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LAO PEOPLE'S DEMOCRATIC REPUBLIC

FEASIBILITY STUDY
ON
THA NGON BRIDGE CONSTRUCTION PROJECT

FINAL REPORT

SUMMARY

FEBRUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

LAO PEOPLE'S DEMOCRATIC REPUBLIC

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ON
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FINAL REPORT

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JAPAN INTERNATIONAL COOPERATION AGENCY

P R E F A C E

In response to a request from the Government of the Lao People's Democratic Republic, the Japanese Government decided to conduct a feasibility study on Tha Ngon Bridge Construction Project and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Lao PDR a study team headed by Mr. Kimio Chiba three times between February 1990 and December 1990.

The team held discussions with the officials concerned of the Government of Lao PDR, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

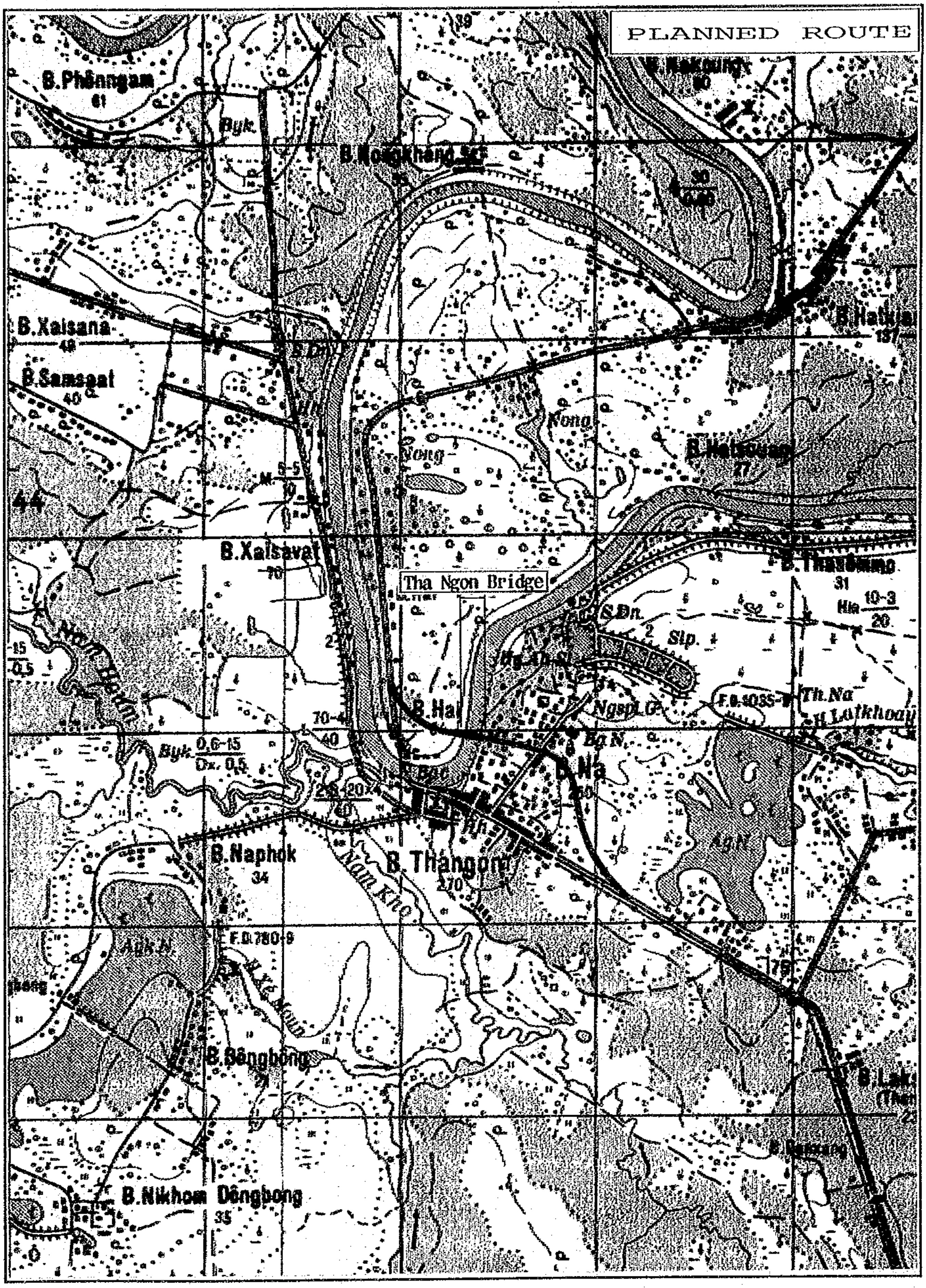
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Lao PDR for their close cooperation extended to the team.

