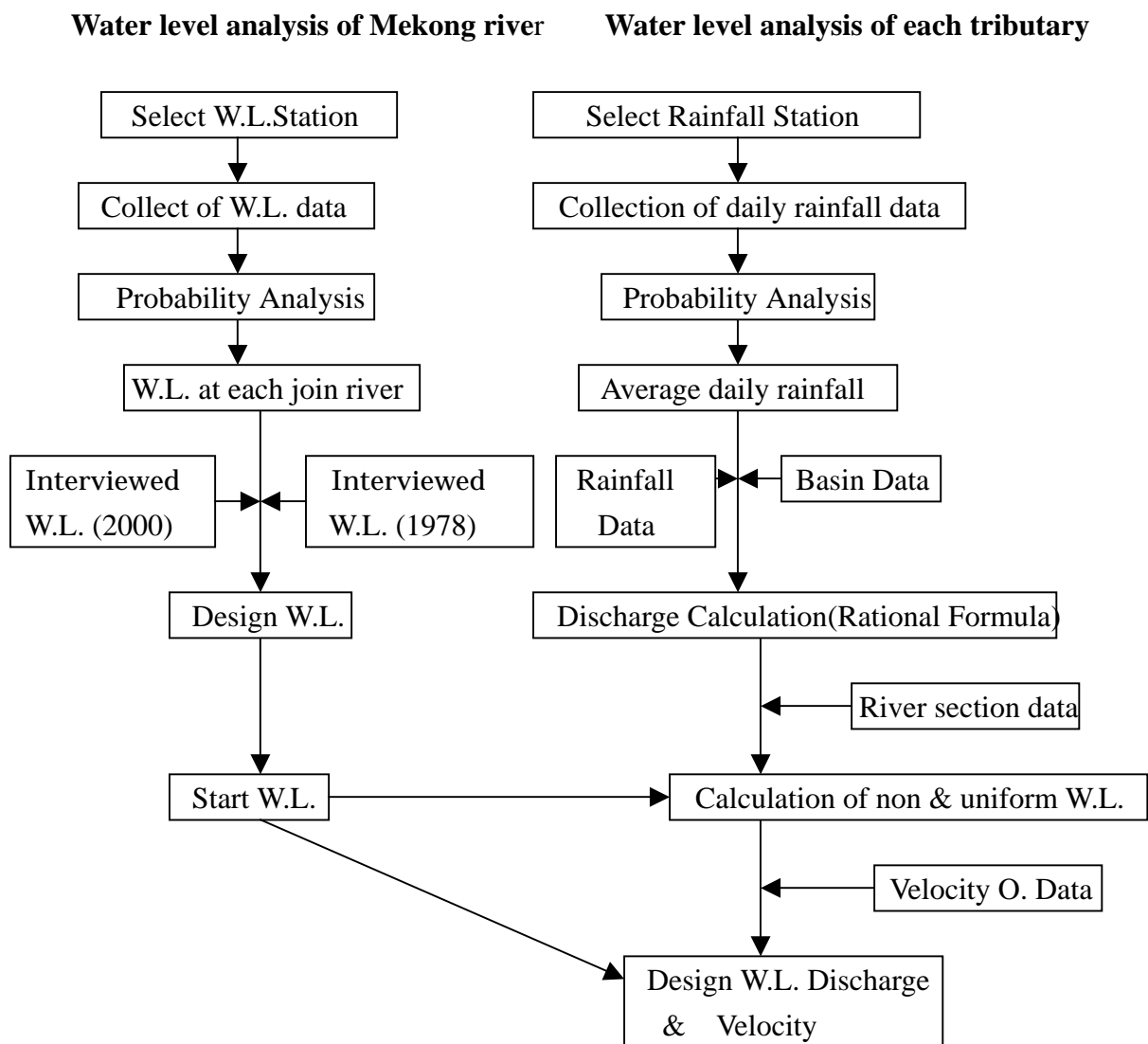
The characteristics of the rivers on Route 16A are diverse in the catchment area and river length. In general, those rivers have rapid flow and the riverbed with boulders and rock.

