(3) Present Land use of Champasak Province

Total area of the Champasak province is about 1,541,000 ha. and classified broadly into two areas i.e. Plain and Plateau. The present land use of the province is shown in Figure 2.2-1.

Land use	Area (%)	Plain area	Plateau area
– Rice planting area	287,034ha(19%)	283,839	3,195
– Industrial crops and fruits trees	151,923 (10%)	123,148	28,775
– Coffee planting	127,333 (8%)	–	127,333
– Tea planting	972 (–)	–	972
– Grass plain	107,762 (7%)	80,097	27,665
– Forest for replanting the tree–plants	245, 960 (16%)	245,960	–
– Deep forest	78,323 (5%)	77,597	726
– Conserved forest	541,680 (35%)	323,845	217,835
Total	1,541,000 (100%)	1,134,500	406,500

About 56% of total area is covered with the forest area (= 866,000 ha) and 26% is identified as plateau area.

2.2.2 Population

Table 2.2-2 indicates the population distribution by district in the Champasak province in 1985 and 1994. Pakse is the most densely populated city with 187 people per square km in 1994. The districts with the fastest growth rates are Mounlapamok (3.0% per year), Bachiang (2.6%) and Pakse (2.4%).

2.2.3 Economic Activity

(1) Characteristics of each District in Champasak Province

- The Paksong district is located on the Bolovens Plateau and assigned as a forest development zone, coffee production zone, hydropower development and natural tourism development zone.
- The Bachiang district is assigned as industrial production plantation zone for short and long term.
- The district of Champasak, Phonthong, Soukhouma and Sanasomboun have good soil suitable for the plantation of coffee and other fruit trees.
- The Pathoumphon district is an area for livestock and for the construction of pool water.
- The Khong district is the natural and cultural tourism zone which can link with other provinces where there are some antique ruins.
- The Pakse district is the center of economic production, commerce and tourism.

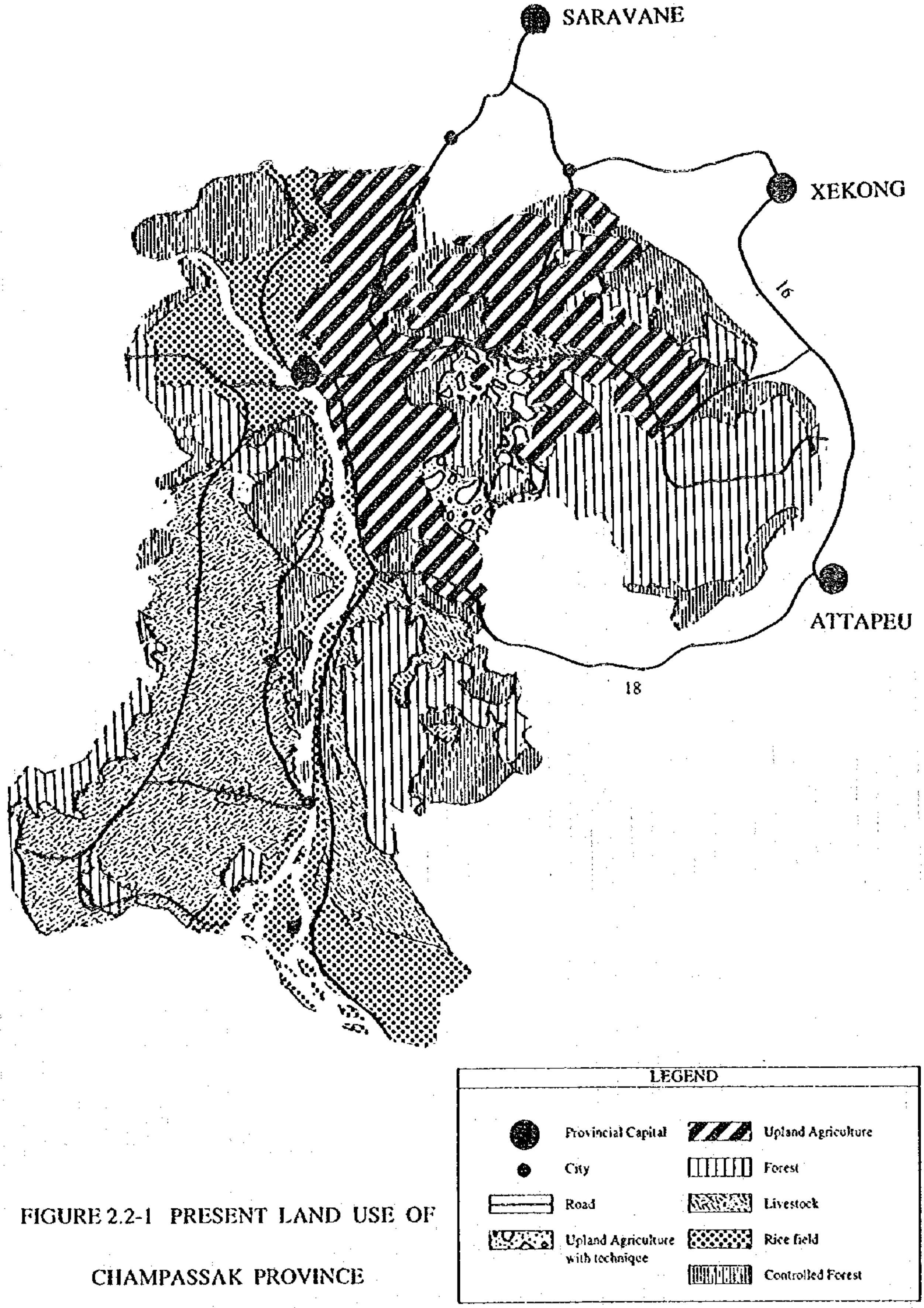


FIGURE 2.2-1 PRESENT LAND USE OF CHAMPASSAK PROVINCE

TABLE 2.2-2 POPULATION BY DISTRICT IN CHAMPASAK PROVINCE (1985 - 1994)

District	Land Area (km^2)	1985	1994	Density 1994 (persons/km^2)	Avg.Annual Growth Rate(%)
1. Pakse	320	48,519	59,934	187.3	2.4
2. Sanasomboun	780	43,660	52,782	67.7	2.1
3. Bachiang	828	24,112	30,363	36.7	2.6
4. Paksong	3,532	37,130	41,658	11.8	1.3
5. Pathoumphon	2,204	34,226	41,517	18.8	2.2
6. Phonthong	1,190	58,682	68,698	57.7	1.8
7. Champasak	798	42,265	46,717	58.5	1.1
8. Soukhouma	1,200	30,489	36,258	30.2	1.9
9. Mounlapamok	2,198	23,554	30,726	14.0	3.0
10. Khong	2,360	60,404	63,653	27.0	0.6
TOTAL	15,410	403,041	472,306	30.6	1.8

Source : CPC-Champasak Province

(2) Agriculture in the Study Area

Agriculture activities in the study area are dominated by rice cultivation. Harvested area for rice and its production are about 77% of total crops in the study area as shown in Table 2.2-3. Coffee and tea of the whole country are mainly planted in the study area with 96% and 92% of the total harvested area respectively. The central feature of the study area is the Boloven Plateau, which extends from Champasak to Saravane and Sekong provinces. This has a temperate climate and can grow a wide variety of fruits and vegetables with export potential. Production of coffee of this area is very important.

(3) Industry and Commerce in the Study Area

According to the statistical information, small establishments (fewer than 10 employees) dominate private businesses in Lao and study area as shown in Table 2.2-4. More detailed information provided by the Ministry of Industry in Pakse is summarized in Table 2.2-5. The table indicates that about 40% of manufacturing factories in the Champasak province are located in the Pakse district and each of the district has its own sawmill. Of the total 890 factories in the province, 515 factories are rice mills

TABLE 2.2-3 HARVESTED AREA AND PRODUCTION OF CROPS IN STUDY AREA

(1994)

Harvested Area in Study Area (ha)							Whole	%
	Saravane	Sekong	Champasak	Attapeu	Total (A)	%	country (B)	(A/B)*100
Rice	41,976	6,376	76,896	13,109	138,357	77.4	599,900	23.1
Maize	381	1,134	304	510	2,329	1.3	28,100	8.3
Starchy roots	500	2,640	89	654	3,883	2.2	21,900	17.7
Vegetable/Beans	2,150	2,800	180	700	5,830	3.3	16,500	35.3
Soybeans	785	7	593	27	1,412	0.8	6,300	22.4
Peanuts	449	5	466	40	960	0.5	5,000	19.2
Tabacco	740	260	633	50	1,683	0.9	7,300	23.1
Cotton	112	1,100	72	9	1,293	0.7	7,200	18.0
Sugarcane	80	70	70	50	270	0.2	2,700	10.0
Coffee	4,012	1,200	13,955	23	19,190	10.7	20,000	96.0
Tea	3,217	0	358	0	3,576	2.0	3,900	91.7
Total	54,402	15,592	93,616	15,172	178,783	100.0	718,800	24.9
Production of Harvested Area in Study Area (tons)							Whole	%
	Saravane	Sekong	Champasak	Attapeu	Total (A)	%	country (B)	(A/B)*100
Rice	124,600	13,100	226,700	34,200	398,600	76.9	1,577,100	25.3
Maize	862	1,361	1,113	608	3,944	0.8	55,800	7.1
Starchy roots	17,210	19,294	598	1,131	38,233	7.4	159,500	24.0
Vegetable/Beans	18,275	30,800	1,830	2,450	53,355	10.3	156,400	34.1
Soybeans	785	4	476	24	1,289	0.2	6,000	21.5
Peanuts	763	3	352	39	1,157	0.2	4,800	24.1
Tabacco	3,750	1,326	301	50	5,427	1.0	31,800	17.1
Cotton	56	660	39	2	757	0.1	5,900	12.8
Sugarcane	2,289	1,780	917	1,194	6,180	1.2	65,100	9.5
Coffee	1,253	720	6,280	17	8,270	1.6	9,000	91.9
Tea	907	0	86	0	993	0.2	1,900	52.3
Total	170,750	69,048	238,692	39,715	518,205	100.0	2,073,300	25.0

Source : Basic Statistics about the Socio-Economic Development in the LAO PDR 1975-1995, CPC, NSC.

TABLE 2.2-4 BUSINESS ESTABLISHMENTS

	Establishment Size			
	Large	Medium	Small	Total
Saravane	3	7	984	994
Sekong	2	7	89	98
Champasak	27	20	3893	3940
Attapeu	0	0	350	350
Total	32	34	5316	5382
Lao PDR	444	611	24752	25807

Source : Basic Statistics 1975-1995,CPC, NSC.

Remark : Largr > 30 employees
Medium = 10-29 employees
Small < 10 employees

TABLE 2.2-5 NUMBER OF FACTORIES IN CHAMPASAK PROVINCE (Aug. 1995)

No. Factory type	Pakse	Phonthong	Champasak	Sanasomboun	Soukhoumma	Muangkhong	Paksong	Bachieng	Mounlapamok	Pathoumphone	TOTAL
1 Fish sauce	2										2
2 Charcoal										3	3
3 Pottery	1										1
4 Ice	52	1	1	4							58
5 Medicines	2										2
6 Rice mill	65	52	1	87	55	97	34	64	32	28	515
7 Coffee mill							26				26
8 Saw mill	10	1	1	1	1	1	1	1	1	1	19
9 Coffee pulverizer	3										3
10 Noodle	18					5					23
11 Furniture	31			1	1	3	1				37
12 Printing	2										2
13 Grinding shop	25										25
14 Bean sprout	1										1
15 Paper	1										1
16 Drinking water	5										5
17 Bread / cake	16										16
18 Garment	18										18
19 Seat	2										2
20 Shoes	1										1
21 Silver / gold	7										7
22 Bricks	24	1							1	1	27
23 Alcohol	1										1
24 Welding shop	21										21
25 Electrical repair	7										7
26 Electrical installation	3										3
27 Electricity supply							1				1
28 Car & motor repair	54										54
29 Nails	1										1
30 Cotton	1										1
31 Machinery engineering	1										1
32 Rice miller factory	1										1
33 Steel bar	1										1
34 Rattan	1										1
35 Refrigerator repair	3										3
TOTAL	381	55	3	93	57	106	63	65	34	33	890

Source : Ministry of Industry (Pakse)

(4) Water Resources

There are many big and small rivers in the Champasak province. The most important river is the Mekong River snaking across from north to south and supplying enough water for agriculture works and for rural transportation. Another important river, Xedone, comes from Saravane province through Sanasomboun district and enter to the Pakse district and influence to the Mekong river. The people live at both sides of this river using it in agricultural works, transportation, fishing and for daily life. The rivers in the province are also used to construct the pool water and many irrigation systems.

(5) Hydropower

In addition to agricultural industry, the most important industrial sector in the study area is development of hydro electric schemes. At present, 2 hydro electric power stations are under operation, one is 45 MW station at Xeset in Saravane province and the other is Selabam 5 MW hydrostation in the Champasak province. From these, electricity can be exported to Thailand in the rainy season.

Hydro electric projects which are under construction or planned to be operated in near future in the study area are listed below :

- Houei Ho project (Attapeu province) a US$200 million 150 MW capacity, DAEWOO Corporation of South Korea, on a BOT basis.
- Se Kaman project (Attapeu province) 250 MW capacity, HEC (Australia),
- Senamnoy project (Boloven Plateau (Champasak province) 300MW, DONGAH (South Korea)

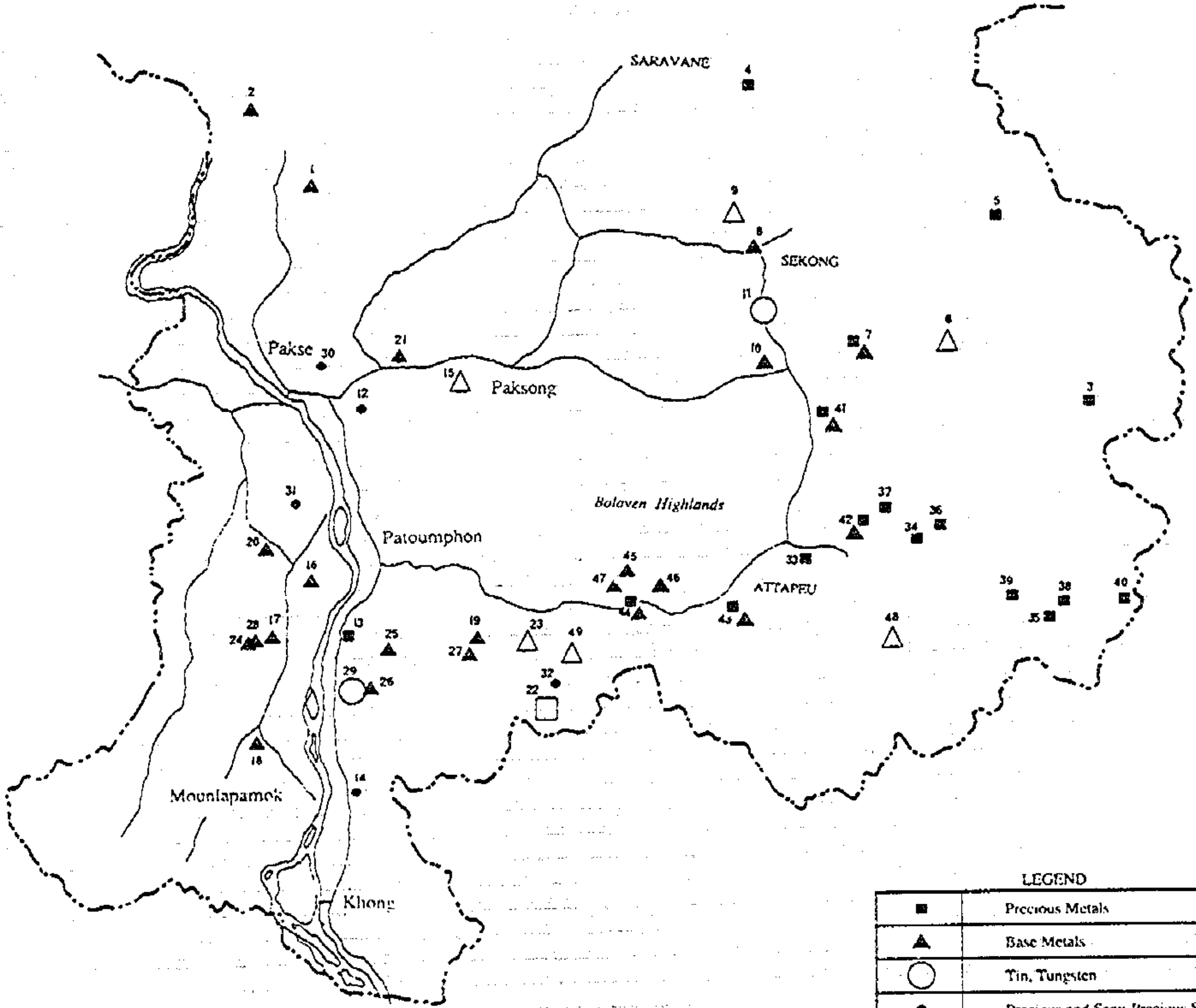
Total 17 hydro power projects are planned in the study area toward the next century.

(6) Mining Potential in the Study Area

The mineral potential in the study area is good. There is a 50-km band of coal across eastern Saravane and north western Sekong provinces. Gold production on a artisanal scale is important in Sekong and Attapeu provinces. Copper deposits and gemstones in the Champasak province are attracting commercial interest. There are many kinds of mineral deposits in the study area as shown in Figure 2.2-2.

(7) Vehicle Ownership

The past trend of number of registered vehicles (1985 - 1995) in the Champasak province is shown in Table 2.2-6. Total 12,000 vehicles are registered at the mid-year of 1995 of which the share of motorcycles is about 80% (=9,600). The rate of ownership is about 2 vehicles (including motorcycles) per 100 persons. The table shows the volumes of newly registered vehicles by each year and together with its accumulation. A rapid growth in motorcycle registration is observed. Total 2,885 motorcycles were registered from 1994 to mid-year 1995.



Province	No.	Mineralogy of Deposit	
Saravane	1	Cu	copper
	2	Ph	lead
Sekong	3	Au	gold
	4	Au	
	5	Au	
	6	bx	bauxite
	7	Cu,Au, Ag	+ silver
	8	Cu	
	9	gr	graphite
	10	pb, Zn	+ zinc
	11	Sn	tin
Champasak	12	ab	amber
	13	Ag, Au	
	14	am	amethyst
	15	bx	
	16	Cu	
	17	Cu	
	18	Cu	
	19	Cu	
	20	Cu	
	21	Cu	
	22	ha	halite
	23	k	kaolin
	24	ph	
	25	ph	
	26	ph	
	27	ph	
	28	ph	
	29	Sn	tin
	30	tp, zr	topaz,zircon
	31	zr	
Attpeu	32	ab	
	33	Au	
	34	Au	
	35	Au	
	36	Au	
	37	Au	
	38	Au	
	39	Au	
	40	Au	
	41	Cu, Ag	
	42	Cu, Au, Ag	
	43	Cu, Au, Ag	
	44	Cu, Au, Ag	
	45	Cu	
	46	Pb	
	47	Pb	
	48	pd	pagodite, pyrophyllite
	49	pd	

Source : Mineral Exploration and Development Plan
Department of Geology and Mines (DGM)
Ministry of Industry and Handicraft

LEGEND

■	Precious Metals
▲	Base Metals
○	Tin, Tungsten
●	Precious and Semi-Precious Stones
△	Industrial Minerals
□	Evaporites

FIGURE 2.2-2 MINERAL OCCURRENCE IN STUDY AREA

TABLE 2.2-6 NUMBER OF NEWLY REGISTERED VEHICLES BY EACH YEAR CHAMPASAK PROVINCE (1985 - 1995)

Vehicle Type	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Motorcycle	43	492	557	883	765	569	916	1,359	1,174	1,304	1,581
Bus	27	87	97	146	72	126	415	284	326	198	252
Car, Pickup, Truck	6	46	86	46	30		81	34	9	3	2
Total	76	625	740	1,075	867	695	1,412	1,677	1,509	1,505	1,835
Accumulated Volume(Total)	76	701	1,441	2,516	3.383	4,078	5,490	7,167	8,676	10,181	12,016
Accumulated Motorcycles	43	535	1,092	1,975	2.740	3,309	4,225	5,584	6,758	8,062	9,643

Source : MCTPC-Pakse 1995

2.2.4 Road Network in Study Area

The road network in southern provinces(Saravane, Sekong, Champasak and Attapeu) is shown in Figure 2.2-3. The major National Roads (NR) and Provincial Roads (PR) including "Intended" defined by Decree are NR 13S, NR 16, NR 18, NR 10, PR 13 and PR 20.

NR 13S passes through Pakse along the left bank of the Mekong river sectioning of 290 km long. NR 16 connects Saravane to Attapeu through B.Beng, Thateng and Sekong in the total length of 171 km. This road is not passable in rainy season.

The NR 18 extends from Phatoumphon, located on NR 13S in the south of Pakse, through Attapeu to Vietnam border. This network also is difficult to pass vehicles in even dry season through whole section of 220 km.

Provincial road PR 13A starts from Pakse km 8 through Paksong to Thateng, however the section between Paksong and Thateng is a seasonable road. PR 20 connecting B. Houei and B.Beng is a paved road with bitumen of 72 km long.

NR 10 extends a section of 41 km long from Pakse crossing over the Mekong river by ferry to Chong Mek of Thai border. This road is a exit to Thailand of southern provinces.

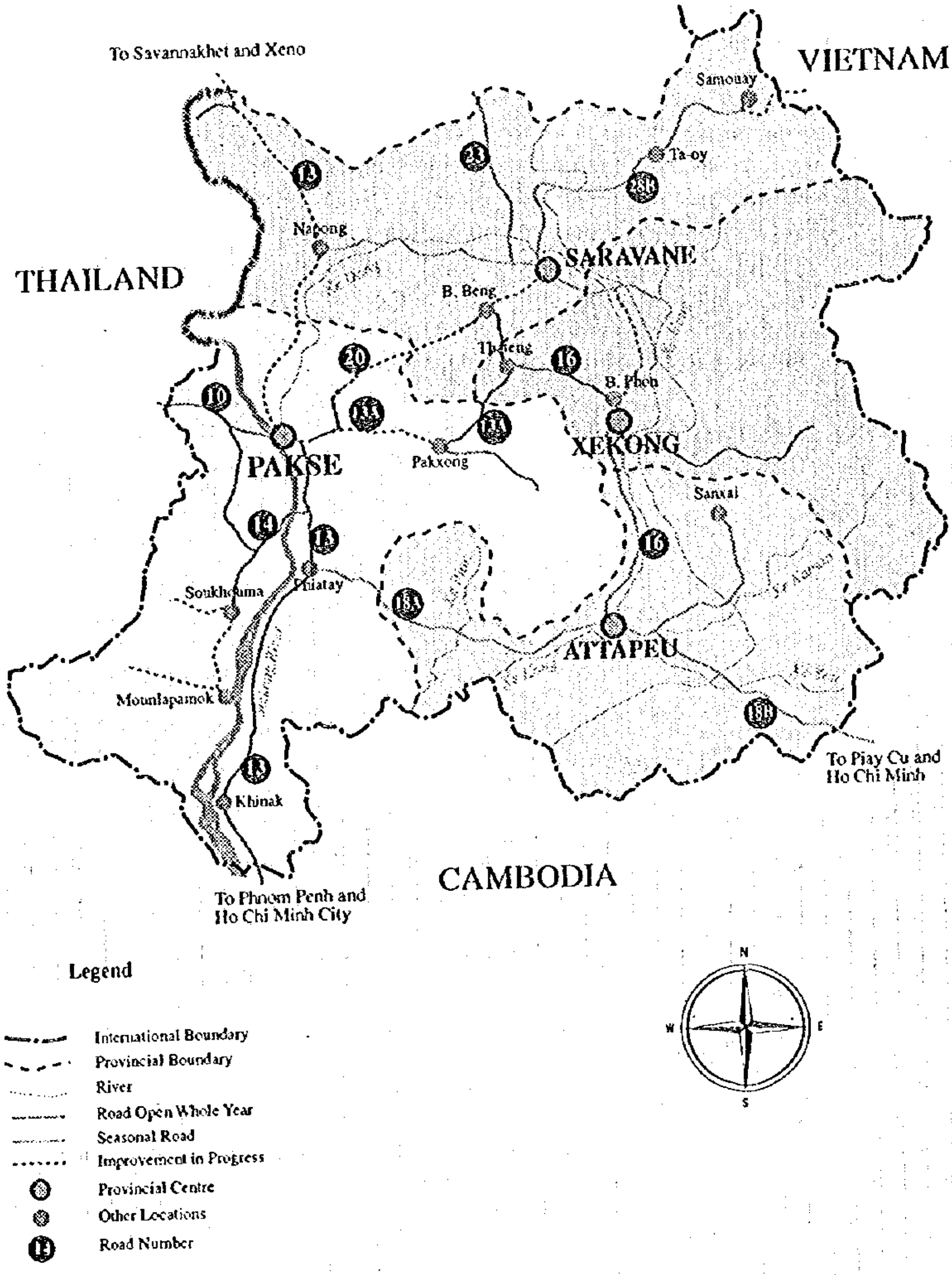


FIGURE 2.2-3 EXISTING ROADS IN THE STUDY AREA

2.2.5 Socio-Economic Development Plan

(1) Future Macro Economic Targets

The provincial government of Champasak has prepared detailed strategic plans for socio-economic development for the next five years (1996 - 2000). The targets, policies and strategies are presented by each sector and compiled in a report " Champasak Province Strategic Plan for the Development of Socio-Economy for Year 1996 - 2000 : prepared by Planning & Cooperation Division 5 August 1995". Among these targets, estimated future Gross Domestic Product (GDP) for the Champasak province is a macro target and shown in Table 2.2-7. In the above estimation, total GDP is set to increase with an annual growth rate of 22.5% up to 2000 and the share of industrial sector will reach to 46% and will exceed the agriculture sector.