February, 1991

Kensuke Yanagiya
President
Japan International Cooperation Agency


LOCATION MAP
PROJECT SITE
VIENTIANE
LAO PDR
THAILAND
KAMPUCHEA
VIET NAM
NAM KHONG
NAM NGUM


PLANNED ROUTE
Tha Ngon Bridge
B.Phônngam
B.Xaisana
B.Samsaat
B.Xaisavat
B.Naphok
B.Thangon
B.Bôngbông
B.Nikhom Dôngbong
B.Hai
B.Thaxômmo
Nam Kho
Nong
Slp.
Th.Na
H.Latkhoau
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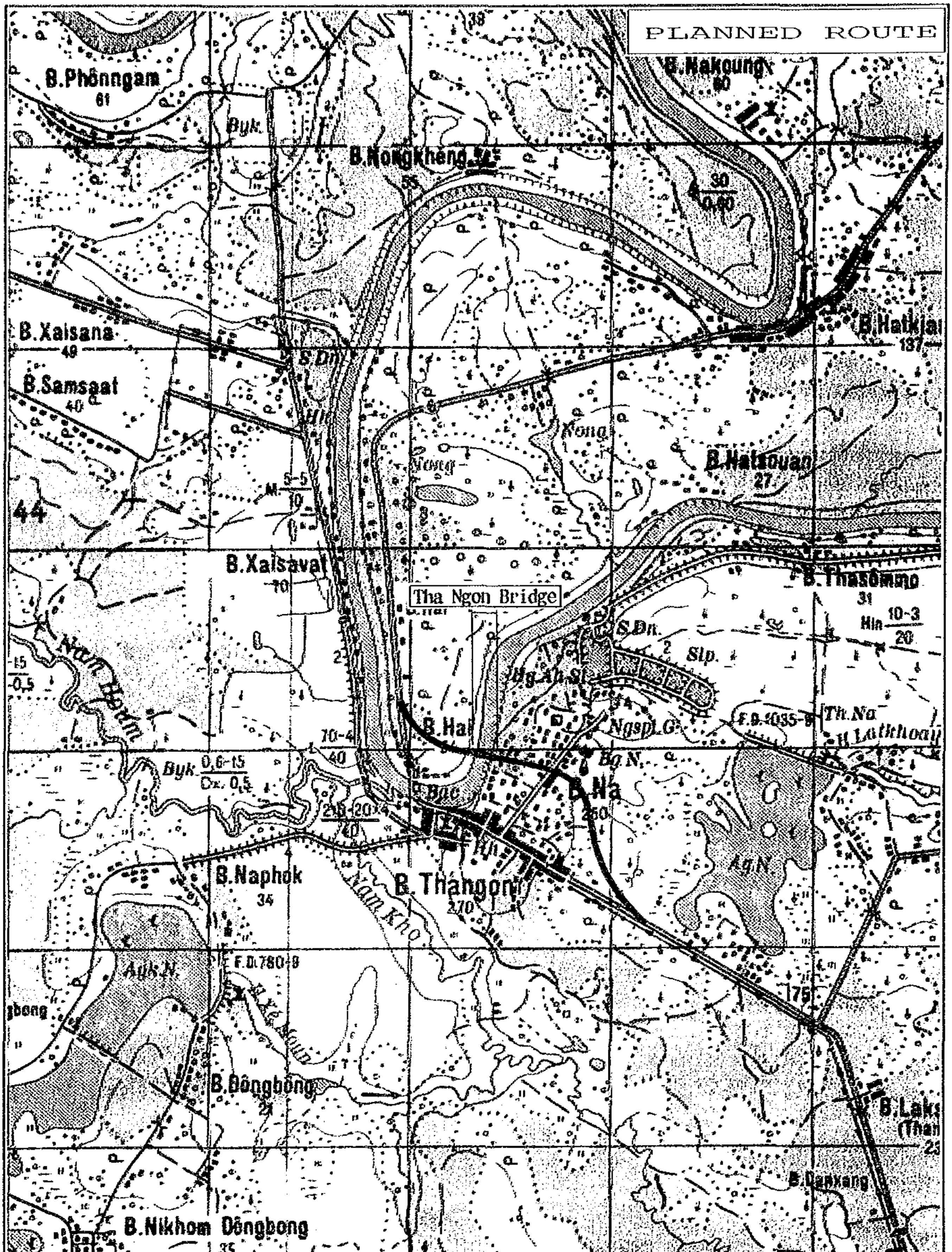
PLANNED ROUTE
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B.Hatkia
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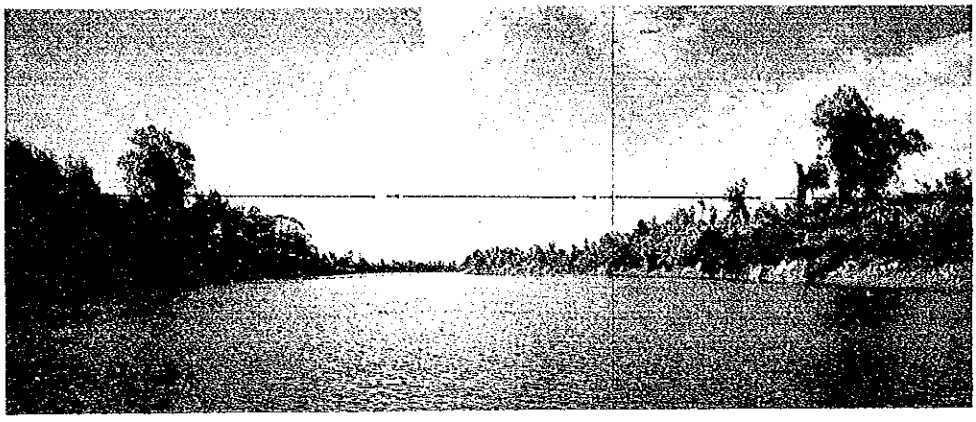
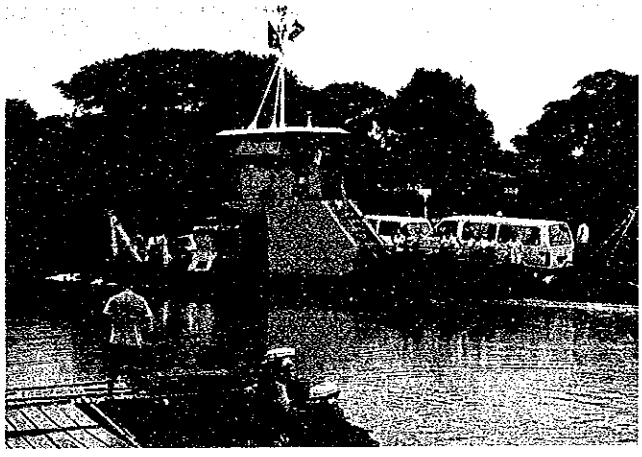
B.Thangon
Nam Houm
Nam Kho
B.Dôngbông
B.Nikhom Dôngbong
B.Danxang