3.3 Hydrological Analysis of the Study River

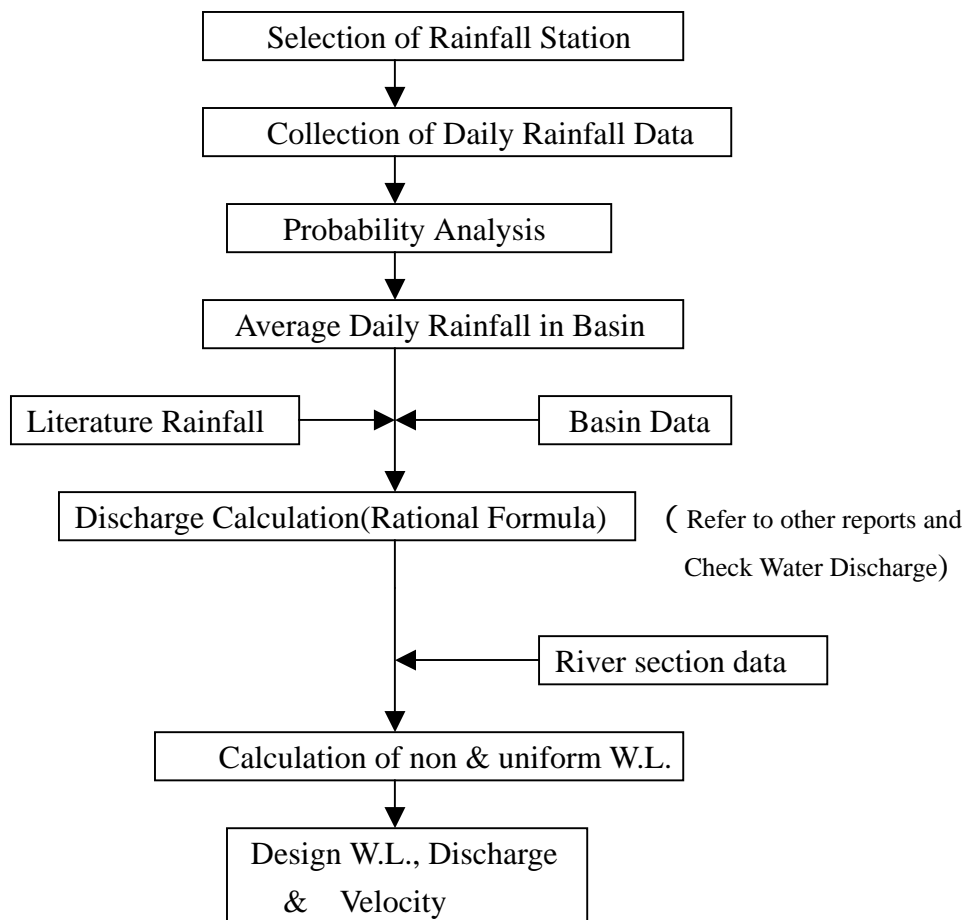
3.3.1 Hydrological Analysis Approach

The hydrological analysis is undertaken to determine the design water level, discharge and velocity at proposed bridge sites. The procedure of the analysis is shown by each road route i.e., 14A and 16A based on their characteristics.

(1) Route 14A



(2) Route 16A For Xe Namnoy Basin



3.3.2 Selection of Hydrological Station

The location of the hydrological observation stations, which the data were obtained for this study, is indicated in Figure 3.3.1.

(1) Route 14A

As for the water level of Mekong River, there are three observatories near the route; namely Pakse, Phaphin and Channoy. The location of each observatory is indicated in Figure 3.3.1. In addition, the availability of water level data is indicated in Table 3.3.1.

The each data in detail are shown in ANNEX F-10.