TABLE 2.2-7 ESTIMATION OF FUTURE GDP OF CHAMPASAK PROVINCE

Sector	1995	1996	1997	1998	1999	2000	Avg. Annual Growth Rate(%)
Agriculture	69,003	73,833	79,390	85,322	92,148	99,981	7.70
Industry	6,120	34,499	49,364	77,162	146,015	157,208	91.40
Services	44,547	49,624	55,381	62,304	70,092	79,204	12.20
Import Duties	5,111	5,618	6,159	6,796	7,510	8,336	10.28
Total GDP (Million Kip)	124,781	163,574	190,294	231,584	315,765	344,729	22.54
Population of Province	503,612	515,708	528,084	540,758	553,737	567,026	2.40
Per Capita GDP (Kip/person)	247,772	317,183	360,348	428,258	570,244	607,960	19.66

Source : "Champasak Province Strategic Plan for the Development of Socio-economy for Year 1996 - 2000". Planning & Cooperation Division, Pakse, 05 Aug.1995.

(2) Relevant Development Projects

The development projects in the study area relating directly or indirectly to the Mekong bridge project at Pakse are:

- Road improvement projects
- Agricultural development projects
- Hydroelectric projects
- Tourism development projects

1) Road Development Projects in the Study Area

As shown in Figure 2.2-4,the road improvement projects in the southern area of the Lao PDR are ADB 2nd, ADB 6th and ADB 7th Road Improvement Projects. ADB 2nd Project (bituminous pavement work for PR 13A from Pakse to Paksong of 43 km long), will be completed by the end of 1995. ADB 6th Projects, mainly composed of the improvement work for the section from Paksong to B.Beng of PR 13 and the whole section of NR 16, are expected to start its construction within 1995. ADB 7th Project covers whole section of NR 10, the section of NR 13S from Pakse to Cambodia border and urban roads of 10 km in Pakse. This project pertaining directly to the proposed routes of the Mekong bridge at Pakse is now under tender stage for the construction.

2) Agricultural Development Projects

- Lao Upland Agricultural Development Project (LUADP)

The LUADP is financed by the World Bank and Lao PDR with technical assistance of the Australian and French Governments which are also taking a part of funding. The project aims at (i) increasing farmers' income, (ii) reducing the area of shifting cultivation through introducing more suitable production techniques, and (iii) increasing the level of food security and strengthening national agricultural research. The present activities in the study area are as follows :

i) Improvement of upland farming systems including coffee and field crops, vegetables, fruits and other economic trees, and animal health,
ii) Opening of feeder roads to ease the transportation of goods and agricultural inputs needed for the development of the local market,
iii) Upgrading and development of coffee culture on the Boloven Plateau, and
iv) Technical assistance and training

- Swedish International Development Agency (SIDA) Project

Under SIDA, two irrigation projects, one is in Thongvay in Paksong district, and the other in B.Len i Laongam district (Saravane Province), have been implemented. Main purpose of SIDA projects is to provide agriculture infrastructures in order to reduce slash and burn cultivation and to prevent deforestation.

- Coffee Feeder Roads in Laongam (Saravane province) and Paksong District

About 100 km of coffee feeder road with a 5.5 m width of laterite paved, in Laongam district has been constructed under the fund of the World Bank in 1988. In addition, about 315 km long of coffee feeder roads in Paksong, Laongam and Thateng districts respectively are being constructed under LUADP financed by the World Bank.

- Integrated Agricultural and Rural Development Project in Boloven Plateau (IARDPBP)

This project is now at the stage of a master plan formation under the technical assistance of the Government of Japan through the Japan International Cooperation Agency (JICA). The project area covers the Boloven Plateau which extends over Champasak, Saravane and Sekong provinces with approximate area of 7,000 km^2. The ultimate objectives of IARDPBP are to increase farming output in the area through improvement and development of irrigation, drainage, rural infrastructures, together with appropriate support services and to achieve substantial and sustainable improvement in the living conditions of the habitants and their life improvement. Based on the master plan, 16 priority projects were selected and implementation program for the next 15 years were prepared.

- Fruit Trees Research Station under the Champasak Provincial Government

This station is located at KM20, about 20 km east of Pakse along the road NR 20. The present activities are producing improved seedling of several kinds of fruit tree, and distributing those to farmers.

3) Hydroelectric Project

As pointed out in the study of ADB 7th Road Improvement Project, hydroelectric projects in the study area will affect the traffic volume on the project roads and on the project bridge at Pakse from the following aspects ;

i) generation of economic activities and new employment
ii) generation of significant road traffic during construction, for transportation of timber from areas cleared for the reservoir area and transmission line corridor, and for transportation of equipment and materials to the dam sites.

Future consequences, however, depend on the Government policies to solve a trade-off problem i.e. logging restrictions for natural forest reservoir or promotion of hydroelectric projects for economic development of other sectors.

Apart from the issues above, it is recognized that the Southern provinces of Lao PDR have many candidate sites suitable for hydroelectric projects. The Mekong Committee Secretariat has prepared the inventory for the promising tributary projects which exist in Laos. Of the 57 potential hydroelectric projects listed in the above inventory, the following 17 sites are identified in the study area :

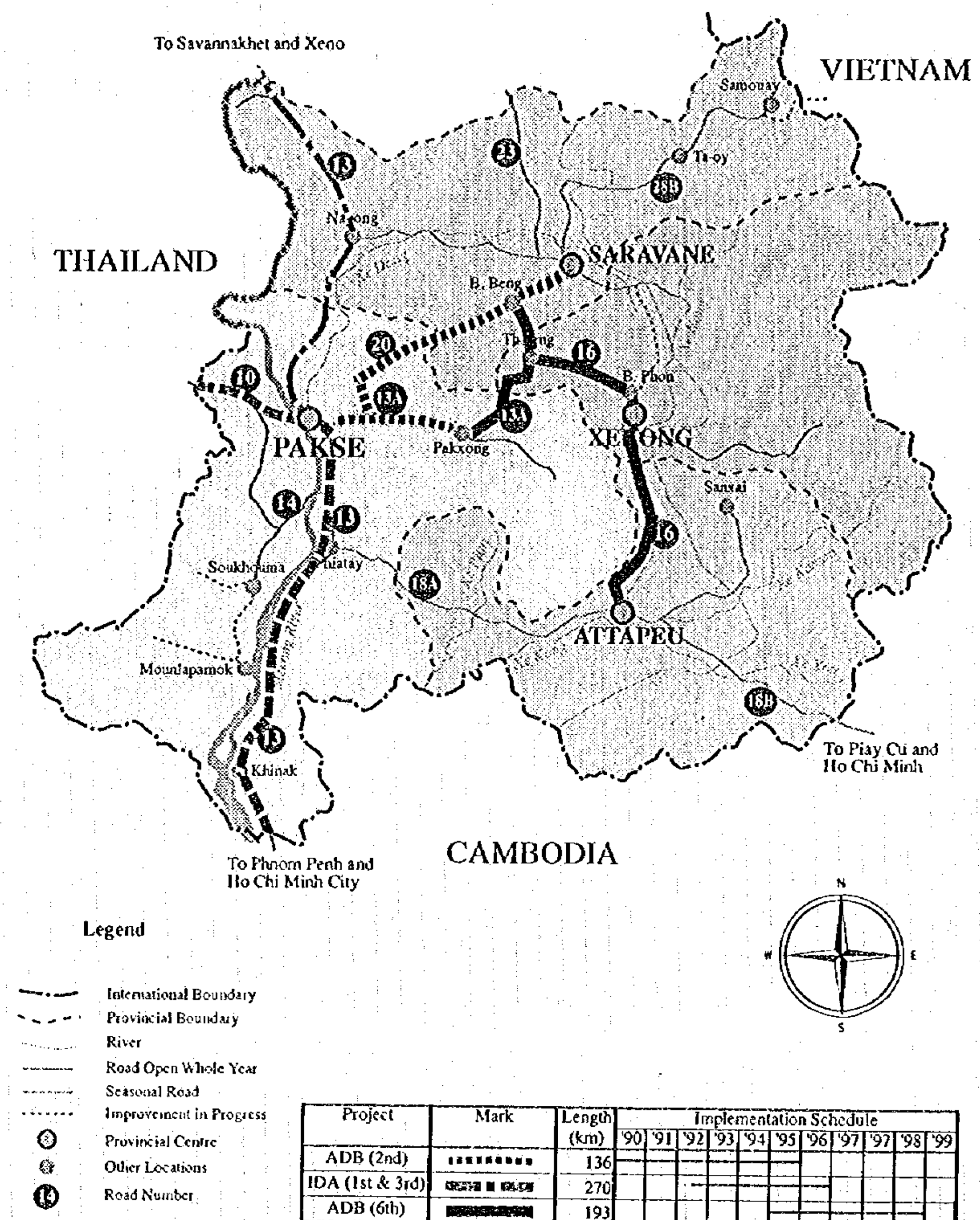
Project Name	Province	Capacity	Annual Generation
1.Se Kong-3	Attapeu	320 MW	1,581GHW
2.Se Kong-4	Sekong	470	2,327 GHW
3.Se Kong-5	Saravane	305	1,533
4.Dak E.Meule	Sekong	185	932
5.Houay Lamphan	Sekong	185	580
6.Xe NamNoy	Attapeu	530	2,653
7.Xe Kaman-1	Attapeu	390	1,940
8.Xe Kaman-3	Attapeu	230	1,143
9.Xe Kaman-4	Attapeu	155	769
10.Sekong-7	Sekong	290	1,516
11.Xe Kaman-2	Attapeu	135	668

12.Xe Xou	Attapeu	95	474
13.Nam Kong-1	Attapeu	150	763
14.Nam Kong-2	Attapeu	60	302
15.Nam Kong-3	Attapeu	30	146
16.Se Done-2	Saravane	54	315
17.Houay Ho	Attapeu	150	657

The total capacity of above 17 projects will reach to 3,700 MW, about 30 % of 57 potential projects in the Lao PDR.

4) Tourism Development Project

The potential tourism development projects include Wat Phu temple, Khong fall, Khong island and Boloven Plateau, among which the Khon Phapheng Waterfall Resort Project was concretely planned as expecting tourists of more than 30 thousand in the year 2001.



Project	Mark	Length (km)	Implementation Schedule '90	'91	'92	'93	'94	'95	'96	'97	'97	'98	'99
ADB (2nd)		136											
IDA (1st & 3rd)		270											
ADB (6th)		193											
ADB (7th)		160											

FIGURE 2.2-4 ROAD DEVELOPMENT PROJECTS IN THE STUDY AREA

CHAPTER 3

GEOMORPHOLOGY AND HYDROLOGY IN STUDY AREA

3. GEOMORPHOLOGY AND HYDROLOGY IN STUDY AREA

3.1 Geomorphology in Study Area

The location of the Project area is approximately 3,500 km from the origin of the 4,500 km long Mekong river. In this area there is the Sedon river, one of the tributary rivers of the Mekong basin, with a river course of about 200 km length flowing into the Mekong from its left bank near the middle part of Pakse city.

The summary of geomorphologic characteristics in this area is as follows:

- The plain consists of basic elevated peneplane of triassic orogeny and alluvial plain formed by the sedimentation and erosion of the Mekong and Sedon rivers.
- An extensive flat land, of about 100 m to 150 m above m.s.l. of elevation and 15,000 km^2 of area, is spread out in circumference, where natural forest (coconut, beech, etc.) and cultivated rice fields reflect the existence of a fertile soil.
- The alluvial plain is conformed along the Mekong river course by a natural bank, a terrace and a back marsh, located in the cultivated land area, with an elevation of about 90 m to 100 m. above m.s.l., at the left bank of the Mekong river near the confluence with the Sedon river. Central part of the Pakse city is developed in this terrace.
- There is a table mountain composed by a series of high mountains the elevation of which range from 1,000 m. to 1,500 m above the m.s.l. in the hinterland of the Project site. The old famous ruins Wat Ph (*Mountain Temple*) is located at the foot of this mountain at 30 km from the South of Pakse city. Its feature is shown by a flat peak and a side cliff formed as a result of old orogenic cycle, assumed as the triassic era.

  Moreover, peaks and down slope are widely covered by natural forest, and in the cliff, of about 100 m high, sandstone outcrops present stronger resistance against erosion.
- The Mt. Bachiang appears like a monadnock with an elevation of 904 m above the m.s.l., is located approximately at 4.0 km in the north-east of Pakse at the left bank of the Mekong river. Moreover, Mt. Malong with an elevation of 1,304 m above the m.s.l., located at the south-east of Pakse city, face the left bank of the Mekong river and makes its width becomes narrow.
- The basalt plateau of younger geological era (assumed as tertiary) is located in the left bank of the Mekong river. A large scale plateau is distributed around 500 m to 800 m high land area about 400 km^2 of Salavan province. This basalt is used for crushing rock material for road construction.
- Similarly, there is a minor scale basalt plateau at the left bank of the Mekong river near Pakse region. This plateau appears forming a hill of an elevation of about

110 m above the m.s.l., slightly higher than the surrounding flat terrace. Natural trees are comparatively well preserved in this area, and the hill plane is distinguished from the terrace where mostly are fields of cultivated rice.

3.2 Meteo-hydrology in Study Area

3.2.1 General

The meteo-hydrological factors and conditions in the Study Area have been examined for the Project. The following data were collected for the hydrological analysis:

- Air Temperature
- Precipitation and Rainfall Intensity
- Evaporation and Humidity
- Wind Pattern
- Tropical cyclones

These data have been obtained from the Ministry of Agriculture and Forestry: Province Meteorology Service at Pakse, and Department of Meteorology and Hydrology at Vientiane. Comparison and selection analysis of available data were carried out to improve the accuracy on the results.

Relevant data, analysis procedure and results of the meteo-hydrological analysis are summarized below.

3.2.2 Air Temperature

Temperature data for a period of 35 years, from 1960 to 1994, at Pakse meteorological station is available for this study. Statistics of these data, summarized in Table 3.2-1 (Refer to Annexes), show that the annual mean air temperature at Pakse is around 27.2°C degrees while the monthly mean maximum and minimum are around 30°C and 24°C respectively. The extremely highest air temperature, going on 40°C, is recorded in around April to May and the extremely lowest, less than 10°C, in around December to January.

Besides the above mentioned data of air temperature, data about daily air temperature differences are also available, recorded during the same period from 1960 to 1994 (Refer to Annexes). The annual mean of daily temperature differences at Pakse is around 7.7°C degrees while the annual maximum and minimum are around 13.3°C (January 1980) and 3.5°C (September 1973) respectively.

TABLE 3.2-1 AIR TEMPERATURE (°C) AT PAKSE, PERIOD 1960-1994

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	MAX	MEAN	MIN
Extreme Maximum	36.6	37.3	39.5	40.0	40.0	36.1	34.2	33.8	35.0	35.0	34.7	36.0	40.0	36.5	33.8
Mean Maximum	31.1	32.8	34.5	34.9	33.1	31.1	30.5	30.1	30.3	30.8	30.6	30.3	34.9	31.7	30.1
Mean	24.7	26.9	29.1	30.2	29.1	27.9	27.4	27.1	27.1	26.8	25.6	24.4	30.2	27.2	24.4
Mean Minimum	18.2	21.0	23.8	25.3	25.0	24.7	24.3	24.3	23.9	22.7	20.6	18.5	25.3	22.7	18.2
Extreme Minimum	10.1	12.5	11.7	16.3	20.5	20.0	21.0	20.9	20.5	16.0	13.2	10.2	21.0	16.1	10.1

Source: Province Meteorology Service - Pakse

3.2.3 Precipitation and Rainfall Intensity

1) Precipitation

Since Lao Territory is located in the tropical belt, the meteo-hydrology of the study area is mainly influenced by the southwest and northeast monsoon air masses. The rainy season caused by the southwest monsoon begins in the middle of May and ends toward the end of October. The remaining period, called the dry season, has extremely no rainfall in the effect of the northeast monsoon.

Table 3.2-2 is shown the summary of precipitation data recorded during a period of 35 calendar years, from 1960 to 1994, at Pakse station. The annual total precipitation records ranges between a minimum of 1,372 mm, recorded in 1993, and a maximum of 2,938 mm, recorded in 1979, with a mean annual precipitation ranging around 2,062 mm, some 95% of which assemble in rainy season. The same table shows that the annual average of maximum daily precipitation ranges around 133.3 mm, between a maximum of 450.3 mm and a minimum of 60.4 mm recorded in June 25, 1983 (Tropical Cyclone "Sarah"), and 1980 April 26 respectively. (Refer to Annexes)

The data of annual maximum of monthly precipitation show that the average for the above mentioned period of 35 years ranges around 621 mm per year, with a maximum of 1,037 mm (August 1984) and a minimum of 293 mm (September 1980) per year.

TABLE 3.2-2 MONTHLY PRECIPITATION, PERIOD 1960 -1994

(Unit: millimiters)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	MAX. DAILY PREC.
MEAN	6	14	24	69	214	401	382	528	315	103	19	5	2,062	133.3
MAX	22	68	83	245	381	905	663	1,037	769	302	77	19	2,938	450.3
MIN	0	0	1	9	36	148	169	240	75	2	1	0	1,372	60.4

Source: Province Meteorology Service - Pakse

Moreover, Table 3.2-3 shows records of the rainy days at Pakse station during the same period of 35 years.

TABLE 3.2-3 MONTHLY RAINY DAYS, PERIOD 1960 - 1994

(Unit: Days)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	0	1	3	7	17	22	23	26	20	12	4	1	135
MAX	3	4	9	14	26	29	28	31	28	22	8	4	164
MIN	0	0	0	2	8	15	17	15	14	2	0	0	112

Source: Province Meteorology Service - Pakse

Isohyets of annual average precipitation in the Bolaven Plateau and isohyets of monthly precipitation for the rainy season at Pakse are shown in the Annexes. The isohyets of the average annual precipitation at Pakse station from 1929 to 1984 are around 1,950 mm.

2) Rainfall Intensity

There is not available data of rainfall intensities at Pakse meteorological station. However, for this Project, an estimation of rainfall intensity was carried out for Pakse station by extrapolation from short period isohyet curves of data recorded at Mounlapmonk, Saravan and Paksong stations. The results of intensity duration analysis for 5, 10, 25, 50 and 100 years of return period are shown in the Annexes.

3.2.4 Evaporation and Humidity

1) Evaporation

The summary of evaporation data is shown in Table 3.2-4. The total annual evaporation (Piche), recorded at Pakse during a period of 28 calendar years (1967 to 1994), ranges from 1,134 mm to 1,885 mm with an average of annual total evaporation ranging around 1,461 mm. While the maximum monthly total evaporation rise to its highest magnitude around April (318.5 mm), and the minimum decrease gradually to its lowest magnitude around August (51.9 mm).

TABLE 3.2-4 TOTAL EVAPORATION (PICHE), PERIOD 1967-1994

(Unit: millimiters)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	175.9	189.0	233.0	193.3	140.1	85.1	78.4	68.5	70.9	102.9	128.0	156.3	1,461
MAX	237.3	262.2	303.9	318.5	214.4	153.4	108.1	91.6	101.3	155.7	191.2	193.4	1,885
MIN	130.6	126.6	160.1	120.3	72.3	65.6	59.7	51.9	53.8	65.7	86.8	104.2	1,134

Source: Province Meteorology Service - Pakse

Moreover, the mean of daily maximum evaporation is around 11.3 mm ranging from 7.8 mm to 17.2 mm; while the highest and lowest magnitude of maximum "max. daily evaporation", 17.2 mm and 6.1 mm, are around in March and from July to August respectively. (Refer to Annexes)

Statistics on data of evaporation and precipitation show that the monthly evaporation exceeds the monthly precipitation during about 7 months from November to May of next calendar year.

2) Relative Humidity

Table 3.2-5 is shown the data of relative humidity for 30 calendar years, the period from 1965 to 1994, recorded at Pakse station. The annual mean relative humidity for this period ranges from a minimum of 59% to a maximum of 85%, with an average of the annual mean of 72%; while the monthly average of relative humidity ranges from an absolute minimum and maximum of 47% and 93% respectively.

The data of monthly average of maximum and minimum relative humidity, for a period from 1960 to 1994 (Refer to Annexes), show that the humidity gradually rises to its highest magnitude, around of 100%, in June and its lowest magnitude, around of 26%, in January.

TABLE 3.2-5 MONTHLY MEAN RELATIVE HUMIDITY, PERIOD 1965-1994

(Unit: %)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL		
													Mean	Max	Min
MEAN	62	60	59	64	73	81	82	85	83	78	70	66	72	85	59
MAX	71	70	70	75	82	93	91	91	89	87	78	74	81	93	70
MIN	51	48	51	52	47	58	65	77	77	69	57	54	59	77	47

Source: Province Meteorology Service - Pakse

3.2.5 Wind Pattern

Data of monthly maximum wind velocity, measured at 10 meters height at Pakse meteorological station, for a period of 38 calendar years, from 1957 to 1994, are available for this study (Refer to Annexes). A maximum wind velocity of 40 m/sec, recorded two times (March 1974 and April 1976), is the absolute maximum record during this period. Figure 3.2-1 is shown the wind-rose of maximum wind velocity describing the magnitude and the frequency of wind velocity per each direction.

The main characteristics of wind events for the period 1957 and 1994 are summarized as follows:

- The prevailing wind direction shifts to the SE (South-East) between February and September; while during the remaining period (i.e., November to January) the wind direction shifts to N or NE (North or North-East).
- The maximum frequency of prevailing wind direction SE (South-East) exceeds to 50% in March and to 40% in September.

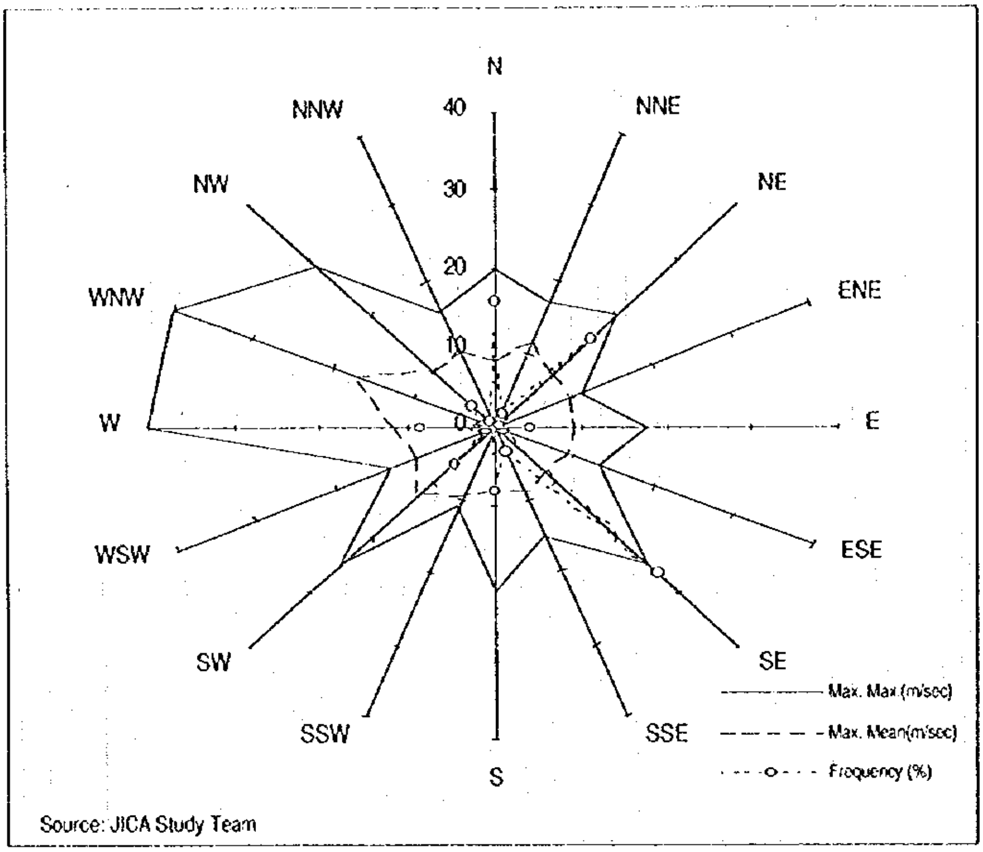


FIGURE 3.2-1 WIND-ROSE OF MAXIMUM WIND VELOCITY AT PAKSE (1957-1994)

- The maximum wind velocity of wind direction W (West) and WNW (West-Northwest) has reached to its highest magnitude of 40 m/sec between Mach and April. However, since this wind velocity was not sustained for longer than 10 minutes, it is not considered as a "tropical cyclone" event.

- The annual mean of monthly maximum wind velocity ranges between 8.14 m/sec (South direction) to 17.5 m/sec (West-Northwest direction).

Moreover, probable wind velocities for several return periods were estimated by a probabilistic analysis (Refer to Table 3.2-6).

TABLE 3.2-6 PROBABLE WIND VELOCITIES AT PAKSE

RETURN PERIOD	MAXIMUM WIND VELOCITY	
(year)	(m/sec)	(knots)
2	16.2	31.6
5	24.0	46.8
10	29.2	56.9
50	40.6	79.1
100	45.5	88.6

Source: JICA Study Team

3.2.6 Tropical Cyclones

The intensity of tropical cyclones is classified as follows according to the World Meteorological Organization (WMO): Guide to Marine Meteorological Services, and Manual on Marine Meteorological Services:

Tropical Cyclone	Maximum Sustained Winds (*)	
	(m/sec)	(knots)
1) Tropical Depression	up to 17.2	up to 34
2) Tropical storm	17.2 - 24.4	34 - 47
3) Severe tropical storm	24.5 - 32.6	48 - 63
4) Typhoon	32.7 or more	64 or more

(*) Sustained wind refer to wind velocities averaged for a period of 10 minutes

According to the data collected from the Japan Meteorological Agency, for Tropical Cyclone Tracks in the Western North Pacific from 1951 to 1994, statistics of those tropical cyclones that attained tropical storm intensity or higher in the North Pacific show that the frequency of events is in the range from 19 to 39 events per year with an average of about 27 tropical cyclones per year. (Refer to Annexes)

Moreover, records of the cyclones tracks show that some of 21 tropical cyclones have passed through the Pakse area (latitude 14° N to latitude 16° N) during the period from 1951 to 1990; however, most of them are changing from a condition of tropical storm or higher intensity, to a tropical depression or lower intensity.

The following main tropical cyclone events have been recorded at Pakse area (Refer to Annexes for respective isohyets of rainfalls):

- SARAH (1983 June)

  This tropical cyclone passed over the Bolaven Plateau producing heavy rainfall in the area between Pakse and Paksong slope. The maximum daily precipitation at Pakse meteorological station (450.3 mm) has been recorded in this month. Moreover, according to the wind velocity data, the maximum wind velocity recorded at Pakse in June 1983 is around SW 22 m/sec.

- BESS (1978 August)

  This tropical cyclone is the cause of the largest flood in Champasak and Savanakhet provinces. The gage height of Mekong river at Pakse station has its higher record in this month. However, according to the wind velocity data, the maximum wind velocity recorded at Pakse in August 1978 is around E 13m/sec.

3.3 River Hydrology

3.3.1 General

1) Gauging Station

The gauging station of Pakse was located, until 1971, at latitude 15°06.8' N and longitude 105°47.8' E, on the north bank of Sedon river, about 50 m from the confluence of Sedon and Mekong rivers, opposites stairways leading to the river from the intersection of roads. All measurements were made from boat at section 100 m. upstream of D.C.T.P.C. office. Zero of gage elevation was 86.507 m. above M.S.L. Ko Lak datum.

From 1972 to the present, the gauging station of Pakse has been relocated to latitude 15°07' N and longitude 105°48' E, on the left bank of the Mekong river, at approximately 869 km of distance from the sea. All the measurements made from boat at section 50m upstream of gauge. This station, for gauging of the Lower Mekong Basin, has an elevation of gauge zero of 86.49 m above M.S.L. Ko Lak datum.

It is worthy to note that Mean Sea Level South China Sea Datum is approximately below Mean Sea Level Ko Lak Datum by 0.140 m.

The data concerning daily flow of this station is considered as of excellent quality, and suitable techniques for quantifying the Mekong river flow regime have been improved for this purpose.

2) Collected Data

Data related to gage height and discharge measurements for the hydrologic analysis of the Mekong River, carried out in this section, have been collected from:

- Lower Mekong Hydrologic Year Book from 1962 to 1991,
- D.T.P.C., Pakse (data from 1904 to 1994), and
- Ministry of Agriculture and Forestry at Vientiane (data from 1961 to 1994).

3.3.2 River Conditions

1) River Morphology

Around the north-west area of the Pakse city, the Mekong river presents a width broadly wide where some sediment deposits are observed in the middle and especially near the right riverbank. However, this conditions change gradually from the confluence of the Sedon river through the south-east area of Pakse city until the Mount Saleo side, about 2.0 km downstream. This narrow river section of the Mekong continue along the south-east approximately 5.0 km until the Mount Malong side where the river section becomes wide again and sediment deposits are observed.

According to the collected data, hearing investigation at the site, and considering the geographic pattern of the area, it is learned that most of the flooding events affect the flat north-west area of the Pakse city.

As shown in Figure 3.3-1, the catchment area and flow contributions of Mekong tributaries from the north until the Pakse area, before the confluence of the Sedon river, represent approximately the 76.0% of the catchment area (total: 760,000 km^2), and the 66.7% of the yearly flow average (total: 14,000 m^3/sec). Moreover, the Sedon flows into the Mekong with about the 0.9% of the yearly flow average, and approximately its catchment area represent the 1.6% of the Mekong.

2) Hydraulic Conditions

The river course was examined by referring to different previous studies and survey results concerning factors that could affect the river conditions at the Study area.

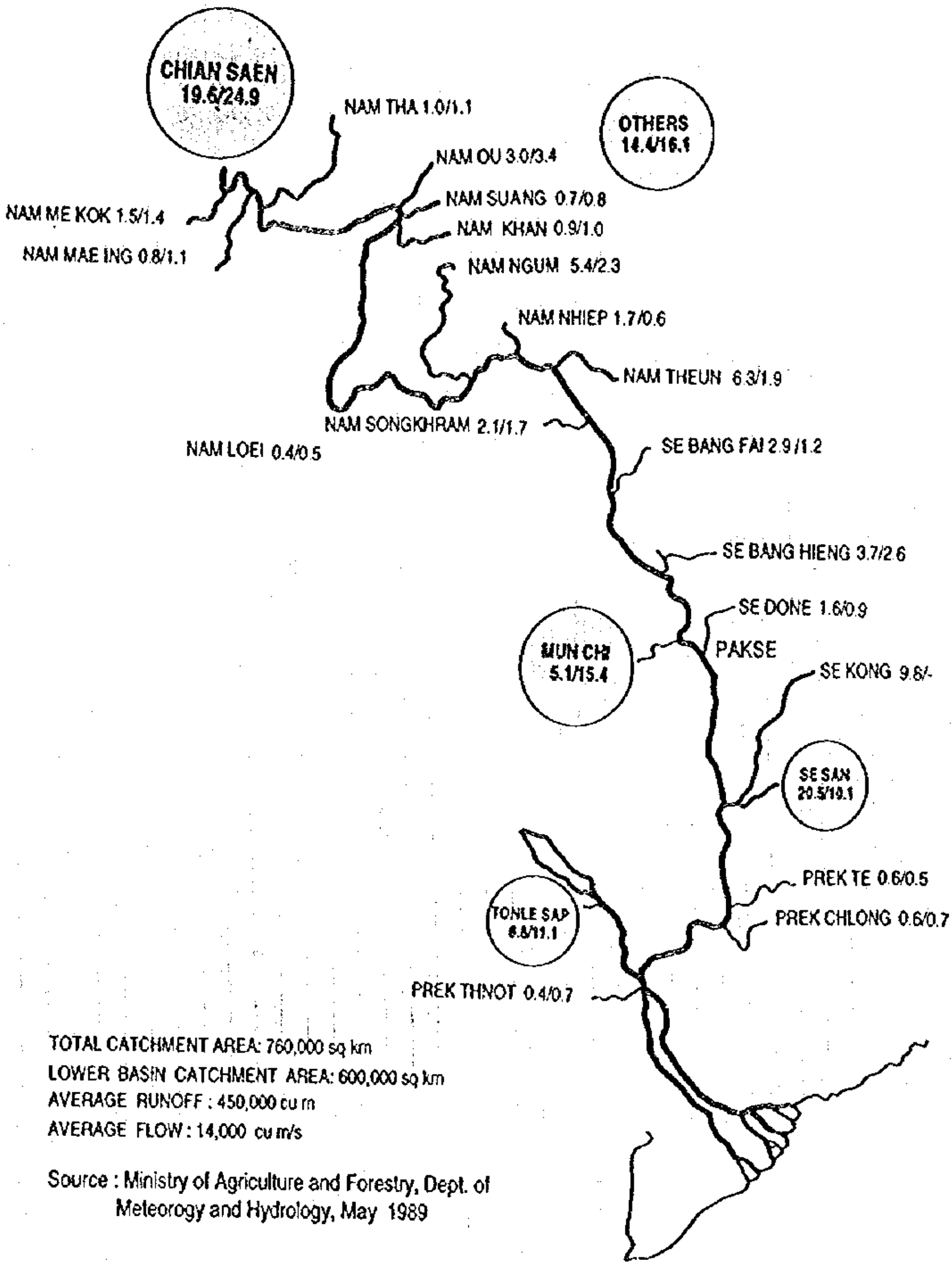
River width, riverbed and consequently discharge area vary greatly from the flat and the widest section of approximately 1,500 m width upstream of the Sedon confluence point, to the deep and narrowest of about 900 m width downstream within the Study area.

Basically, the water flow conditions of the Mekong river in this area can be classified, from a point of view of hydraulic analysis, as a river section with a gradually varied flow (non-uniform flow) conditions.

3.3.3 Discharge and Water Level

Comparison and selection analysis of the available data was carried out in order to improve the accuracy on the results. The Annexes is shown a summary of the data used for the maximum and minimum water level/discharge estimation.

As shown in Figure 3.3-2, the water level of the Mekong river at Pakse station becomes lowest during March and April, at the end of the dry season; while from May, the begin of the wet season, increases and reaches its highest level during August and September. The maximum range difference, of about 10 meters, has been recorded in August 1978 (max.= 14.48 m, and 1979 min.= 4.00 m).



TOTAL CATCHMENT AREA: 760,000 sq km
LOWER BASIN CATCHMENT AREA: 600,000 sq km
AVERAGE RUNOFF : 450,000 cu m
AVERAGE FLOW : 14,000 cu m/s

Source : Ministry of Agriculture and Forestry, Dept. of Meteorogy and Hydrology, May 1989

LEGEND
CHIANG SAEN A/B
A : PERCENTAGE OF AVERAGE YEARLY FLOW
B : PERCENTAGE OF TOTAL CATCHMENT AREA

FIGURE 3.3-1 CATCHMENT AREA AND FLOW CONTRIBUTIONS OF MEKONG TRIBUTATRIES

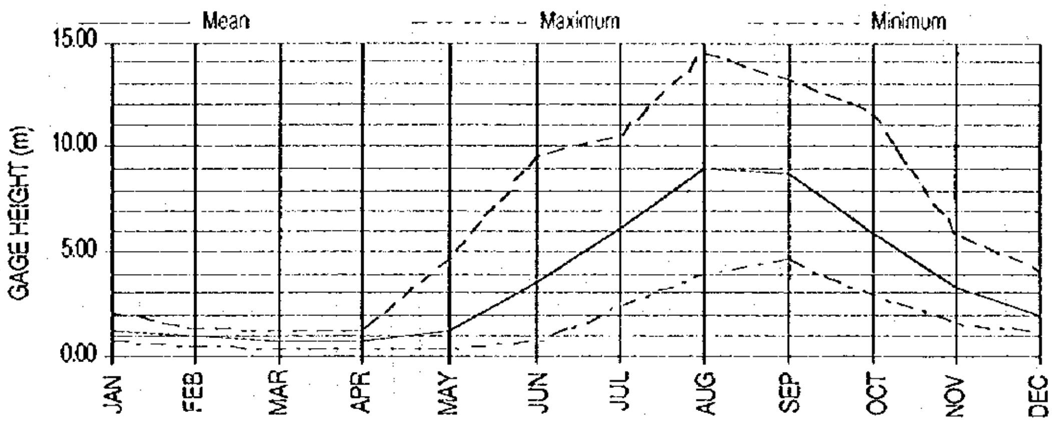


FIGURE 3.3-2 GAGE HEIGHT AT PAKSE STATION, PERIOD 1972-1994

Data of the variation of absolute maximum and absolute minimum gage height, and the differences between them, for the period from the year 1972 to 1994, show that the average of the maximum annual gage height differences is approximately of 10.82 m, with a maximum gage height of 13.95 m measured in 1978, when the maximum gage height reached to its highest level of 14.48 m, against a minimum equal to 0.53 m. (Refer to Annexes)

Moreover, as shown in Table 3.3-1, the average of the annual mean of gage height, discharge and total run-off for the period from 1972 to 1994 are around to 3.64 m, 9,328 m^3/sec and 304,150 million cubic meters, respectively.

TABLE 3.3-1 AVERAGE OF ANNUAL MEAN GAGE HEIGHT/DISCHARGE AND TOTAL RUN-OFF AT PAKSE, PERIOD (1972- 1994)

YEAR	MEAN GAGE HEIGHT (m)	MEAN DISCHARGE (m3/sec)	TOTAL RUN OFF (million m3)
MEAN	3.64	9,328	304,150
MAX	4.45	12,800	402,000
MIN	2.89	3,007	231,000

Source: Ministry of Agriculture and Forestry, Vientiane.

Table 3.3-2 is shown records of the absolute maximum and minimum gage height and river discharges of daily recorded data during the period of year 1972 to 1994 at Pakse station:

TABLE 3.3-2 ABSOLUTE MAXIMUM & MINIMUM GAGE HEIGHT

	Maximum	Date	Minimum	Date
Discharge (m^3/sec)	56,000	1978/08/17	1,380	1989/04/25
Gage Height (m)	14.48	"	0.42	"

Source: Ministry of Agriculture and Forestry, Vientiane.

1) High Water Level

The analysis of high water level was carried out using records from year 1972 to 1994 at the relocated Pakse gauging station. The probability analysis of the collected hydrologic data was performed applying statistical and probability criteria for an Extremal Distribution (*Gumbel*).

The annual average of maximum gage height and discharge, estimated by the above mentioned probabilistic analysis, are shown in Table 3.3-3.

TABLE 3.3-3 ANNUAL AVERAGE OF MAXIMUM GAGE HEIGHT AND DISCHARGE, PERIOD (1972- 1994)

	Annual Average of Maximum
Gage Height	11.51 (m)
Discharge	36,291 (m^3/sec)

According to these results, the gage height of 11.51 m will be used to determine the design High Water Level.

Maximum high levels and maximum discharges at gauging station for several return periods are shown in Table 3.3-4. While, Figure 3.3-3 and Figure 3.3-4 are shown the curves of Maximum Gage Height vs Return Period, and Maximum Discharge vs Maximum Gage Height respectively.

Taking into account the analysis results and available data, a maximum gage height of 15.00 meters (i.e., 101.49 m above m.s.l.) and a discharge of 54,070 cubic meters per second are defined as the "Maximum Stage" of the high water level and discharge pattern.

TABLE 3.3-4 HIGH WATER LEVEL AND DISCHARGE AT PAKSE GAUGING STATION

RETURN PERIOD (year)	MAX. GAGE HEIGHT (m)	MAX. DISCHARGE (m^3/sec)	REMARKS
2	11.24	35,009	
5	12.70	42,037	
10	13.67	46,959	
25	14.89	53,475	
50	15.80	58,517	Maximum stage is overpassed
100	16.70	63,693	- ditto -

Note: Maximum Stage for Pakse Station: Gage height = 15.00 m (i.e., 101.49 m above m.s.l.), and discharge = 54,070 m^3/sec, correspond to a return period of around 27 years.

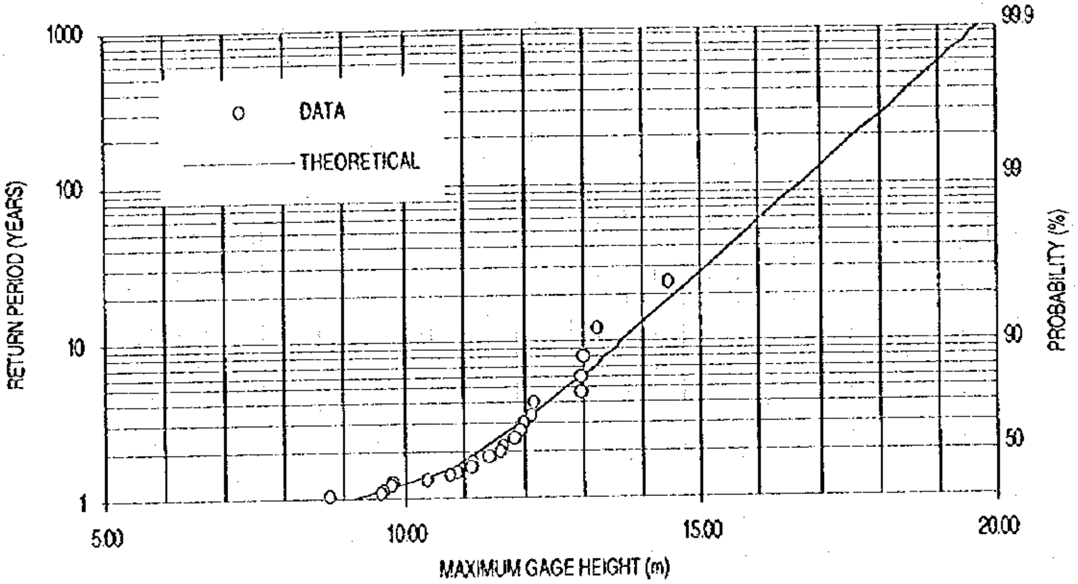


FIGURE 3.3-3 MAXIMUM GAGE HEIGHT AND RETURN PERIOD OF MEKONG RIVER AT PAKSE

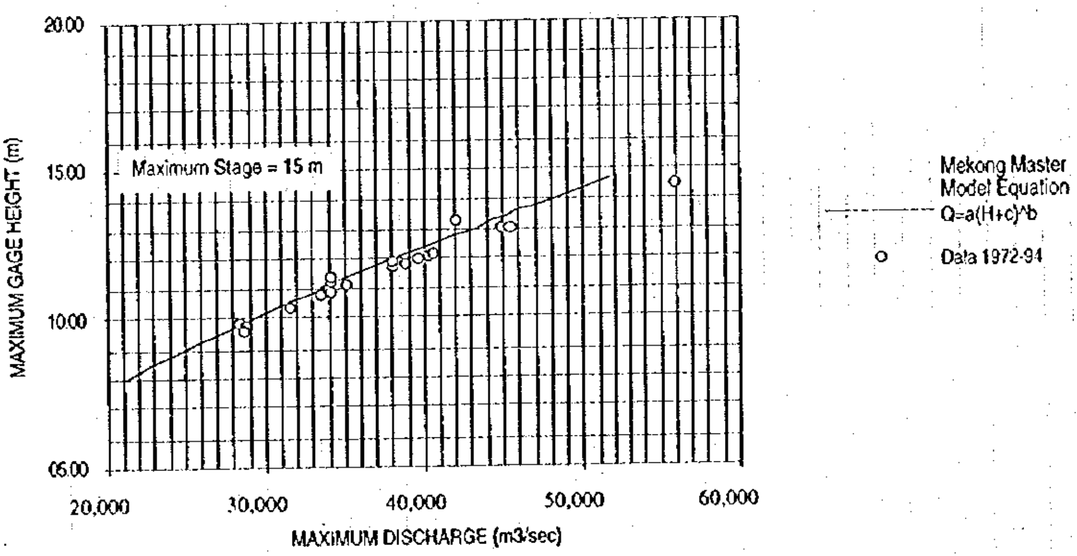


FIGURE 3.3-4 PROBABLE MAXIMUM GAGE HEIGHT & MAXIMUM DISCHARGE OF MEKONG RIVER AT PAKSE

2) Low Water Level

The analysis of low water level was carried out following a similar procedure than the used for high water level analysis, and also using records from 1972 to 1994 at Pakse gauging station. Results of the analysis on minimum gage height are shown in Table 3.3-5.

TABLE 3.3-5 ANNUAL AVERAGE OF MINIMUM GAGE HEIGHT AND DISCHARGE, PERIOD (1972- 1994)

	Annual Average of Minimum
Gage Height (m)	0.61 (m)
Discharge (m^3/sec)	1,692 (m^3/sec)

According to these results the gage height of 0.61 m will be used to determine the design Low Water Level; besides, results of comparing analysis of High Water Level to Low Water Level, the ratio of the averages of maximum and minimum gage height is approximately 19:1.

Moreover, Table 3.3-6 shows the annual average of minimum gage height for several return periods, estimated by the probabilistic analysis.

TABLE 3.3-6 LOW WATER LEVEL AND DISCHARGE AT PAKSE GAUGING STATION

RETURN PERIOD (year)	MIN. GAGE HEIGHT (m)	MIN. DISCHARGE (m^3/sec)
2	0.63	1,719
5	0.53	1,577
10	0.47	1,485
20	0.41	1,399

3) Flood

The flow conditions of Mekong river at Champasack province is greatly affected by the typhoons and depressions generated in the South China Sea and near Philippines islands. Then, as a consequence of this phenomena Champasack plain is frequently affected by seasonal flooding.

Table 3.3.7 is shown a summary of the maximum water level at the time when flooding events occurred during the period from 1929 to 1995 (Refer to Annexes). According to this data, the 1978 flood (assumed gage height equal to 14.48 m) is considered as the most severe flood from 1929.

According to results of the analysis on maximum water level records, the maximum gage height at Pakse for a 100 years return period, exceeds the before defined Maximum Stage. Therefore, the maximum gage height of 15.00 meters (101.49 m above m.s.l.) and a discharge of 54,070 cubic meters per second (i.e., the Maximum Stage) are assumed as the gage height and discharge to determine the design Flood Water Level for the Project.

TABLE 3.3-7 FLOOD RECORDS AT PAKSE GAUGING STATION

	GAUGE HEIGHT (m)	ELEVATION (msl)
MEAN	12.90	99.39
MAX	14.48	100.97
MIN	12.08	98.57

Source: Ministry of Agriculture and Forestry, Vientiane.

3.3.4 River Flow Velocity

1) Existing Data of River Flow Velocity

Some data related to the results of a flow velocity survey collected from the Ministry of Agriculture and Forestry at Vientiane was applied for a preliminary estimation of some parameters related to the riverbed conditions.

2) Computer Calculation of River Flow Velocity

The water flow velocity was estimated by the input of data related to the river cross section, existing water flow velocity data, hydrological records, and results of discharge and water level calculation into a computation program prepared by the Study Team for this analysis.