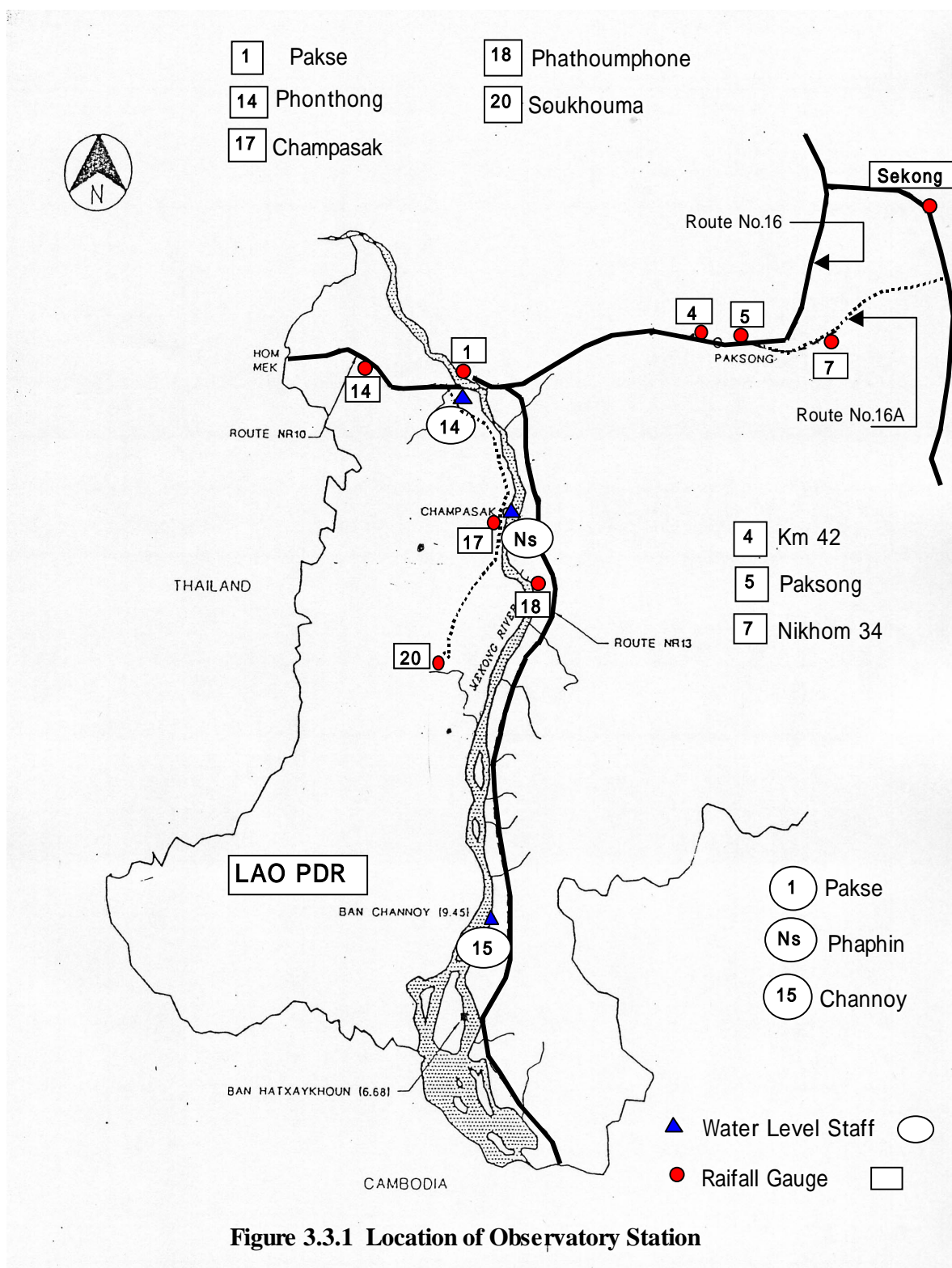


Figure 3.3.1 Location of Observatory Station