Basically, the above mentioned computation program was applied for the hydraulic analysis of a gradually varied flow (non-uniform flow) conditions. The following equations were applied for the calculation.

Dynamic equation:

$$Y = z + d \cdot \cos\theta + \alpha \cdot V_m^2 / (2g)$$

where,

Y : Level of energy line (m)
z : Elevation of riverbed (m)
d : Depth of flow section (m)
θ : Bottom slope angle
α : Energy coefficient
V_m : Mean velocity of flow through the section (m/sec)

Manning's equation:

$$Q = A \cdot V_m$$

$$V_m = (1/n) \cdot R^{2/3} \cdot I^{1/2}$$

where,

Q : Discharge (m^3/sec)
A : Discharge area of the water flow (m^2)
n : Coefficient of roughness
R : Hydraulic radius (m)
I : Slope of energy line

The relation of discharge area and hydraulic radius is calculated by a subroutine applied to data of the river section. Moreover, the coefficient of roughness is estimated by an analysis of the mean flow velocity, estimated by the existing data of flow velocity applied on the following Toffaleti logarithmic equation (recommended by the Ministry of Agriculture and Forestry), and the Manning equation.

$$V_m = V_h / \{0.1472 \cdot [\ln(h/H) / 0.000463]\}$$

where,

V_h : Velocity measured at point "h" from the bottom (m/sec)
h : Height of the measuring point from the river bottom (m)
H : Total water depth at the measured point (m)

Table 3.3-8 shows a summary of the computation results for river flow velocity along the Mekong river in the Study area.

TABLE 3.3-8 RIVER FLOW VELOCITIES

Condition at Gauging Station→	F.W.L. Q = 54,070 m3/sec Gage Height = 15.00 m	H.W.L. Q = 36,291 m3/sec Gage Height = 11.51 m	L.W.L. Q = 1,692 m3/sec Gage Height = 0.62 m
SECTION, KM	VELOCITY (m/sec)		
(upstream) 4 + 000	2.133	1.789	0.341
2 + 500	2.126	1.777	0.318
1 + 500	2.125	1.768	0.295
Gauging Station	2.140	1.767	0.273
- 1 + 500	2.121	1.747	0.254
- 2 + 500	2.103	1.723	0.237
- 4 + 000 (downstream)	2.799	2.222	0.218

3.3.5 River Erosion, Scouring and Sedimentation

1) River Erosion

The river erosion conditions were evaluated by an a comparative analysis of river bank maps prepared at different years and a hearing investigation carried out in the site. Results of these investigations show that the river bank is eroded, by the wearing action of water flow, approximately 1.0 m per year (each side).

2) Scouring and Sedimentation

The scouring and/or sedimentation phenomena that could affect the riverbed conditions have been examined by the Lacey's theory described by the following empirical equations:

$Q \cdot f = 3.8 \cdot Vs^6$ "Sediment-load Equation"

$f = (0.75 \cdot V^2) / R$; or $f = 1.76\, d^{1/2}$

$Ps = 2.668 \cdot Q^{1/2}$ "Width Equation"

where,

V	:	Mean flow velocity (fps)
Vs	:	Average flow velocity on sediment conditions (fps)
R	:	Hydraulic radius (ft)
S_e	:	Energy slope
Q	:	Discharge (cfs)
Ps	:	Wetted perimeter on sediment conditions (ft)
f	:	Silt factor
d	:	Representative diameter of sediment particles (mm) (approx. d = 1.0 mm)

Table 3.3-9 is shown a summary of the results of scouring/sedimentation evaluation at representative sections of the Mekong river within the Study area related to the Pakse gauging station (KM 0+000) under the Maximum Stage Conditions (Q = 54,070 m3/sec).

According to results of the above mentioned evaluation, the following conclusions are drawn:

- Scouring could affect the riverbed and foundations in Section No. 3; however, since piers' piles will be founded on rock, the effect of scouring could be neglected.
- However, since piles need to be able to resist water forces assuming scouring of at least 5.0 m, a scouring depth of 5.0 m is adopted for the Study.

TABLE 3.3-9 EVALUATION OF SCOURING AND SEDIMENTATION

SECTION		V	Vs (m/sec)		P	Ps	Remarks
No.	KM	(m/sec)	for f(d=1mm)	for f(V,R)	(m)	(m)	
1	(upstream) from 4+000 to 0+000	2.13	2.96	2.52	1,471	1,132	V<Vs, P>Ps: Sedimentation effect should be considered
2	from 0+000 to -2+500	2.10	2.96	2.47	1,369	1,132	- ditto -
3	from -2+500 to -4+000 (downstream)	2.80	2.96	2.65	896	1,132	V≥Vs, P<Ps: Sedimentation effect could be neglected, but scouring effect shall be examined

Note: Pakse gauging station = KM 0+000

CHAPTER 4

PROPOSED BRIDGE ROUTES

4. PROPOSED BRIDGE ROUTES

4.1 Site Conditions

1) On Land (Pakse Side)

The town of Pakse is developed in narrow area between the Mekong and Xedone rivers. NR13S passes through the town center from north to south. The old Xedone bridge is a single lane steel truss bridge with insufficient traffic capacity. In order to resolve this problem, the new Xedone bridge was constructed in 1990 improving the cross section to two lanes of carriageway with side walks, along the Pakse bypass at eastern side of Pakse town.

The project area of Pakse Side extends on a flat terrain with an altitude of 100 - 110 m. In the south of Pakse town there are some temples and several farmers' houses scattered in paddy field. Pakse Airport is located at northern verge of Pakse town along with NR13.

In the south of the town, land has some rolling along NR13S. This area is more populous than the northern area. There are several public facilities, such as high school, water supply station, electric power substation, etc. located in this area.

2) River

River width, formulated with river banks of being loose and sharp bents, varies from 900 m to 1700 m in the vicinity of the Pakse town. River bed also varies irregularly. Upstream site of the Xedone estuary has a flat river bed. Downstream site varies the depth. The deepest river bed is located more than 10 m below from the Pakse Zero Gauge of EL 86.495 m.

3) On Land (Phonthong Side)

The area between NR10 and the Mekong river bank is flat. The land is used for paddy fields. Several villages are located along the river bank from the ferry pier to upstream side. Moreover, several houses, small shops, schools and some small scaled buildings are located along both sides of NR10 in the section from the ferry pier up to km 4.5.

However, the area in downstream side of the ferry pier has varied topographies, the 1.5 km area from the pier has rather flat area and the land is used for agriculture and several farmers' houses. The Mt. Salao, about 300 m high above the surrounding flat area, formulates steep slope with bared rock. The slope has a gradients of 1:3 to 1:10 on the Mekong river side.

4.2 Selection of Bridge Route

4.2.1 General

The Bridge route will be connected with NR10 in Phonthong side, and with NR13 in Pakse side. The following aspects shall be considered in selecting the proposed bridge routes:

- contents of relevant development plans in and around the Project site,
- the route location shall be closer to Pakse town, but not to pass through Pakse town from the viewpoint of road network efficiency in and around the Project site,
- the land acquisition and compensation shall be minimum, and
- avert of religious and/or traditional facilities.

Consequently, the subject areas for alternative routes are selected as three route areas.

1) Northern area of the town

This area is the northern part of Pakse town, upstream side of Xedone river. The appropriate locations for bridge route are selected in the area in the north of Xedone estuary away from Pakse airport site. Pakse Airport is planned to extent the runway. According to the plan, the boundary of the airport will be developed 850 meters to the north. The proposed route, considering the extension plan, should be located at more than 900 m from the site border of the existing airport to the north. In the opposite bank, Phonthong Side, paddy fields, some villages, some schools and temples are located.

2) Southern area of Pakse town

The area between the Xedone bridge of NR13S and the junction of Pakse bypass and NR13, near the Champasak Palace Hotel, is the most crowded commercial and business area in Pakse town. The remained area, between the junction and the Water Supply Station, is selected as an appropriate location for the new road, while several public facilities, such as Pakse High School and Water Supply Station are located. Phonthong Side has some residential houses along the river bank , some paddy fields and rare forest up to foot of Mt. Salao.

3) Area of the narrowest river section

The river width is estimated as 900 m. It is remarkably narrower than other locations, but the river banks have some sharp bents and drastically changed topographies on river bed, and complicated soil/rock distribution due to the affect of volcanic layers. On the bank of Phonthong Side, the existence of Mt. Salao with steep slope just beside the river bank gives difficult condition to road planning.

4.2.2 Long-listed Alternative Routes

Based on the above conditions, the above three areas were selected for planning of alternative routes.

The selection of routes will be done in two step procedures as follows;

(First Step) List up several candidate alternative routes in each selected area, the northern area, the southern area and the mountain side area,

(Second Step) Evaluate the candidate alternative routes in each area and select the most appropriate route in each area.

1) In Northern Area of the Town (Area - A)

In this area, three major obstacles are located, which are the Pakse airport on the bank of Pakse Side, rapids in river and school on the bank of Phonthong Side, beside NR10. The candidate alternative routes are planned without disturbance to the said obstacles and looking for engineering and economical advantages, the long listed candidate alternative bridge routes are selected as follows:

Alternative Route A-1

Pakse Side:

Estimated road length is 1.0 km. It will pass the paddy field with a few houses, about 4 km at the north of the town center and uncrowded area of paddy field at the end of Pakse airport site and 200 m at the north of edge of future development plan of the airport.

River Crossing:

Estimated bridge length is 1,680 m. It is located on stable portion of river behavior. The river bank has less bent, rather flat river bed comparing with other routes, and shallow water depth in dry season.

Phonthong Side:

Estimated road length is 2.7 km. It passes the paddy field and connects with NR10 forming a T-shaped at-grade junction.

Alternative Route A-2

Pakse Side:

Estimated road length is 0.6 km. The planned route on east side is located between the town and the Pakse airport, and is very close to both areas.

River Crossing:

Estimated bridge length is 1,900 m. The river conditions are similar to Alternative Route A-1.

Phonthong Side:

Estimated road length is 0.3 km. It will have one of the most favorable alignment in connection with NR10, but it will pass slightly crowded area near NR10.

2) In Southern Area of the Town (Area - B)

In this area some obstacles exist on land. However it is considered that this area might provide most appropriate route of the Project because of vicinity location from this center of Pakse town.

Alternative B-1

Pakse Side:

Estimated road length is 0.5 km. The existing roads pass through residential area and major temple is located beside the river.

River Crossing:

Estimated bridge length is 2,000 m. More flat river bed appears than other alternatives in the same area.

Phonthong Side:

Estimated road length is 1.2 km. Some houses are located along the river bank and paddy fields spread behind the village.

Alternative B-2

Pakse Side:

Estimated road length is 0.5 km. The conditions are similar to Alternative Route B-1.

River Crossing:

Estimated bridge length is 1,700 m. The river conditions are similar to those of Route B-1, but deeper portion is less length than Route B-1.

Phonthong Side:

Estimated road length is 1.9 km. Bush and fields are located around the foot of

Mt. Salao

Alternative B-3

Pakse Side:

Estimated road length is 0.7 km. Connecting point with NR13 is located near the stadium. The route pass through residential and field areas. Small hill on this route has major public facilities and temple near the river.

River Crossing:

Estimated bridge length is 1,580 m. The sharp bent of river banks starts from this point to the down stream. The deeper portion is widened also from this point.

Phonthong Side:

Estimated road length is 1.9 km. The conditions are similar to Alternative Route B-2.

Alternative B-4

Pakse Side:

Estimated road length is 0.7 km. The conditions are similar to Alternative Route B-3.

River Crossing:

Estimated bridge length is 1,400 m. The section length of deeper portion increases by some 100 m although bridge length is shortened comparing with Route B-3.

Phonthong Side:

Estimated road length is 2.1 km. The conditions are similar to Alternative Route B-3.

3) In the Area of the Narrowest River Section (Area-C)

The route in this area gives the shortest bridge length, while the river water is deepest in comparison with other areas.

Alternative C-1

Pakse Side:

Estimated road length is 1.6 km. The route crosses the existing feeder road which accesses to NR13. The area around the proposed route is roughly categorized as bushy lands.

River Crossing:

Estimated bridges length is 900 m. The river width is drastically shortened from 1,500 m to 900 m around the proposed route. The deeper portion shares a half of the total width.

Phonthong Side:

Estimated road length is 3.2 km. Mt. Salao has steep slope and bared rock in the foot of the mountain. The route passes through bush and paddy fields up to the connection of NR-10.

The above seven long listed alternative routes are shown in Figure 4.2-1.

4.3 Alternatives of Proposed Bridge Route

Out of the long-listed candidate alternative routes, most appropriate route were selected in each area. The summary of each evaluation in the three areas are as follows:

4.3.1 In Area-A (Northern Area of the Pakse Town)

Candidate alternative routes in each selected area are evaluated as follows:

Alternative Route A-1

Advantages	Disadvantages
• Planned river crossing section is more stable than others in river behaviors, river stream and river bed topographies. • Less obstacles and rather flat topographies on land in both sides.	• Slightly too far from the Pakse town

Alternative Route A-2

Advantages	Disadvantages
• Shortest length for road and bridge • Rather stable bank of the river	• To be connected with NR-13 in the crowded city area

Based on the result of above evaluation, the Alternative Route A-1 shown in Figures 4.3-1 and 4.3-2 was selected as the appropriate route in the Area-A.

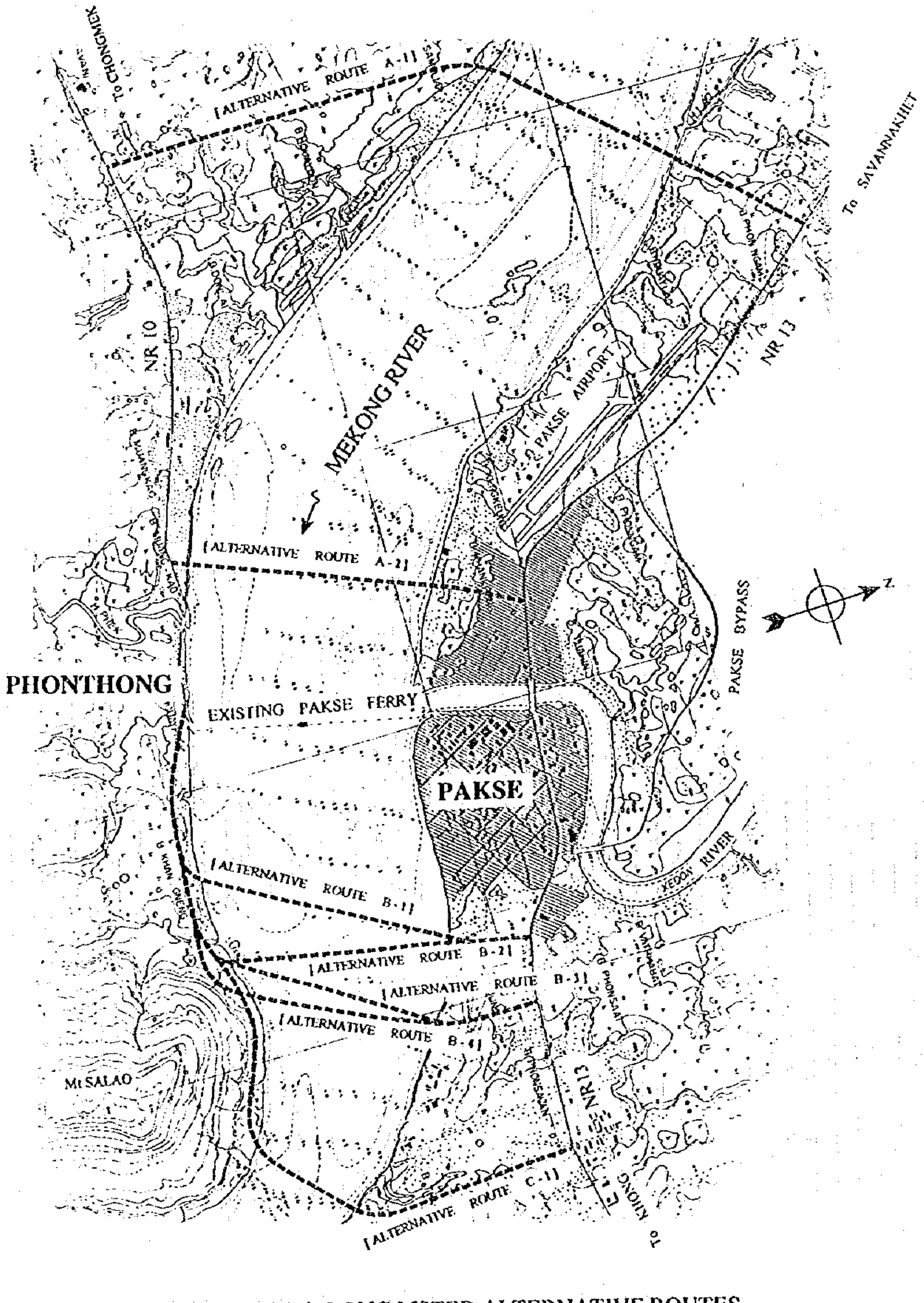


FIGURE 4.2-1 LONG LISTED ALTERNATIVE ROUTES

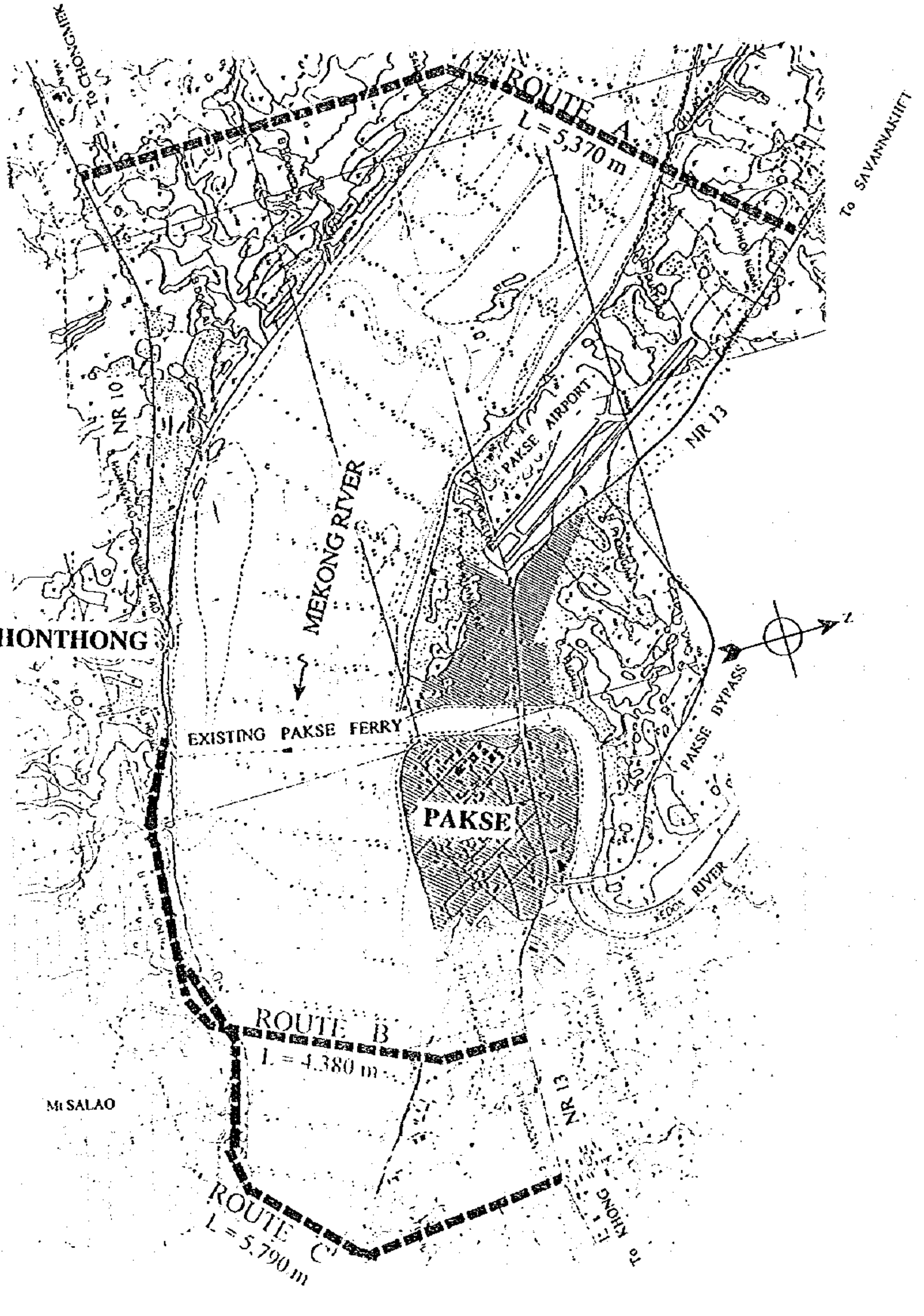


FIGURE 4.3-1 SELECTED ALTERNATIVE ROUTES IN THE AREA - A, B & C

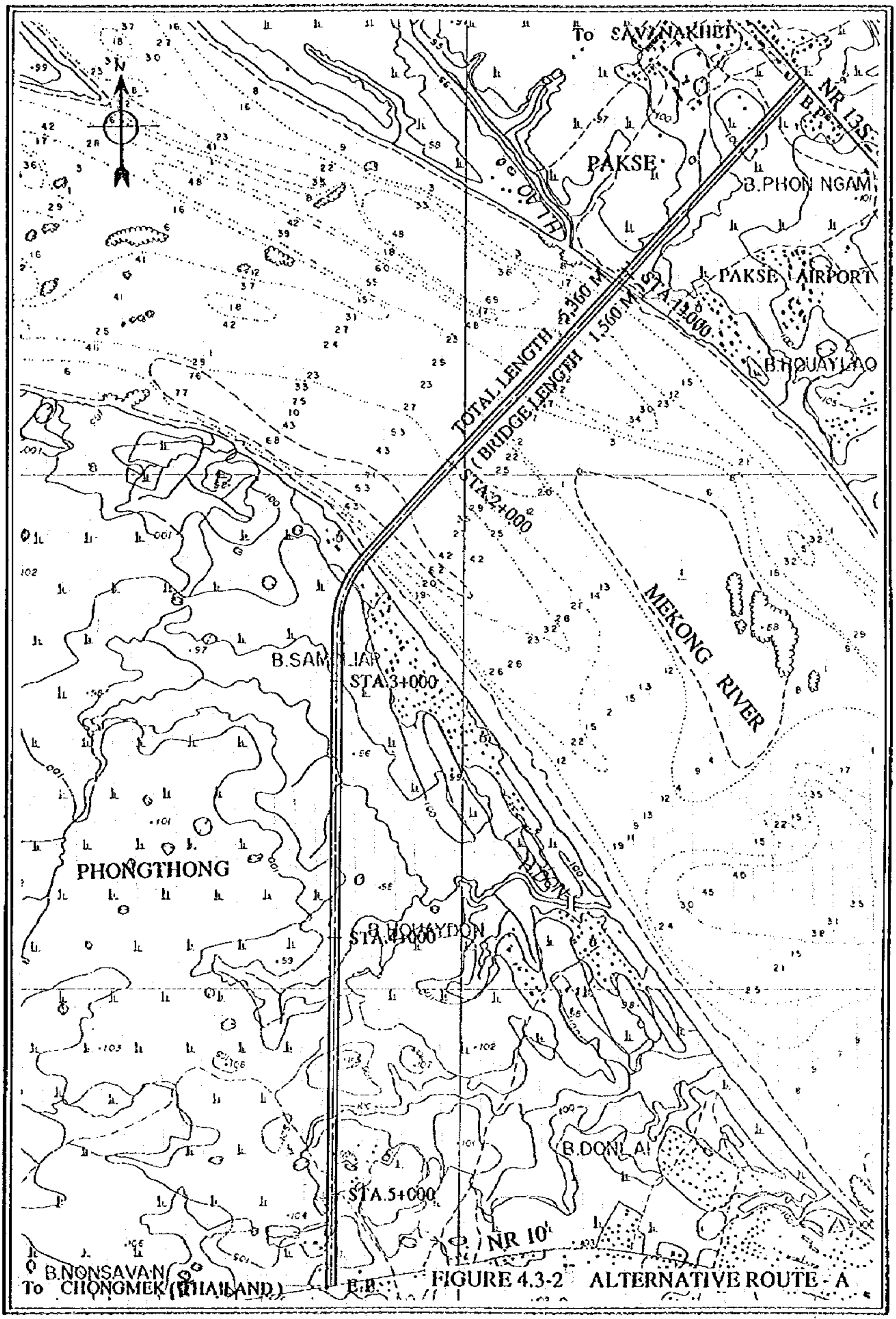


FIGURE 4.3-2 ALTERNATIVE ROUTE - A

4.3.2 In the Area-B (Southern Area of the Town)

Alternative Route B-1

Advantages	Disadvantages
• Closer connecting point with NR-13 • Rather flat river bed and stable on river behavior • Less relocation of houses in Phonthong side	• Longest river width (about 2 Km) • Much relocation of houses in Pakse side

Alternative Route B-2

Advantages	Disadvantages
• Shorter river width than B-1 • Shallow river depth than B-3 and B-4	• Much relocation of houses in both sides than (B-1) • Wider River width than (B-3) and (B-4)

Alternative Route B-3

Advantages	Disadvantages
• Shorter bridge length than B-1 and B-2 • Less relocation of houses in Pakse side	• Crossing the river with skew angle

Alternative Route B-4

Advantages	Disadvantages
• Shortest bridge length in the group of B • Less relocation of houses in Pakse side	• Some deeper

As the result of the above evaluation, Alternative Route B-4 shown in Figure 4.3-3 was selected as the appropriate route in the Area-B.

4.3.3 In the Area-C (Narrowest River Section)

The candidate route in the Area-C was selected as the shortest bridge length as shown Figure 4.3-4.

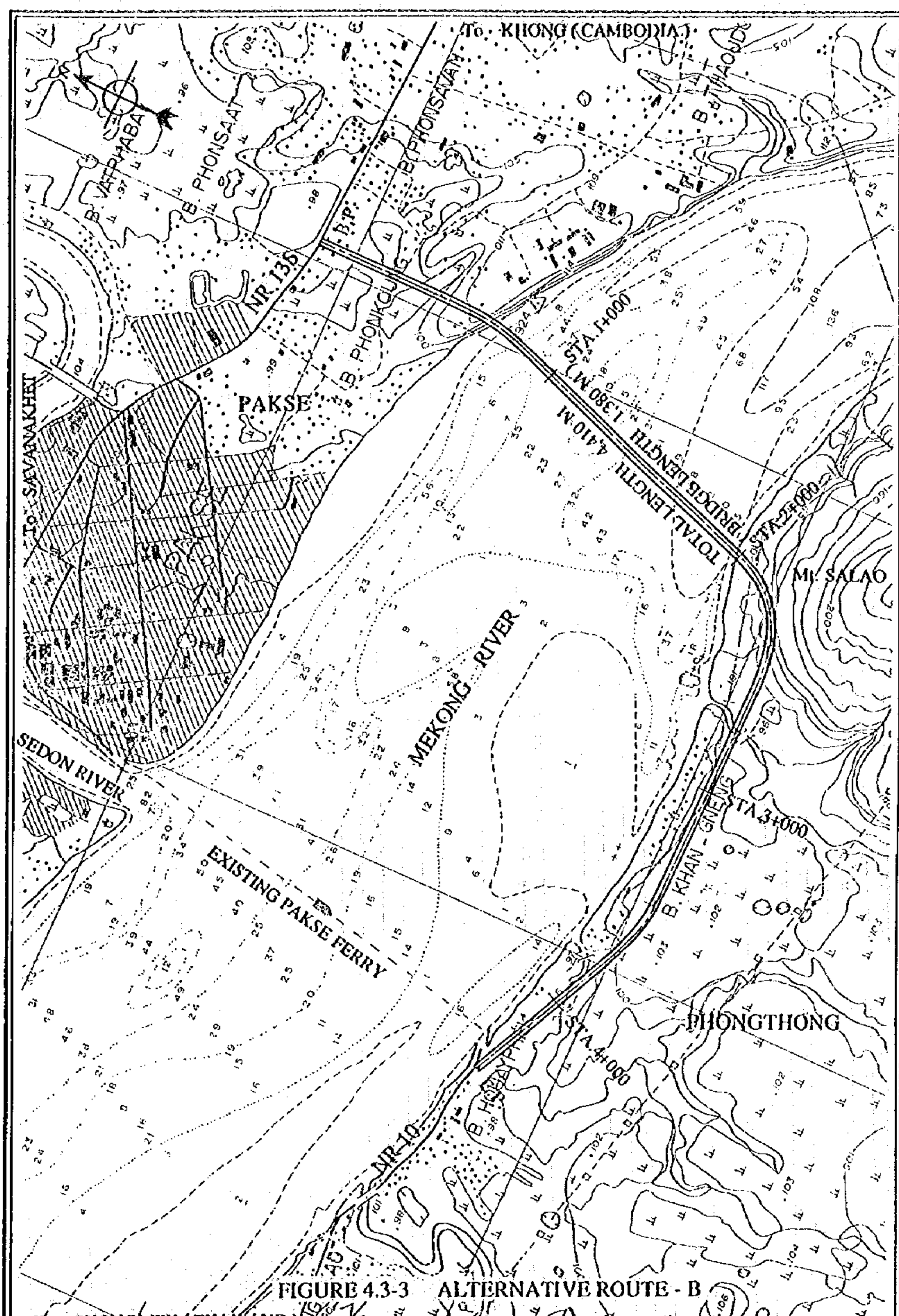


FIGURE 4.3-3 ALTERNATIVE ROUTE - B

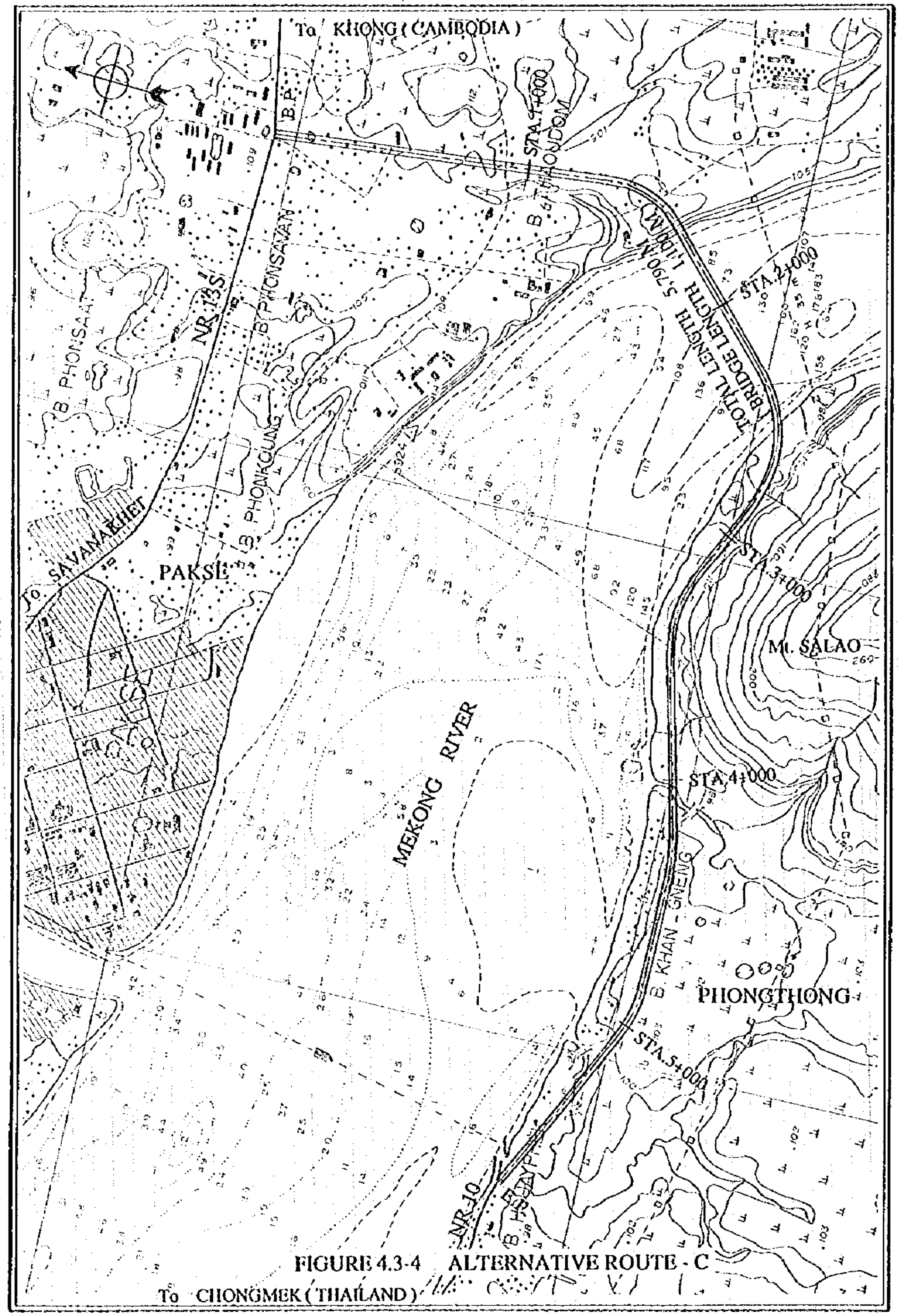


FIGURE 4.3-4 ALTERNATIVE ROUTE - C

CHAPTER 5

TRAFFIC STUDY

5. TRAFFIC STUDY

5.1 Present Traffic Characteristics

5.1.1 General

As the project bridge is expected to eliminate a bottleneck crossing over the Mekong river, it will affect the future traffic flows in the study area extensively. The characteristics of the present traffic are investigated based on the existing data and conducting a traffic survey.

5.1.2 Existing Traffic Data

Existing road traffic data relating to the study area was available from the following sources:

- National Transport Study (NTS) 1989
- Transport Planning Unit (TPU) MCTPC -- traffic counting for the whole country of Lao (3 to 4 survey sites in Southern provinces from 1990 -1994).
- The ADB 6th Road Study -- traffic counting and O-D survey (11 survey sites in Southern provinces, May 1992)
- The ADB 7th Road Study -- traffic counting at 6 sites and O-D survey at 2 sites in the Champasack Province
- Ferry operating company -- river crossing traffic (daily traffic from 26th January 1995 to 25th July 1995)

In order to compare past traffic data with the results of traffic survey by this Study, the existing traffic data were selected taking the differences of vehicle classifications and survey locations into account.

(1) Traffic Volume

Among the data above, the ADB 6th study (Sixth Road Improvement Project 1992) provides traffic count data covering the whole study area with 11 survey sites. Figure 5.1-1 indicates the summary of traffic volumes (ADT) surveyed by ADB 6th project. In 1992, the link traffic volumes in the study area showed comparatively low level not more than 300/day. Main traffic flows are observed along the NR 13, NR 10, NR 20 and NR 13A.

The ADB 7th project conducted the traffic count survey in 1994 at 6 sites on NR13 and 2 sites on NR10. Traffic volumes obtained by this survey, although limited road sections, also indicate the same patterns of flows with high volumes on the NR13 around Pakse and NR10 from Pakse to the Thai border as illustrated in Figure 5.1-2.

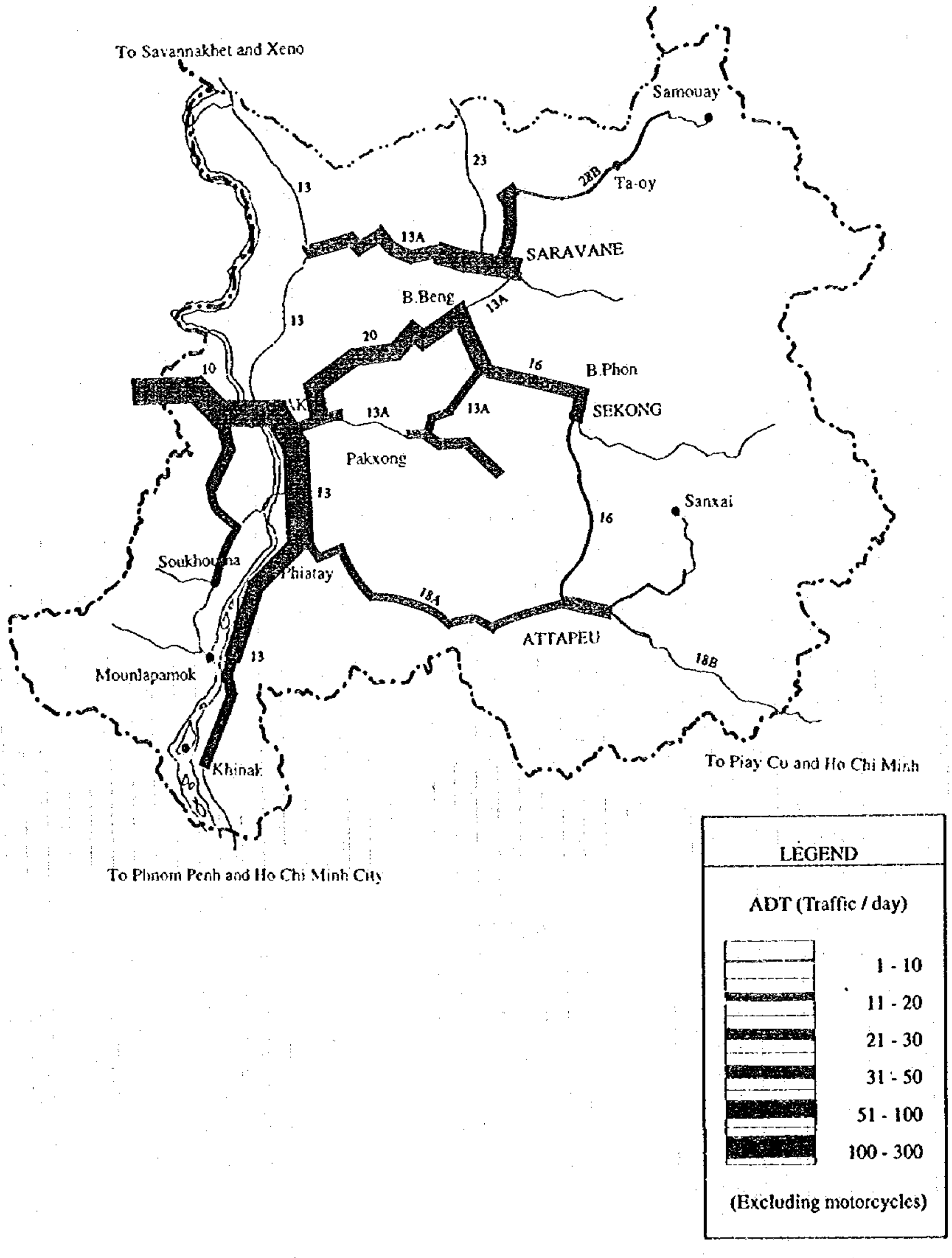


FIGURE 5.1-1 TRAFFIC VOLUME : ADT 1992 (ADB 6TH ROAD PROJECT)

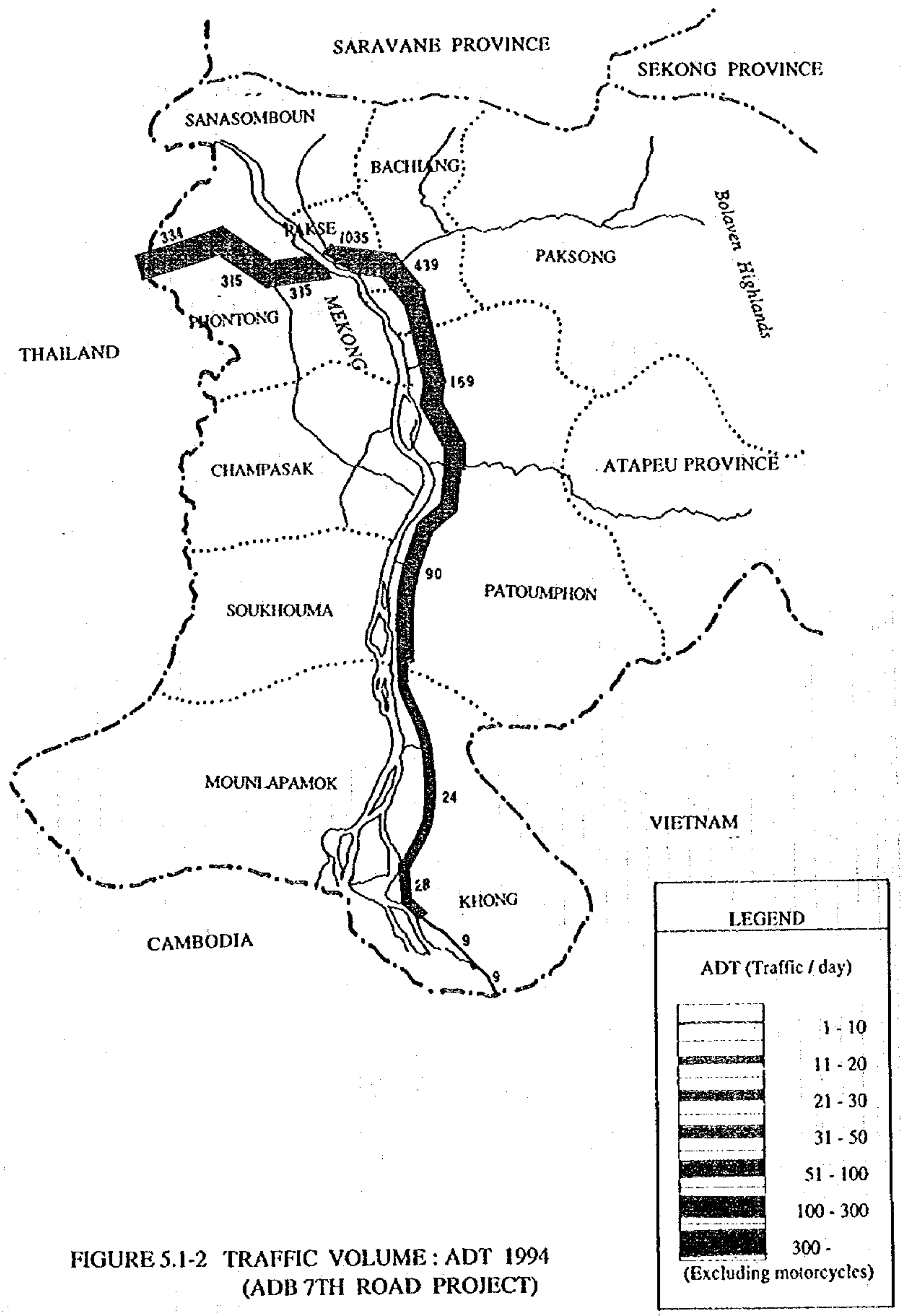


FIGURE 5.1-2 TRAFFIC VOLUME : ADT 1994
(ADB 7TH ROAD PROJECT)

(2) Vehicle Composition

The ADB 7th study reported the percentage ratios of motorcycle in total traffic as about 22 % - 34 % on the NR10 and 20 % - 58 % on the NR 13. The shares of heavy vehicles (2 axle, 3 axle truck, trailer truck and bus) in total traffic excluding motorcycles are about 40 % on the NR 10 and 40 % - 72 % on the NR13.

(3) International Commodity Flows through NR 10 (Chommeck)

National Transport Study estimated the international commodity flows (import and export) in 1987/88 from/to Thailand through NR10 at Chommeck. Import from Thailand via Chommeck on road network counted about 12,000 tons (8.6% of total import by road transport in the whole country), mainly construction materials and fuel.

On the other hand, export via Chommeck was at 38,000 tons (about 28% of the import by road transport from Thailand), of which 97 % was timber export and rest of 3% was agricultural products.

5.1.3 Traffic Survey

(1) Purposes of the Traffic Survey

The Study carried out the traffic survey in order to obtain information on the present traffic volume of vehicles (Average Daily Traffic: ADT) and to analyze characteristics of traffic movements crossing the Mekong river at Pakse and surrounding road sections (NR 10 and NR13).

(2) Type and Locations of Traffic Survey

The classified traffic counts were carried out from Monday (31st July '95) to Sunday (6th August '95) at the following 3 sites as shown in Figure 5.1-3.

- Survey Station 1 : Pakse ferry terminal (ferry traffic counts)
- Survey Station 2 : National Road 10 (km 12 at Phonthong)
- Survey Station 3 : National Road 13 (km 08)

The sites No.2 and 3 were selected to compare the results of the survey with the traffic volume counted in 1994 by the ADB 7th Road Study.

(3) Survey Hours

The traffic counting survey was conducted continuously 24 hours a day for 7 days (= 168 hours) at the sites No.2 and 3 and 12 hours a day at the ferry terminal.

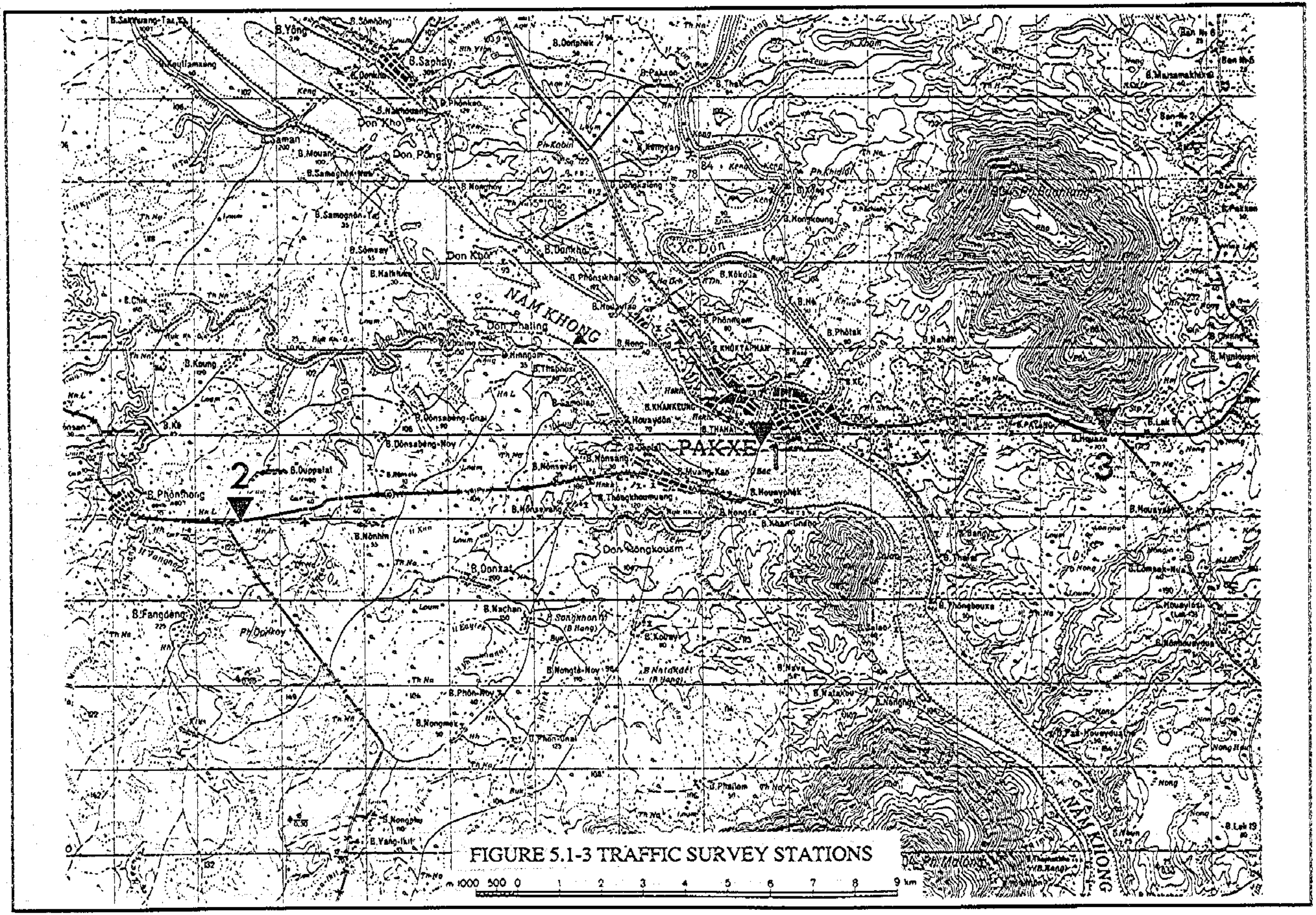


FIGURE 5.1-3 TRAFFIC SURVEY STATIONS

(4) Vehicle Classification

Vehicle categories in this survey are the same of 11 categories adopted in the ADB 7th Study as shown below :

1) Motorcycles (M/C)
2) Samlor
3) Mini bus (M / B)
4) Small bus (S /B)
5) Large bus (L / B)
6) Car / Jeep / Taxi
7) Pickup
8) 2 Axle Truck
9) 3 Axle Truck
10) Articulated Truck
11) Other

In addition to the categories above, bicycles and pedestrian passengers were counted as well at the ferry crossing site.

(5) Results of Traffic Survey

1) Traffic Volume

The surveyed daily traffic volumes were presented in Table 5.1-1 to Table 5.1-3 and comparison of ADT with the past traffic data is summarized in Table 5.1-4.

The ADT estimation in this Study was based on the seasonal factor of 0.85 (for traffic in July / August = average of 1.00 and 0.70) established by NTS.

Among the total volume of traffic, motorcycles are dominant at every survey sites..

2) Weekly Variations

Weekly variations of traffic passing through the each sites are shown in Figure 5.1-4. The weekly averages are observed on Wednesday or Thursday at each site. Sunday shows the highest traffic of the week at every site which is a different pattern from a normal urban traffic characteristic.

3) Time Variation

Time variations of traffic are presented in Figure 5.1-5 to Figure 5.1-7. High peaks in the morning and afternoon are clearly observed together with lower peak at midday time.

TABLE 5.1-1 SUMMARY OF CLASSIFIED TRAFFIC COUNTING SURVEY

(Survey Station No.1: Both directions - 12 hours)

Date	M/C	Sl	M/B	S/B	L/B	C/J/T	P-up	2 A	3 A	Art.	Subtotal	Bicycle	Pedes-trian
31/7/95 (Mon.)	369	6	4	0	0	23	44	32	20	19	517	181	1,462
01/8/95 (Tue.)	383	8	9	2	0	28	41	34	23	32	560	243	1,453
02/8/95 (Wed.)	318	6	10	5	1	22	39	65	38	41	545	246	1,511
03/8/95 (Thu.)	384	16	9	2	0	16	49	46	31	13	566	227	1,537
04/8/95 (Fri.)	349	21	7	0	0	23	48	39	27	15	529	445	1,838
05/8/95 (Sat.)	400	10	19	1	0	22	51	30	20	15	568	298	1,697
06/8/95 (Sun.)	516	22	11	2	0	14	52	18	13	13	661	281	2,176
Weekly Average	388	13	10	2	0	21	46	38	25	21	564	274	1,668
ADT*	388	15	12	2	0	25	55	45	29	25	595		
ADB 7th (July '94)	174					25	41	44	31		315	121	868
Records by Ferry Company (2nd week of July '95)						82 (incl. bus)	Mini	43	29	13			

Note: M/C: Motorcycle, Sl: Samlor, M/B: Minibus, S/B: Small bus, L/B: Large bus, C/J/T: Car/Jeep/Taxi, P-up: Pickup, 2A: 2 Axle truck, 3A: 3 Axle truck and Art.: Articulated truck

*: Day time traffic

TABLE 5.1-2 SUMMARY OF CLASSIFIED TRAFFIC COUNTING SURVEY

(Survey Station No.2: Both directions - 24 hours)

Date	M/C	SI	M/B	S/B	L/B	C/J/T	P-up	2 A	3 A	Art.	Total
31/7/95 (Mon.)	351	40	4	10	19	153	48	47	32	35	739
01/8/95 (Tue.)	364	32	7	17	23	149	49	42	28	37	748
02/8/95 (Wed.)	317	37	10	16	25	157	60	82	56	52	812
03/8/95 (Thu.)	329	40	4	19	16	139	61	56	38	20	722
04/8/95 (Fri.)	303	54	5	15	20	119	50	49	32	14	661
05/8/95 (Sat.)	425	57	13	21	17	149	58	38	26	15	819
06/8/95 (Sun.)	560	52	8	16	29	130	42	18	12	10	877
Weekly Average	378	45	10	16	21	142	53	47	32	26	768
ADT*	378	53	9	19	25	168	62	56	38	31	838
ADB 7th (May '94)	148	48	36	29	8	73	49	46	27	12	476
ADB 6th (May '92)				10		102	40	69	44	8	
TPU ('92ADT)				39		72	25	54	16	0	

Note: M/C: Motorcycle, SI: Samlor, M/B: Minibus, S/B: Small bus, L/B: Large bus, C/J/T: Car/Jeep/Taxi, P-up: Pickup, 2A: 2 Axle truck, 3A: 3 Axle truck and Art.: Articulated truck

TABLE 5.1-3 SUMMARY OF CLASSIFIED TRAFFIC COUNTING SURVEY

(Survey Station No.3: Both directions - 24 hours)

Date	M/C	Sl	M/B	S/B	L/B	C/J/T	P-up	2 A	3 A	Art.	Total
31/7/95 (Mon.)	1,769	811	17	6	13	170	375	256	170	7	3,594
01/8/95 (Tue.)	1,818	790	30	15	17	213	399	253	169	20	3,724
02/8/95 (Wed.)	1,690	833	26	7	27	183	359	296	198	27	3,646
03/8/95 (Thu.)	1,985	769	49	14	36	278	461	281	187	41	4,101
04/8/95 (Fri.)	1,772	799	23	11	14	228	397	289	193	21	3,747
05/8/95 (Sat.)	1,769	850	39	13	15	244	445	362	241	11	3,989
06/8/95 (Sun.)	2,841	776	31	10	14	264	308	284	189	41	4,758
Weekly Average	1,949	804	31	11	19	226	392	289	192	24	3,937
ADT*	1,949	949	36	13	23	266	463	341	227	28	4,295
ADB 7th (May '94)	427	179	110	104	71	224	171	149	91	40	1,566

Note: M/C: Motorcycle, Sl: Samlor, M/B: Minibus, S/B: Small bus, L/B: Large bus, C/J/T: Car/Jeep/Taxi, P-up: Pickup, 2A: 2 Axle truck, 3A: 3 Axle truck and Art.: Articulated truck

TABLE 5.1-4 COMPARISON OF ADT

Survey Station	Source	M/C	Car/Jeep, Pickup, Samlor	Bus	Truck	Total
Pakse Ferry	*JICA (1995)	388	95	14	99	596
(Day time traffic)	Ferry Company (July 1995)	-	82	-	85	
	ADB 7th (1994)	174	66	-	75	315
		**(348)	**(132)		**(117)	**(597)
NR 10	*JICA (1995)	378	283	53	125	839
(Km 12)	ADB 7th (1994)	169	213	26	97	505
	ADB 6th (1992)	-	144	7	122	
	TPU (1992)	-	97	39	70	
	NTS (1989)	-	45	20	55	
NR 13 (Km 8)	*JICA (1995)	1,949	1,678	72	596	4,295
	ADB 7th (1994)	465	592	173	270	1,500

Note: *: Study Team
**: Estimation by ADB 7th Study

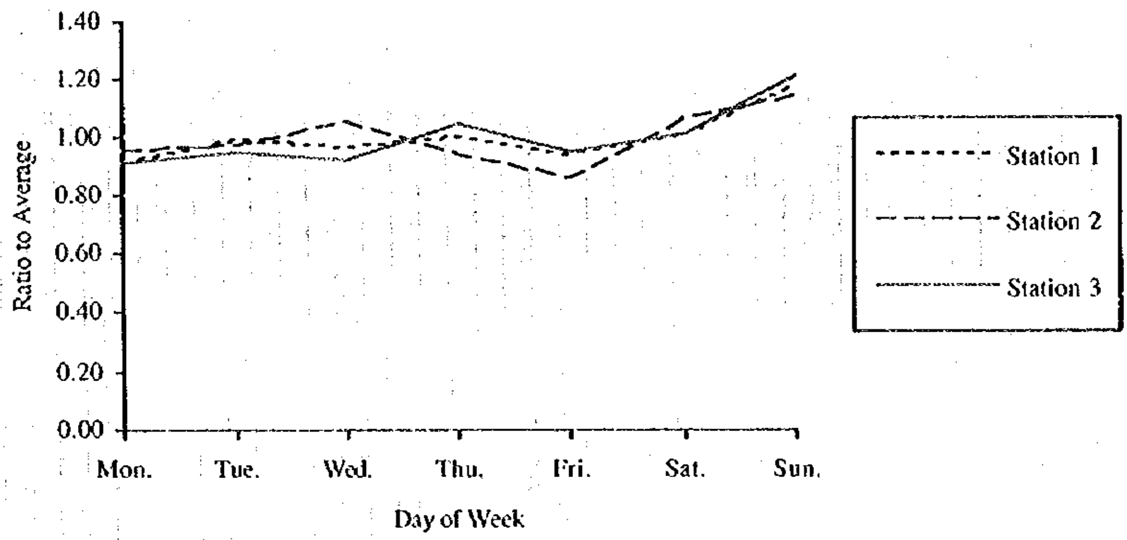


FIGURE 5.1-4 WEEKLY VARIATION

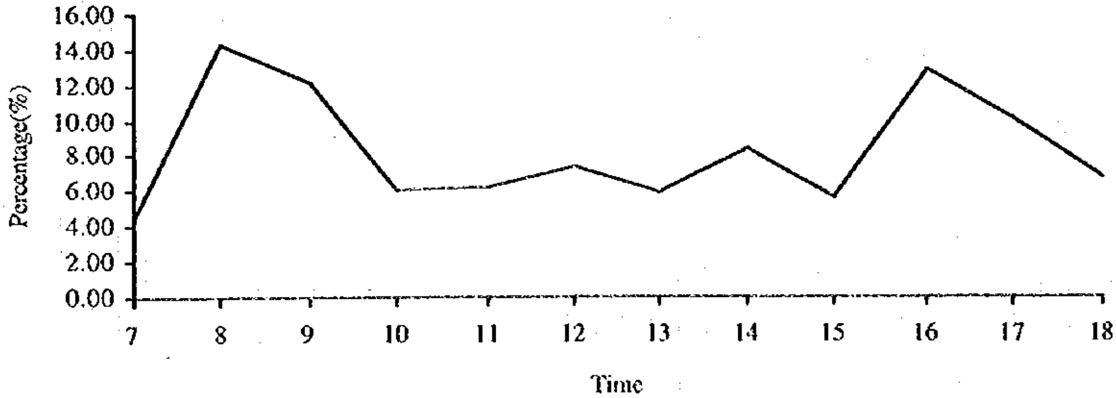


FIGURE 5.1-5 TIME VARIATION (STATION 1)

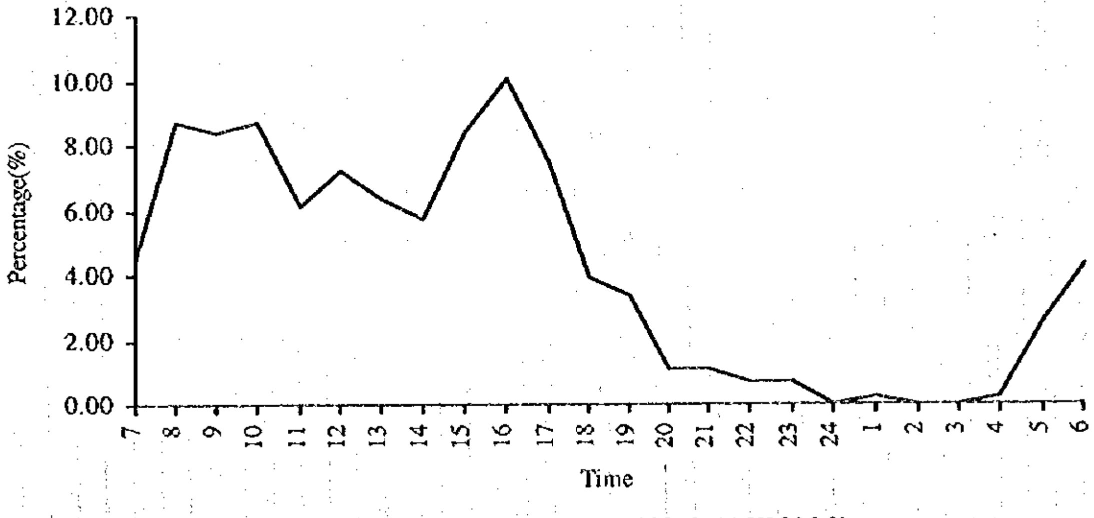


FIGURE 5.1-6 TIME VARIATION (STATION 2)

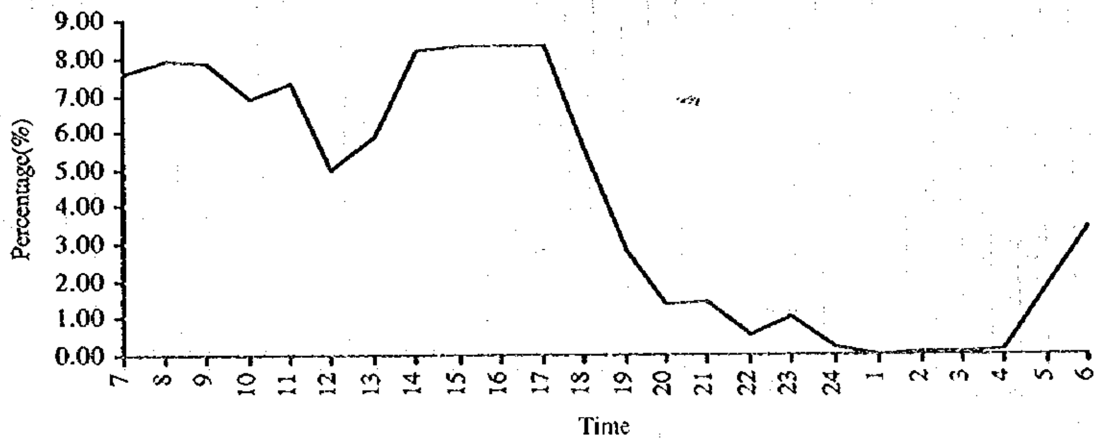


FIGURE 5.1-7 TIME VARIATION (STATION 3)

4) Night time Traffic Ratio

The percentages of night traffic (19:00 to 7:00) to the total daily traffic are calculated as follows:

- Station 2 (NR 10, km 12) 14.4 %
- Station 3 (NR 13, km 8) 12.6 %

(6) Existing Ferry Services

The information on the existing ferry services at Pakse were collected from the ferry company and summarized as follows :

1) Ferry Company

- Name of ferry operating company : "Boat Association"
- Total number of ferry boats owned : 5 boats
- Number of boats operated at Pakse : 5 boats
- Official agency in control of the company : D.C.T.P.C.

2) Characteristics of Ferry Boats Operated at Pakse

No.	Acquired Year	Length (m)			
		Length (m)	Width (m)	Capacity (in truck unit)	Capacity (tons)
1	1978	21.9	6.80	2	40
2	1982	26.00	8.00	4	60
3	1984	24.00	10.25	4	60
4	1986	34.00	7.00	6	80
5	1995	36.00	9.40	8	120

3) Ferry Operation

- Normal daily operation hour : From 7 :00 AM to 7 :30 PM
- Average number of round trips per day per boat : 5 trips / day / boat
- Average river crossing time : 25 minutes in high water season
20 minutes in low water season
- Average river crossing time (estimation) :

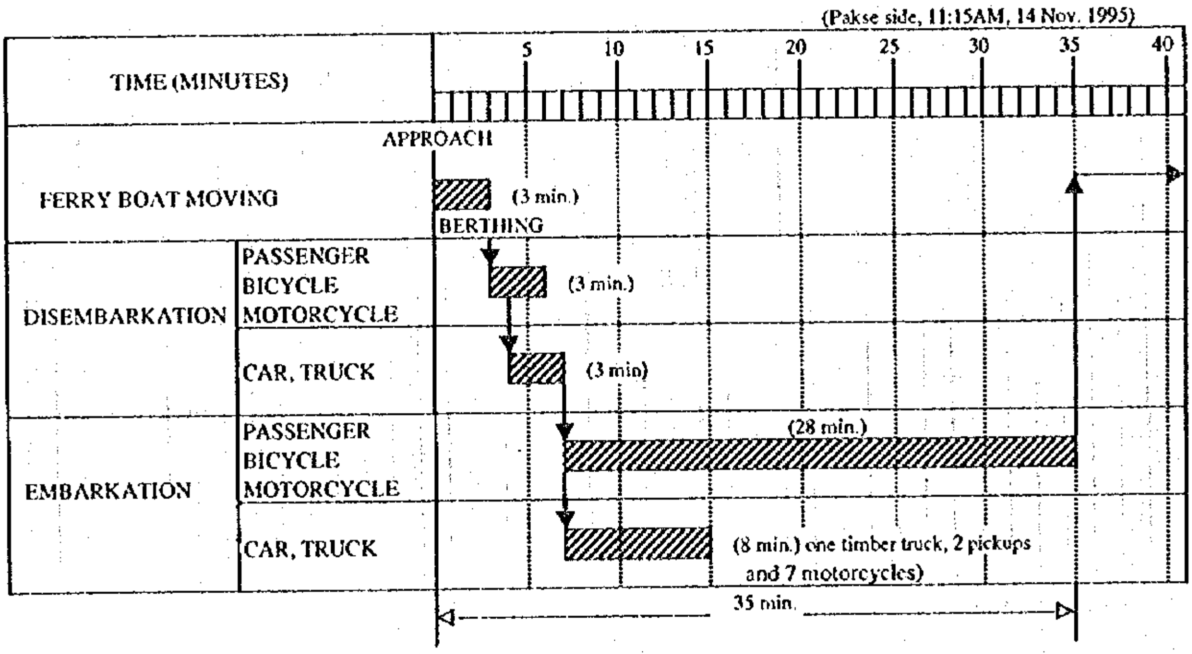
Operation	Truck (min)	Car (min)
Vehicles wait and roll on	30	45
Ferry casting off, sailing and docking	25	25
Vehicles roll off	10	5
Total	65	75

4) Traffic Processing Time at the Terminal

Figure 5.1-8 indicates an example of traffic processing time at Pakse terminal. About 35 minutes are required from ship berthing to embarkation.

5) Ferry Tariff (November 1995)

Motorcycle	300 K	Car/Jeep/Pickup	3,600 K
Samlor	1,500 K	2 Axle Truck	5,500 K
Minibus	3,600 K	3 Axle Truck	7,500 K + 585 K/ton
Smallbus	5,500 K	Trailer Truck	10,500 K + 585 K/ton
Largebus	7,500 K	Pedestrian	100 K



Source : JICA Study Team

FIGURE 5.1-8 PAKSE FERRY TRAFFIC PROCESSING TIME

5.2 Traffic Forecast

5.2.1 General

Future traffic demand on the project bridge at Pakse was forecasted based on the future socio-economic framework and applying the results of traffic analysis. The overall procedure of Average Daily Traffic (ADT) by vehicle type and alternative route of bridge is presented in the flowchart of Figure 5.2-1.

The traffic zone within the area of influence are shown in Figure 5.2-2.

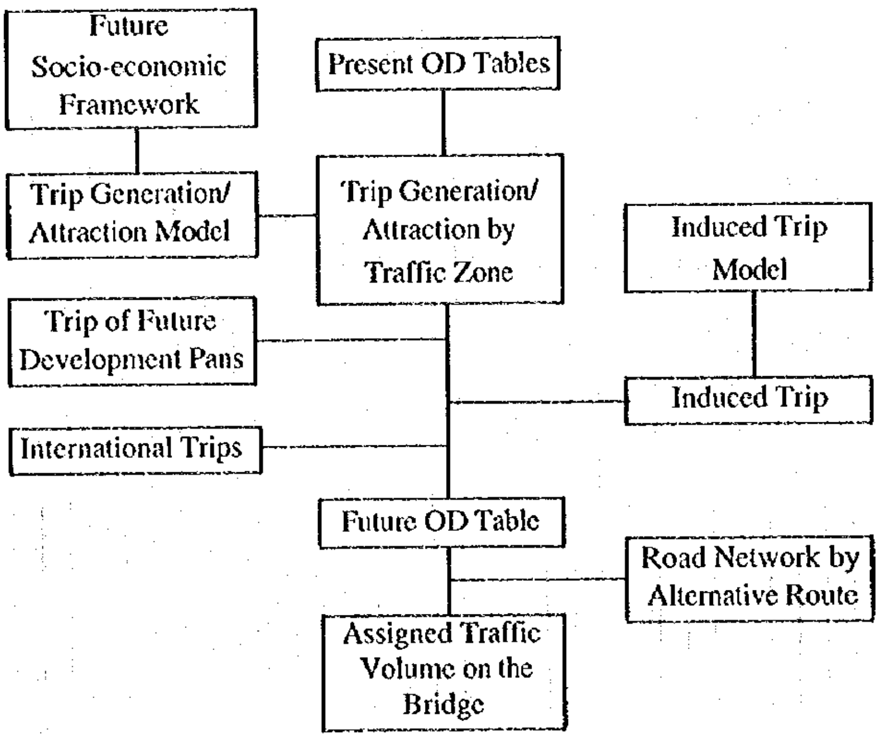


FIGURE 5.2-1 TRAFFIC FORECAST PROCEDURE

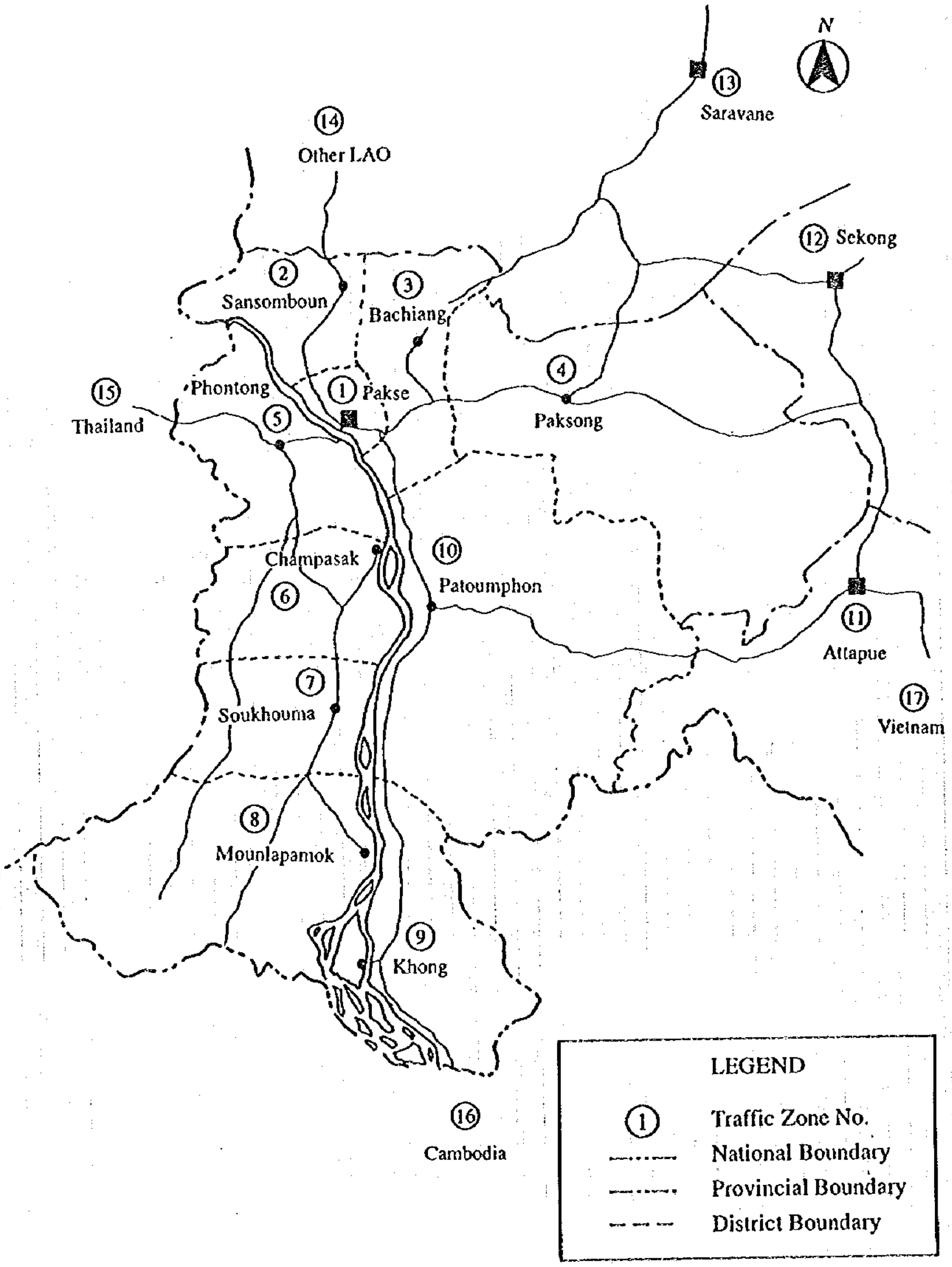


FIGURE 5.2-2 ZONING MAP

5.2.2 Establishment of Socio-Economic Framework

Formation of socio-economic framework aims at preparation of basic data required for the future traffic demand estimation. Population and Gross Domestic Product (GDP) were selected as a major items of framework, because they are highly associated to traffic generation and attraction. Target years for the socio-economic framework were set at 2000, 2010 and 2020.

1) Population Growth

Future population is formulated on the basis of past trend of population increase and projection by "Seventh Road Improvement Project". The expected population Growth rate for each zone are shown in Table 5.2.1.

2) Economic Growth

The expected macro economic growth for LAO PDR and other countries was set based on the National Development Plans and results of related studies such as "Sub regional Transport Sector Study, ADB" and "Seventh Road Improvement Project, ADB" as shown in Table 5.2-2. As data for Gross Provincial Product are not available, the economic growth rate of Champasak Province was assumed as same as the growth of whole country.

TABLE 5.2-1 POPULATION GROWTH

(Unit: % per year)

Zone No.	Zone/Area	Forecast 1994-2000	2000-2010	2010-2020
1	Pakse	2.6	2.2	1.6
2	Sanasomboun	2.3	1.9	1.3
3	Bachiang	2.8	2.4	1.8
4	Paksong	1.5	1.3	1.1
5	Phonthong	2.0	1.6	1.0
6	Champasak	1.3	1.2	1.1
7	Soukhouma	2.1	1.7	1.1
8	Mounlapamok	3.2	2.8	2.2
9	Khong	1.2	1.2	1.1
10	Pathoumphon	2.4	2.0	1.4
	CHAMPASAK	2.0	1.7	1.2
11	Attapeu	2.3	1.7	1.2
12	Sekong	2.3	1.7	1.2
13	Saravane	2.8	2.3	1.7
14	Other LAO	2.3	1.7	1.2
	LAO PDR	2.3	1.7	1.2
15	Thailand	1.5	1.3	1.2
16	Cambodia	1.9	1.5	1.2
17	Vietnam	1.9	1.5	1.2

TABLE 5.2-2 GDP GROWTH

(unit: % per year)

Area	1994-2000	2000-2010	2010-2020
LAO PDR	8.0	6.5	5.0
Thailand	8.0	7.0	7.0
Vietnam	6.0	6.0	6.0
Cambodia	6.0	6.0	6.0
Champasak Province	8.0	6.5	5.0

5.2.3 Traffic Demand Forecast

1) Establishment of Present OD Matrix

The present OD matrix of traffic crossing over the Mekong river at Pakse was established based on the results of traffic count survey at existing ferry terminal conducted by the JICA study team and the OD pattern at Km 26.5 National Road 10 surveyed by the "Seventh Road Improvement Project, ADB".

Unknown OD pair of uncovered district-zones was estimated by using a gravity model. The gravity model has the following form:

$$T_{ij} = k*P_i^a*P_j^b/D_{ij}^c$$

where,

T_{ij}	:	number of trips from zone i to zone j
P_i	:	population of zone i
P_j	:	population of zone j
D_{ij}	:	minimum travel time distance between zone i and j
a, b, c, k	:	parameters. Table 5.2-3 is shown values of these parameters for each vehicle category.

TABLE 5.2-3 PARAMETER FOR GRAVITY MODEL

Vehicle Type	a	b	c	k	Correlation Coefficient R
M/C	1.165199	1.005737	2.899064	0.000019	0.791911
Light	1.088100	0.922077	2.729684	0.000051	0.783085
Bus	0.984356	0.923279	2.090323	0.000004	0.941778
Truck	1.239585	1.079103	2.168265	0.000000	0.894034

The calculated present OD tables by vehicle type are shown in Appendix 5.2-1.

2) Forecasting Future OD Matrix

(1) Estimation of Total Trip Generation/Attraction of Champasak Province:

The historical traffic data by vehicle type were only available at Km 26.5 NR 10. On the basis of those historical traffic data and the socio-economic framework of Champasak Province, the traffic growth model was established. The model has the following form:

$T_k = a*POP+b*GPP+c$

where,

T_k	:	number of trips by vehicle category k
POP	:	population of Champasak Province
GPP	:	Gross Provincial Product (GPP) of Champasak Province
a, b & c	:	parameters with values:
		Light vehicle: a=0.001309 b=0.003770 c=-808.179
		Trucks : a=0.000623 b=0.000563 c=-247.175

The traffic growth was calculated through inputting future socio-economic indices as shown in Table 5.2-4.

TABLE 5.2-4 TRAFFIC GROWTH RATE

(Unit: % per year)

Vehicle Type	1995-2000	2000-2010	2010-2020
Light	13.3	8.7	5.5
Truck	7.5	6.1	4.1

Total trip generation and attraction by vehicle type were calculated using above traffic growth rate and present total trip generation and attraction as shown in Table 5.2-5. In these calculation traffic growth rates for Motorcycle and Bus were as the same that for Light vehicle and Truck.

TABLE 5.2-5 TRIP GENERATION/ATTRACTION FORECAST

(Unit: trip)

Vehicle Type	1995	2000	2010	2020
M/C	1,604	2,995	6,898	11,783
Light	738	1,378	3,174	5,422
Bus	148	212	383	572
Truck	354	508	918	1,372

(2) Estimation of Future Trip Generation/Attraction by Traffic zone:

Future trip generation and attraction by traffic zone were estimated applying the zone growth rates of socio-economic indicators. The estimated zone trip generation and attraction in Champasak Province were re-adjusted using the above mentioned total trip generation and attraction as the control total. The results of estimation of trip generation and attraction by zone are shown in Table 5.2-6.

TABLE 5.2-6 FUTURE TRIP GENERATION/ATTRACTION BY TRAFFIC ZONE

(Unit:trip)

Zone No.	Zone/Area	2000				2010				2020			
		M/C	L	B	T	M/C	L	B	T	M/C	L	B	T
1	Pakse	1,067	395	55	175	2,534	941	103	328	4,449	1,654	159	506
2	Sanasomboun	208	146	23	23	479	338	42	42	816	576	62	63
3	Bachiang	176	92	16	16	427	224	31	31	765	401	48	49
4	Paksong	101	52	8	10	219	114	14	17	366	190	21	24
5	Phonthong	1,200	511	72	253	2,688	1,147	127	445	4,448	1,900	184	648
6	Champasak	61	48	8	8	130	104	14	14	218	174	20	20
7	Soukhouma	59	43	11	7	134	97	20	13	224	162	30	19
8	Mounlapamok	16	12	3	0	39	30	6	0	73	55	10	0
9	Khong	21	12	3	3	46	27	5	5	77	45	7	7
10	Pathoumphone	86	66	12	13	201	154	21	24	347	265	32	36
11	Attapue	21	16	6	6	39	30	11	11	63	49	18	18
12	Sekong	91	38	12	15	171	72	22	28	279	117	36	45
13	Saravane	241	71	25	31	452	132	47	58	737	216	76	94
14	Other LAO	0	0	0	0	0	0	0	0	0	0	0	0
15	Thailand	411	307	57	137	809	604	113	269	1,592	1,188	222	529
16	Cambodia	0	0	0	0	0	0	0	0	0	0	0	0
17	Vietnam	0	0	0	0	0	0	0	0	0	0	0	0

(3) Estimation of Induced Trips:

Induced trips are produced in the case of "with project" due to shortening travel time of crossing the river. Induced trips were estimated according to the methodology shown in Figure 5.2-3.

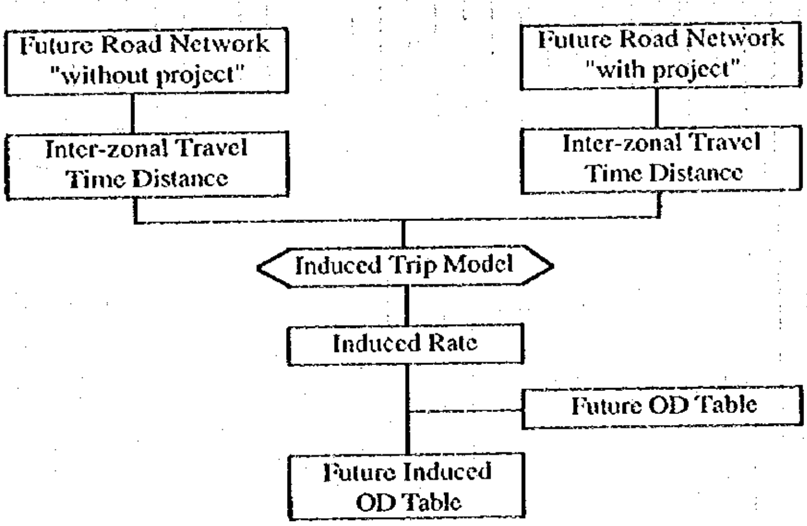


FIGURE 5.2-3 ESTABLISHMENT OF INDUCED OD TABLES

To estimate the induced trips, the following model was applied:

$PT_{ij} > 0$

$FIT_{ij} = FT_{ij} * \{(PD_{ij}/FD_{ij})^{c} - 1\} * A$

$PT_{ij} = 0$

$FIT_{ij} = (k * FG_{i}^{a} * FA_{j}^{b}/FD_{ij}^{c} - k * FG_{i}^{a} * FA_{j}^{b}/PD_{ij}^{c}) * A$

where,

FIT_{ij}	:	number of induced trips from zone i to zone j
PT_{ij}	:	number of present trips from zone i to zone j
FT_{ij}	:	number of future trips from zone i to zone j
FG_{i}	:	number of future generated trips of zone i
FA_{j}	:	number of future attracted trips of zone j
PD_{ij}	:	minimum travel time distance between zone i and j on present road network
FD_{ij}	:	minimum travel time distance between zone i and j on future road network
A	:	adjustment factor = 0.5, as the potential traffic demand will not fully appear with no great effect from other transport modes on the road transport
a, b, c, k	:	parameters. (Refer to Table 5.2-7)

TABLE 5.2-7 PARAMETER FOR INDUCED TRIPS

Vehicle Type	a	b	c	k	Correlation Coefficient R
M/C	0.230734	0.653077	0.228707	1.286814	0.686140
Light	0.314451	0.296534	0.390749	0.350373	0.786892
Bus	0.340429	0.342247	0.418710	0.155288	0.880145
Truck	0.494899	0.494340	0.250983	0.097068	0.849589

Other traffic induced factor may be assumed based on shortening travel time due to simplification of national border pass at Chommeck. This factor was omitted in calculation of the induced trip because there was limited information and this will be an indirect effect by bridge construction.

(4) Trips of Future Development Plans

As trips expected to be generated due to future special development plans related to the project are not included in the normal growth pattern, these trips were estimated for the target year and supplemented to the future OD matrices in order to produce complete future trip distribution and OD tables.

Agricultural and rural development in Boloven plateau in Paksong district will influence to the traffic volumes on the project bridge. The Lao Upland Agricultural development Project (World Bank) and the Master Plan Study on the Integrated Agricultural and Rural Development Project in Boloven Plateau(JICA) are under going. According to these projects, future agricultural products will increase as Table 5.2-8.

TABLE 5.2-8 ANTICIPATED PRODUCTION IN BOLOVEN PLATEAU UNDER LUAD PROJECT AND JICA PROJECT

(Unit: ton/year)

	Year	Coffee	Cowpea	Maize	Soybean	Vegitables	Field crops
LUAD	2000	2,838	1,081	2,703	541		
Project	2010	19,296	3,420	8,550	1,710		
	2020	19,468	3,420	8,550	1,710		
JICA	2000	2,560				18,814	5,010
Project	2010	7,679				56,441	15,029
	2020	10,238				75,254	20,039
Total	2000	5,398	1,081	2,703	541	18,814	5,010
	2010	26,975	3,420	8,550	1,710	56,441	15,029
	2020	29,706	3,420	8,550	1,710	75,254	20,039

On the basis of the assumption that all coffee and half of other agricultural products are exported through Thailand and average load for truck is two ton, trips from Paksong to Thailand in target year are estimated as shown in Table 5.2-9 and to be added to the future OD matrix.

TABLE 5.2-9 TRIPS OF FUTURE DEVELOPMENT PLANS BY TRUCK

(trips/day)

Year	Coffee	Cowpea	Maize	Soybean	Vegitables	Field crops	Total
2000	15	1	4	1	26	7	54
2010	74	5	12	2	77	21	191
2020	81	5	12	2	103	27	230

(5) International Trips

The Project potentially form link in major international trade routes between northeastern Thailand and eastern Cambodia and southern Vietnam. According to "Regional Technical Assistance on Promoting Sub regional Cooperation Among Cambodia, the People's Republic of China, Lao PDR, Myanmer, Thailand and Vietnam Sub regional Transport Sector Study, ADB", estimated trade volumes are shown in Table 5.2-10.

TABLE 5.2-10 INTERNATIONAL GOODS MOVEMENT

(Unit: ton)

Direction	Item	1993	2020
Northern Thailand	Agricultural Products	5,703	26,772
- Southern Vietnam	Wood	4,601	21,564
	Others		1,461
	Total	10,304	49,797

The international movements between northeastern Thailand and southern Vietnam are estimated as shown in Table 5.2-11 and to be added to the future OD matrix using the following assumptions:

- Average tones per vehicle for agricultural products and others : 2
- Average tones per vehicle for wood : 10
- Target years of 2000 and 2010 are interpolated.

TABLE 5.2-11 INTERNATIONAL TRIPS

(trip/day)

Direction	Item	1993	2000	2010	2020
Northern Thailand	Agricultural Products	8	12	25	37
- Southern Vietnam	Wood	1	2	4	6
	Others				2
	Total	9	14	29	45

(6) Future OD Tables

Future OD tables were established using a present pattern method on the basis of present OD tables and future trip generation and attraction. Trips added to the basic OD table are the developed trips of future development plans, international trips and induced trips due to construction of the bridge. Detailed OD tables by vehicle type in target year are shown in Appendix 5.2-2.

The inter-zone traffic flows of river crossing in 1995 and 2020 are shown in Figure 5.2-4 and Figure 5.2-5 respectively. The present and future river crossing traffic consist of traffic demands mainly between Pakse–Phontong and Pakse–Thailand.

3) Assigned Traffic Volumes

Traffic volumes on the project bridge by the alternative routes were forecasted though the assignment of OD tables on the road network of each target year. The results of calculation are shown in Table 5.2-12.

TABLE 5.2-12 FUTURE TRAFFIC VOLUME

	2000	2010	2020	Growth Rate % per year 2000-2010	2010-2020
Route-A	1,467	3,474	5,775	9.0	5.2
Route-B	1,460	3,451	5,737	9.0	5.2
Route-C	1,448	3,422	5,691	9.0	5.2

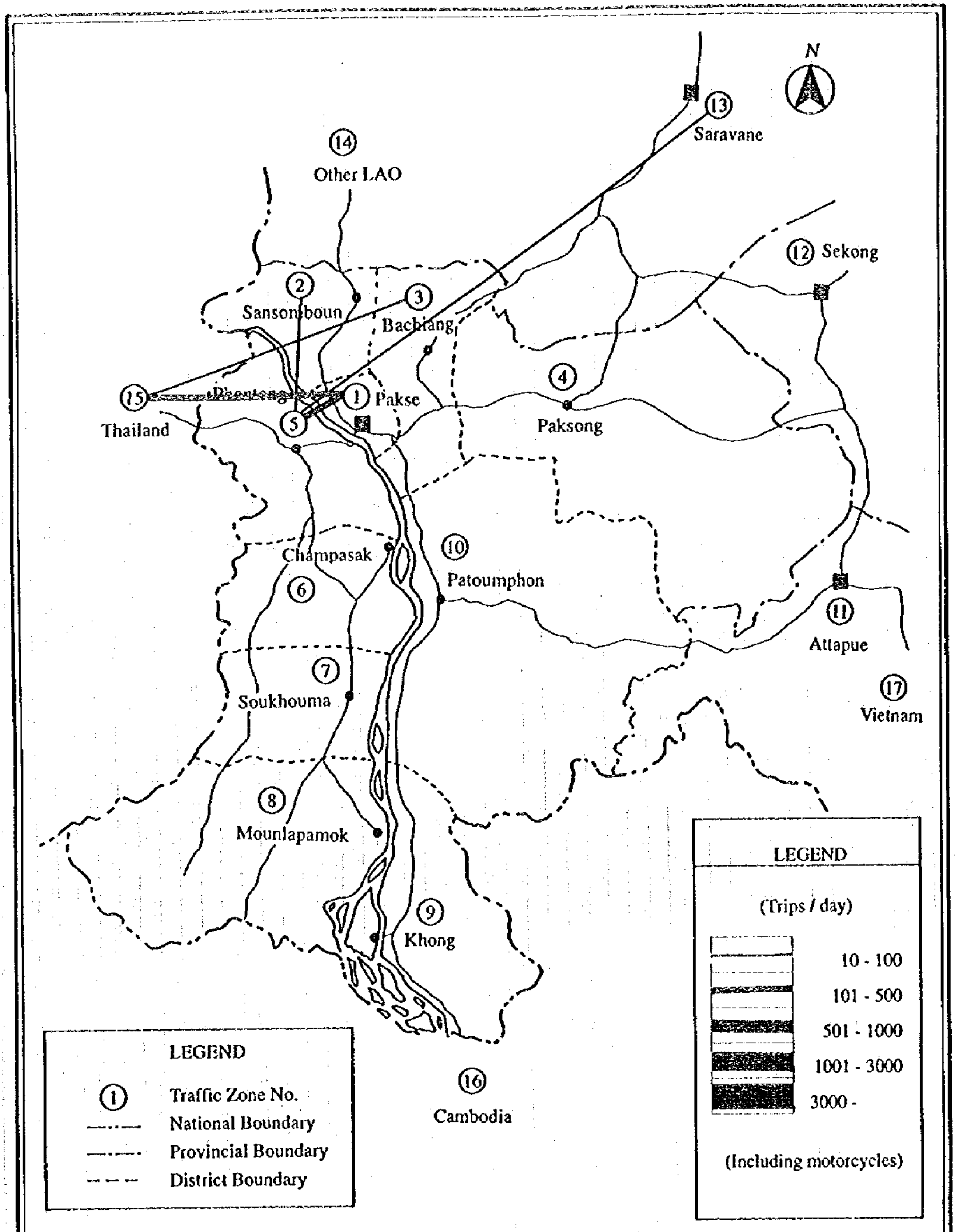


FIGURE 5.2-4 INTER-ZONE TRAFFIC FLOWS : ALL VEHICLES, 1995

(River Crossing Traffic)

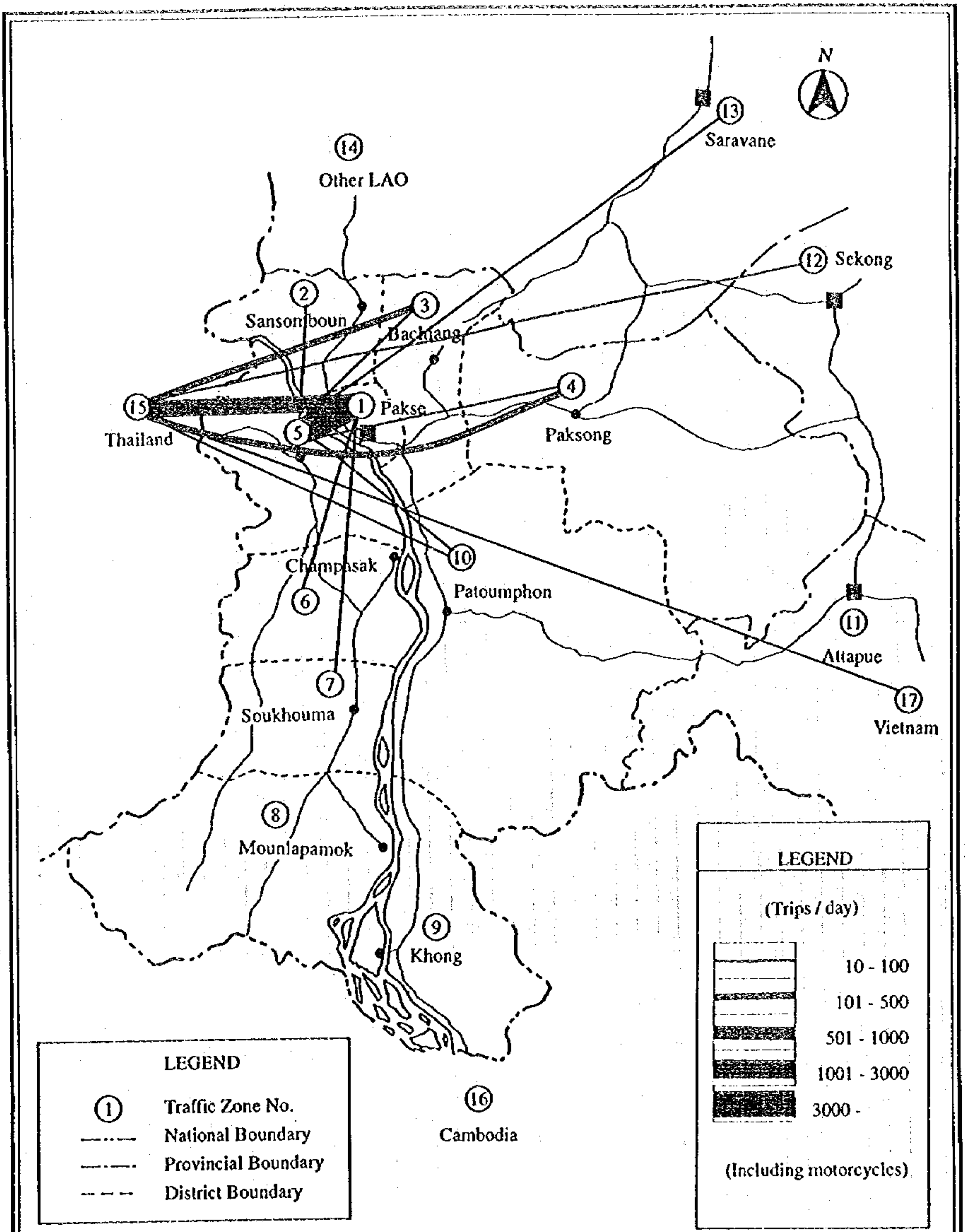


FIGURE 5.2-5 INTER-ZONE TRAFFIC FLOWS : ALL VEHICLES, 2020

(River Crossing Traffic)

CHAPTER 6

ENVIRONMENTAL EXAMINATION

6. ENVIRONMENTAL EXAMINATION

6.1 Objectives

The objective of this section is to present the results of the environmental examination of the three alternative alignments, describing in a comparative manner, their implications for the local bio-physical, human and built ecosystems. The comparison also includes a description of a number of the major and likely mitigation measures.

Based on these results, a preferred option has been identified using only the environmental results. This evaluation has been added to the economic and engineering evaluations, resulting in the recommendation of a preferred alignment based on a multi-disciplinary assessment of each alignment. The environmental evaluation outcome represents 20% of the total evaluation score.

6.2 Methodology

The immediate study area included, broadly, all of Pakse Town and the lands extending North to 1 km past the airport on NR 13 and East on NR 13 to the intersection with NR 23 (to Paksong). It included the Mekong River 3 km N and S from the mouth of the Sedon River. Economic and socio-cultural effect generally extend beyond the immediate area, and therefore the study area for these factors was defined on a case-by-case basis.

The economic and traffic studies used three forecasting years 2000, 2010 and 2020.

Forecasting was completed for two period, 2010 and 2020, as well as using 1995 as the base (existing condition) year.

It was assumed that the impact zone would be at three levels:

(1) a 40 m-wide ROW (20m either side of centerline), cleared of all structures, trees etc.;
(2) a 200 m-wide impact zone, i.e., 100m on either side of the centerline, (which included the 40 m) in which significant effects of the project might be felt; and,
(3) a variable zone dealing with such effects a materials trucking routes, borrow areas, construction waste management, downstream water pollution, etc.

Data assembly involved:

- a review of the complete set of data collected in August 1995;
- a further detailed interviews with technical specialists;
- consultation sessions with key stakeholders (more than 25) on both the Pakse and Muang Kao (West) side of the study area;

- field surveys (windshield type), including walking of entire alignment B and C;
- a photographic record of key features; and,
- a complete inventory of all buildings, rice fields, trees and special structures within the 40 and 200m wide impact areas for all three alignments (based on mapping prepared by Study Team, Sept. 1995).

Data analysis include summation of transportation and construction data and simple comparative graphs for the three alternatives.

Noise estimation was made on the bases of a with and without bridge scenario, using a number of assumptions about noise levels based on the expected traffic mix, speed, road grade and elevation above ground level of the new approach roads and the bridge spans..

Air quality estimates were based on the calculation of vehicle-kilometers (vhk) traveled by 4 categories of vehicles and then applying standard emission factors (gr/vhk) for a number of major pollutants (Table 6.2-1). Pollutant loadings were estimated for both total traffic and traffic as a result of the bridge (induced traffic). (Refer to Annexes)

TABLE 6.2-1 AIR POLLUTANT EMISSION RATES BY EACH VEHICLE TYPE

(Unit: gr/veh.km)

VEHICLE TYPE	AIR POLLUTION PARAMETERS				
	Total hydrocarbons (THC)	Carbon monoxide (CO)	Oxides of Nitrogen (NO_X)	Sulphur dioxide (SO_2)	Total suspended particles (TSP)
2/3 wheelers	11.40	21.40	0.14	0.65	0.08
Cars/pickups	1.29	10.24	1.31	1.74	0.07
Buses	5.30	6.60	16.50	6.60	1.40
Tructs	2.60	6.00	11.80	4.29	0.90

Note: Avg. speed was assumed to be 45kph. Rates are obtained from World Health Organization, Air Emission Rate Statistical Records, 1993

6.3 Existing Environmental Issues

6.3.1 Biophysical Environment

1) Air Quality

The existing air quality in the study area is generally excellent (Refer to Annexes), since by far the majority of traffic is motor scooters, motorcycles and 3-wheeled samlos. Given that most scooters are modern technology with some pollution abatement equipment installed, total emission loadings remain low. During the dry season there are periods of low airmass movements when emissions accumulate in the town. This is aggravated by the frequent burning of waste papers and plant materials. Within the area considered as representing a section of road in Pakse reflecting background conditions, namely 60% of the existing 5.4 km of NR 13 South of Pakse, on the West side of the river, vehicular emissions in 1995, for five parameters, were roughly as follows:

- Total Hydrocarbons (THC)	31.13	ton/year
- Carbon monoxide (CO)	74.46	ton/year
- Oxides of Nitrogen (NOx)	12.62	ton/year
- Sulphur dioxide (SO_2)	8.53	ton/year
- Total suspended particulate (TSP)	1.08	ton/year

Measured background air quality concentrations are not available and the standard gaussian dispersion model was not applied at this time, given the low levels of emissions. Therefore, emission volumes were not translate into concentrations in ug/m^3.

In overall terms the projected pollutant loadings are low and reflect a non-toxic airmass (Refer to Annexes). This would suggest that, for the next years, there will be little concern for local residents, over common health related air pollution problems. Since all the gasoline used is lead-free, the serious issue of tetra-ethyl lead contamination is avoided.

From and air pollution perspective, prevailing winds patterns do not favour Pakse in that most air masses, polluted or otherwise move from the SE to the NW i.e., along the long axis of the town.

For the Muang Kao side, vehicular emission levels are virtually non existent. In the area to the East (downstream) of the ferry terminal, only motor scooters can pass, and they are limited to only a few km. A common mode of traffic is by small long boat, traveling close to the West bank of the river. From the ferry terminal and NW along NR 10 emissions exist but have not been measures. It is safe to say that existing levels, close to the ferry terminal, rise rapidly during the "rush-hour" periods when vehicles waiting their turn for the ferry, with their engines labouring to power the air conditioning units, emitting a concentrated burst of pollutants. In overall terms the West side of the study area has a very clean airmass.

2) Noise

Existing noise levels in the study area vary considerably but, for the most part, are at or well below the internationally accepted L 90 (i.e., 90% of the time) standard of 55 dBA for urban residential areas. In fact background noise levels are between 40-45 dBA. The exception is the 100m wide band of land along NR 13, East of Pakse which experiences levels in excess of 60 dBA, during the early morning and afternoon "rush-hour" periods, which last from 40 minutes to one hour. This noise is attenuated rapidly as one moves away from the road, since NR 13 is at or near grade and buildings and walls line it in the study area sites. North of Pakse, the traffic is much lighter therefore the overall noise environment is quieter; by as much as 15-20 dBAs.

On the Muang Kao (West) side, landuse is essentially subsistence farming and as such the noise levels are at the natural background levels of 30-40 dBA for the length of the study area. The ferry terminal and the NR 10 link does experience higher noise levels during the morning and afternoon "rush" periods, and will become the intersection point between the new approach roads for the proposed routes B and C and the existing NR 10. Noise exposure for all dwellings within 50 m on either side of the pavement as NR 10 passes through Muang Kao at present is above the 55 dBA levels during the morning and afternoon periods but given the low speed of the vehicles, the noise frequency is lower and much less disturbing then high speed sounds.

3) Water Resources

Water resources in the study area include both surface and ground water. Aside from the Mekong and the Sedon, all surface waters in the study area are intermittent, in that they flow only during the monsoon season from May through October. The only one large tributary river, the Houi Phek, flows into the Mekong just upstream of the Muang Kao ferry terminal. This is just beyond where the approach roads for Alternative routes B and C end. In addition, there are two other smaller intermittent streams, all on the West side of the Mekong near the villages of Ban Houyphek and Ban Khan Gneng. During the dry season these rivers are virtually dry with only pools here and there in the downstream areas. River depth during the monsoon period can be as high as 10 m, with volumes from 300 - 700 m^3/sec. As well, these tributaries are spawning and rearing grounds for several important food fish of the area.

Much of the area to be traversed by the approach roads is irrigated rice paddy lands, flooded by gravity flow systems. This water distribution and management system is a key component of the local farming industry and is considered to be sensitive feature of the study areas water resources environment.

The water quality of the Mekong and its tributaries in the Pakse region is quite good (Refer to Annexes), i.e. for other then body contact and human consumption, without treatment. Exceptions are the stretches of the Sedon which pass around Pakse and the Mekong directly along the Pakse town shore. Although silt laden throughout the year, the Mekong water in this region is otherwise minimally polluted. Contaminants consist primarily of human and animal waste as well as some insecticide and chemical residues from various farming operations, principally around areas of concentrated habitation. Ban Saphay, about 20 km upstream of Pakse, is textile and weaving center, and may discharge a number of toxic chemicals into the Mekong. The nearest upstream city is Savanakhet, some 100 km NW of Pakse. Water quality for fish production is good and in fact the Mekong is hosts a diverse fish population.

However, it is fair to point out the users of the Mekong will not hesitate to dump garbage, spent fuel or even other more toxic materials into the river or its tributaries as needed. Therefore as the population grows and if awareness of the rivers sensitivity is not taught to the users, pollution levels will rise rapidly (as they have in some of the upstream areas such as Vientiane, Yunnan Province, PRC and the lower reaches in Cambodia and Vietnam).

Ground water supplies are abundant and two of the approach roads encroach on existing deep wells. Although not verified, ground water depth in the study area on both sides of the Mekong ranges approximately from 10 m-20 m (the area's ground water supplies are almost unknown). Many local residents obtain their water supply from shallow wells with unknown quality or flow levels. The depth of the ground water aquifers in the study area need to be investigated so that any accidental aquifer damage/drainage does not occur. The Mount Salao area may be a recharge zone, therefore, good knowledge of the ground water system on the SE slope would be needed.

4) Fisheries Resources

Significant wild fisheries resources abound in the Mekong. There are at least four well known species, commercially fished in the Mekong within the study area. In fact the base of the rapids in the Don Ho area about 10 km upstream of the confluence of the Sedon with the Mekong, is an important spawning area for key commercial species.

In the study area, major fishing takes place only on the West nearshore area of the river from Ban Salao northward to the mouth of the Houi Phek. Important species taken are:

- Pa phone (*Cirrhinus microlepis*)
- Pa eun (*Probarbus jullieni*)
- Pa kot (*Mystus nemurus*), and
- Pa thong (*Notopterus notopterus*)

Table 6.3-1 is shown the approximate fish migration season, movements and location. Migration periods vary considerably and are related to water flow conditions as well as diurnal light cycles and total suspended sediment levels. May through August appears to be the most active period with species migrating both up and downstream along the West shore of the river. The Pakse Livestock and Fisheries Section of the Ministry of Agriculture and Forest, in association with the Mekong Committee, is initiating a major fisheries study in the Pakse area in 1996. The findings will yield important information for planning an environmentally compatible construction schedules.

TABLE 6.3-1 SUMMARY OF KEY KNOWN FISHERIES RESOURCES(*) IN THE PAKSE BRIDGE STUDY AREA

SPECIES	Fishing Ground Location	Migration Period From To	Location of Migration	Spawning Area	Capture Method	Catch
Pa Phone Cirrhinus microleps	banks off Ban Salao and northward	Mar. Apr. Jul. Aug.	near west shoreline of Mekong	Don Kho (?)	gill net	2.4 - 3.5 t/yr.
Pa eun Probarbus jullieni	same as above but deeper waters	Nov. Jan. migr. not known	ditto	in the area between Alt. B & C	gill net	N/A
Pa kot Mystus nemurus	same as above	Jun. Jul.	into tribs. such as Houi Phek	Trib. rivers to Mekong	N/A	N/A
Pa thong Notopterus	same area as above but deeper waters	May. Jul. N/A	ditto	ditto	N/A	N/A

(*) Data obtained from interviews with Pakse Livestock and Veterinary Section.

Tributaries such as the Houi Phek and two un-named streams SE of the Houi Phek,, are spawning waters for such species as the Pa kot, and therefore their unobstructed flows must be maintained.

The river bottom in the study area consists primarily of fine sand, gravel and rocks, with no silty overburden (Refer to Section 3.1), thus the shallow areas may be spawning habitat for a number of the bottom spawning species.

5) Terrestrial Resources

The area around Pakse and Muang Kao (Phontong) is extensively cultivated and populated, therefore the terrestrial natural resource has been quite severely "tamed".

Aside from being home to common varieties of birds, small mammals and herptiles the study area is not a significant habitat for wildlife. The only forested area is Mt. Salao, which will be minimally affected by this development (except if its base becomes a source of borrow material). No large animals remain in the area, although the area around Mt. Salao and to the South and West was once the habitat of the Asian elephant and tiger as well as a number of Asian deer species. Tree species which occur in scattered stands throughout the study area and represent important resources as both building material and food supplies are:

- tamarind trees
- mango trees
- teak trees
- large bamboo sunds (clumps of bamboo up to 6m in diameter), and to a lesser extent
- mature coconut palm trees.

Where possible these trees should be spared, particularly the bamboo sunds, as they represent a vary valuable raw material for everything from structural framing to baskets and fishing gear.

6.3.2 Human and Built Environment

1) Landuse

Being a primarily agricultural area, landuse of Pakse and Phontong (Muang Kao area) is principally subsistence and market garden agriculture. Extensive plots of both dry and wet rice are planted throughout the study area, principally along the proposed routes A and C. The shoreline of the Mekong could be considered urban and rural residential landuse since the population density is quite high and uses are many. In fact during the dry season the exposed rich silty flood plains in the Mekong, in some areas extending for thousands of square meters, are planted with a great variety of crops, including maize, cabbage, other leafy vegetables, eggplants, etc. These planting are found on both shores of the river within the study area and are in place from late October through March-April.

In terms of landuse the most sensitive features, would be the homes, interconnecting minor roads and paths and buildings plus the rice field systems, which have been build up over long periods of time and which represent an important food source for all and in some cases a cash crop for area farmers.

2) Settlement

The Pakse side of the study area is densely populated(187 people/km^2) with a mixture of urban and rural housing. Most housing is of simple single story wooden construction, typical for this region. Single story wooden house consist of about an 8 x 12 meter dwelling raised above the ground about 4 meters. Some parts of the study area have more expensive housing using wood-concrete mixtures as well as completely concrete and brick construction. In Pakse many houses have electric power but, outside the town, utilities are very limited, even though power lines pass within meters of the communities . The reason for this, is that communities cannot afford the transformers required to convert high voltage to usable power.

The Muang Kao side is much more rural with only 58 people/km^2 and almost exclusively wooden house construction.

Most travel routes, outside the few roads, are walking, cycling and animal paths which crisscross the farming lands, permitting farmer and their equipment and livestock to move from their yards and sheds to their, field, grazing and foraging areas. Often these paths lead to the river to a boat used to cross over. Obstruction of these travel and work routes can deal a very serious blow to subsistence farming activities, can increase travel time by hours, and can endanger people and animals through possible collisions with vehicles traveling at high speeds since residents will need to cross the road frequently.

Pakse is growing in a South Easterly direction, since access to the North West side of town is now restricted by the single-lane bridge across the Sedon in the downtown area. Dense urban development has reached as far as the stadium and the night market and the town has plans for industrial development further to the Southeast. The creation of a large parade ground on the West side of NR 13 just opposite the new government building and close to the stadium, has required many hectares of land and as such has speeded up this SE push of the residential/commercial urbanization. The government expects that within the next 5 years, the area from the Pakse bypass turn-off on NR 13 to the night market will be heavily residential and/or commercial and urbanized. This condition may extend from NR 13 to the Mekong River. In planning for that growth, the MCTPC has, under construction, a four lane feeder road between the river and NR 13 designed to relieve traffic from NR 13 as this growth comes to pass.

3) Socioeconomics

Although rich in resources the average land owners/users in the study area are poor and are very susceptible to the vagaries of development schemes, construction work or any other activity which impinges on their traditional means of getting food and earning a living. In 1995, the average per capita GDP is estimated to be 247,000 Kip (US$ 250/year). Infant mortality is still considered unacceptably high due to poor potable water supplies and poor medical services. On the Phontong side, this is even more evident as most residents are subsistence farmers and/or part-time farmers (wives) and workers in Pakse (husbands).

Much of the commerce in the study area is small businesses, servicing the principally agricultural industry of the region. It is the center of commerce for many of the outlying villages of the surrounding area. This function has grown very slowly affected by a fair transportation system and limitations of demand for outside commercial goods. Now that the area is experiencing a transportation infrastructure boom with the national roads about to be widened and paved and new E-W roads being planned, the shops are prospering.

Approximately 103 businesses, within 350 m of the ferry and boat terminal in Pakse, were surveyed to determine the extent of their dependence on the car ferry and longboat ferry boat traffic for their annual income (Refer to Annexes).

Results of the above mentioned survey are shown in Table 6.3-2. The overall income of these merchants is healthy, and that they derive less than 15.5% of their income from the pedestrian traffic generated directly from these two types of ferry operation. Furthermore well over 90% of those surveyed indicated that the removal of the car ferry would not change their staff size or that this change would require them to move to survive. Moreover, the results also show that 100% of the businesses were either wholly owned by women or owned in partnership with a man (not one business indicated that it was owned solely by a man).

TABLE 6.3-2 SUMMARY OF BUSINESSES SURVEY RESULTS NEAR THE FERRY DOCKS IN PAKSE

ITEM	VALUE (Million Kips)	ITEM	VALUE	
Total Earnings	1,333.05	Avg. No. Employees	1.8	
Average/bus.	13.07	Women as owners (%)	100	
Median	3.58	Avg. No. of Women as full time employees	1.42	
Std. Dev	28.37	Avg. no. yrs. in business	5.68	
Average annual earning per business from longboat ferry traffic	2.00	Distance from terminal (median)-m	205	
Average annual earning per business from car ferry traffic	1.91		Car ferry	Longboat ferry
Total earnings derived from ferry traffic	194.49	Percentage of total earnings coming from car ferry and long-boat traffic.	14.59	15.30
Total No. businesses surveyed			103	

The concern that women might be the seriously affected by the closure of the car ferry appears to have been unfounded, given the statistics above and in the Annexes.

While interesting and important, these statistics may be skewed on the conservative side since the businesses were leery of the survey as it was preceded by a visit from the customs/tax collection officer (not what was intended), telling them that this was an official survey and that they should cooperate.

The unit prices of lands, rice fields, dwelling and other properties, located within the 40 m-wide ROW, obtained for the Champasack Province, are shown in Table 6.3-3.

The unit prices are presented as ranges of values and thus the actual price paid will be determined during the negotiations with each land owner. For all economic indicators used in the matrix comparison chart, the minimum values for each range was used.

6.3.3 Impact Comparison Indicators

The status of the main components of the study area's ecosystem were defined in Sections 6.3.1 and 6.3.2. Based on this assessment, the sensitivity of each component was determined by measuring the extent of existing human interference and the level of disturbance of the component and finally the components ability to recover from degradation or sustained stress. Based on these criteria each component was given a level of importance (on a scale of 1 = minimal importance to 10 = major importance), thus providing a crude component weighting. Actual values recorded for 26 indicators were scaled (1 to 10) or each alternative. The weighted indicator scales were then summed and the alternative with highest priority, on environmental grounds, was identified. In Table 6.3-4 is shown a list of the indicators, and their weights and scales, while in the Annexes are provided the detailed results of the comparative evaluation.

TABLE 6.3-3 UNIT PRICES FOR PROPERTY WITHIN 40-M WIDE ROW

ITEM	DESCRIPTION	PRICE RANGE PER UNIT (US $)		PRICE RANGE PER UNIT (1000 x Kip)	
		FROM	TO	FROM	TO
Bldgs.	1-SW	6,000	8,000	5,580	7,440
All 8m X10m	1-SWC	7,000	9,000	6,570	8,370
	2-SW	8,500	10,000	7,905	9,300
	2-SWC	13,000	15,000	12,090	13,980
	1-SC	20,000	30,000	18,600	27,900
	2-SC	35,000	50,000	32,550	46,500
	3-SC	40,000	60,000	3,702	55,800
	Other Bldgs.	N/A			
	Relig. Sites: Wats	N/A			
Water	Deep Wells	800	1,000	744	1,395
Roads	Intersections				
Agricult.	Rice Fields (m2)	5	10	4.65	9.30
Trees	Tamarind (No.)	15	30	13.95	27.20
	Teak	70	150	65.10	139.50
	Mango	20	40	18.60	37.20
	Palm	10	20	9.30	18.60
Special	Features	N/A			

Source: Champasak Provincial Government (prices to Nov. 1995).

TABLE 6.3-4 SUMMARY OF ENVIRONMENTAL IMPACT COMPARISON

Environmental Component	Sensitivity Weighting (1-10)	Indicator Number	Indicator Description	Units data collected in	Scale conversion 1=minimal (lease) 10=extreme (worst)
			Definition of scale	N/A	1=minimal (least)
BIOPHYSICAL ENV.				tonnes/yr	
Air	5	1	Emission loadings for 5 pollutant in tonnes/yr	THC	ot=1 - 100t=10
		2	for Yr. 2020-un corrected for avg. speed and temp.	CO	ot=1 - 200t=10
		3		NOX	ot=1 - 50t=10
		4		SO2	ot=1 - 20t=10
		5		TSP	ot=1 - 3t=10
Noise	6	6	Sensitive features (tempes, schools and homes) within 200m wide zone zone exposed to noise environment which is at least 20 dBA above the background level (condidering, vertical elev.,etc.	No. temples, schools, hospitals, houses	<5=1,>200=10
Water Resources	7	7	Presence of a sensitive water resources feature	Scale	1=none to 10=extreme
		8	Potential for chronic water pollution;		1=none to 10=extreme
Fisheries Resources	7	9	Fisheries migration route disruption	% likelihood	<5%=1 - >30%=10
		10	Fisheries habitat loss (% likelihood)	% likelihood	<5%=1, >30%=10
Terrestrial Resources	3	11	Number of economically important tree/plant species(mature) removed in 40-m wide Row(6 species to consider)	No. of trees	0 trees=1 - 20 trees=10
		12	Encroachment on wildlige habitat	Scale	0=none to 10=extreme
Mitigation/ Compensation	6	13	Cost of biophysical environmental impact mitigatiton	0=none to 10=extr. high	0=none to 10=extremely high
HUMAN/BUILT ENV.					
Settlement	10	14	No. dwellings to be taken within 40-m wide ROW	No units	0 strct.=1-60strct.=10
		15	Total cost of dwellings to be taken in 40-m wide ROW	kip	0 $=1-600k$=10
		16	Total No dwellings in 200m wide impact zone	No. Units	0 strct. =1 - 200strct. =10
Landuse	8	17	m2 of rice field taken in 40-m wide ROW	m2	0 m2=1-150K m2=10
		18	m2 rice fields in 200-m wide impact zone	m2	0 m2=1-280K m2=10
		19	Cost of rice fields taken in 40-wide ROW	Kip	0 m2=1-750K m2=10
		20	Extent of access restriction(lost road links)	Scale	0=none-10=extreme
Socioeconomic	9	21	Extent pf omterference with people's livelihood	Scale	0=none to10=extreme
		22	Change in existing landscape	Scale	0=none to10=extreme
		23	Extent of visual intrusion of approach roads	Scale	0=none to10=extreme
		24	Restriction to planned orderly urban growth and development	Scale	0=none to10=extreme
CRITICAL DEVELOPMENT RESTRICTIONS	10	25	Basic local Planning actions (e.g., airport runways) which seriously impede alignment alternative	Scale	0=no impedance, 10=critical impedance
PUBLIC CONSULTATION	9	26	Choice of Goverment of Champasak Province	Scale	most fav.=1 least desirable=10

The indicators do not include impact reductions due to mitigation measures (aside from the assumption that retention of bridge stormwater runoff will be provided) and the scales represent their range of values for this study and do not reflect environmental sensitivity. The Component weightings, are more reflective of the ecological and social significance of the components. Its output defines how people, who must live with the development, view the project.

6.4 Environmental Considerations

6.4.1 Overall Environmental Issues

All bridge and approach road alignments will have the same lane widths and designs, with differing approach road lengths, curvatures as well as vertical alignments. In the river, pier spacing and design will be very similar with a average spacing of 60 m and possibly narrower spacing near the river banks (Table 6.4-1).

TABLE 6.4-1 APPROXIMATE STRUCTURAL DIMENSIONS OF BRIDGE AND APPROACH ROAD ALTERNATIVES

(Length Unit: meters)

Structural Feature	Alternative A	Alternative B	Alternative C
Length of e-Side approach Road(Hwy. 13-Mekong shore	1040	780	1700
Length of W-Side Approach Road (Mekong shore-Hwy.10)	2650	2100	3370
Stream-culvert crossing., East side	n/a	n/a	n/a
Stream-culvert crossing.,West side	two	0	three
Minor Bridges on approach Rd.,East Side	0	0	three
Minor Bridges on approach Rd.,West Side	o	three	three
Approaches:			
Number of Lanes	two	two	two
Lane Width, including shoulder	5.5	5.5	5.5
Right of Way (on centerline)	40	40	40
Environmental Impact Zone (on centerline)	200	200	200
Avg. number m above grade (Pakse side)	4.1	4.1	0.85
Avg. number m above grade (Muang Kao side)	5	3.6	0.9
Estimated total fill (Muang Kao side) in m3	220,000	171,000	186,000
Estimated total fill needed (Pakse side) in m3	99,000	42,000	17,000
Probable source of fill material (East Side)	Hills near electric transfer Stn.	Hills near electric transfer Stn.	hills near electric transfer Stn.
Probable source of fill material (West Side)	Mt. Salao	Mt. Salao	Mt. Salao
Bridge:			
Bridge Length	1680	1400	900
Number of Lanes	two	two	two
Lane Width (incl. sidestrip and sidewalk)	5.5	5.5	5.5
Distance between piers (a)	60	60	60
Environmental zone of influence (river)	variable	variable	variable
Total Length of Section	5370	4380	5970

(a) the distance between bridge piers near shore may be less than 60 meters.

A number of environmental considerations common to all alignment options have been identified and are presented here since they have exerted an overall influence over how this project is being evaluated.