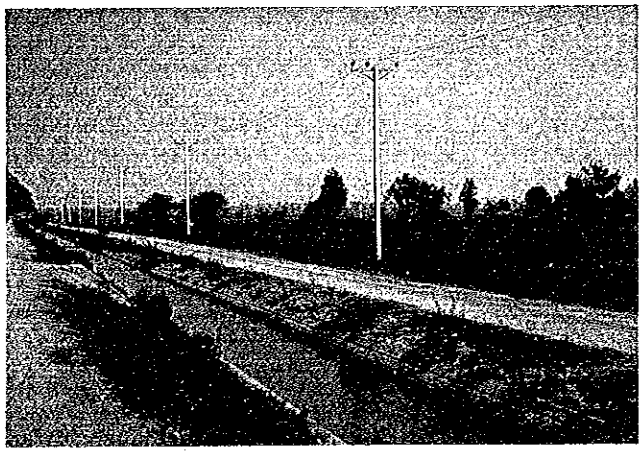


Location of Tha Ngon Bridge



Tha Ngon Ferry

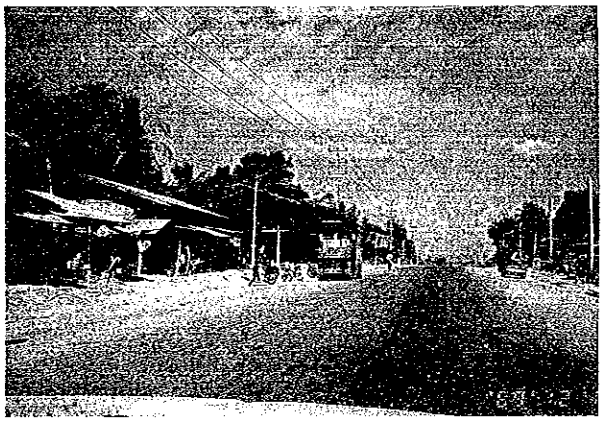
Flood area on right bank side



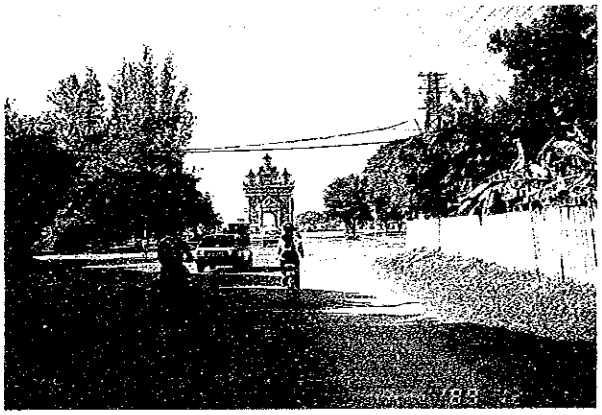
Tha Ngon Farm

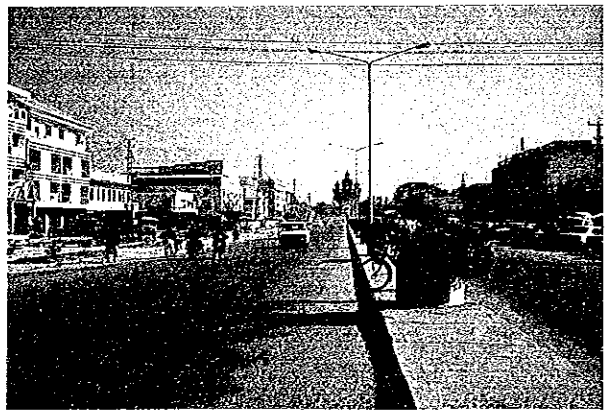
Route 10 on the way from Vientiane to Tha Ngon

Route 10 after rehabilitation

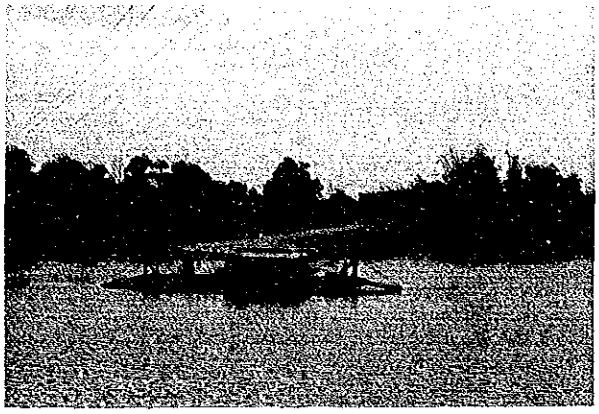


Route 13 near Vientiane

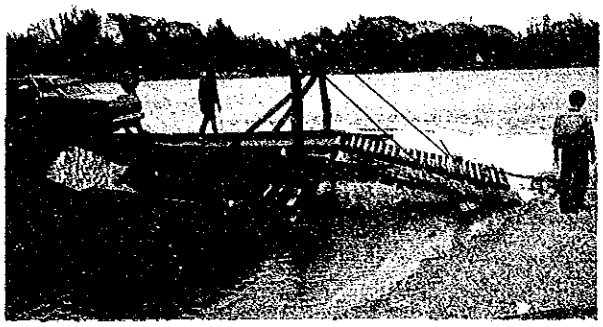




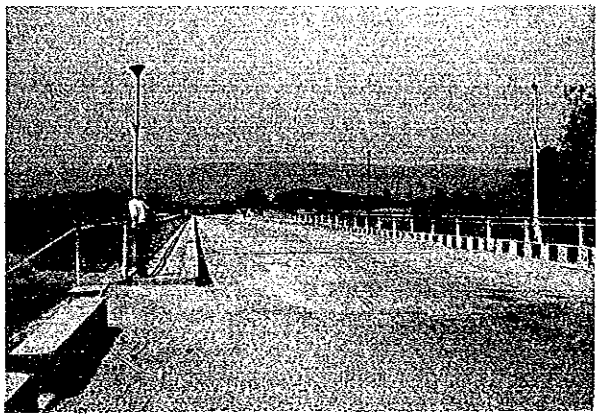
Vientiane



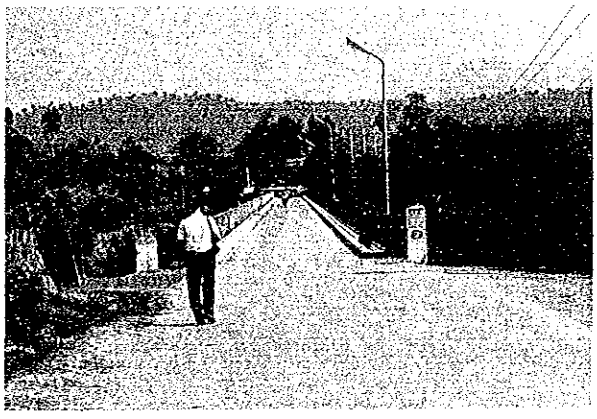
Muang Kao Ferry

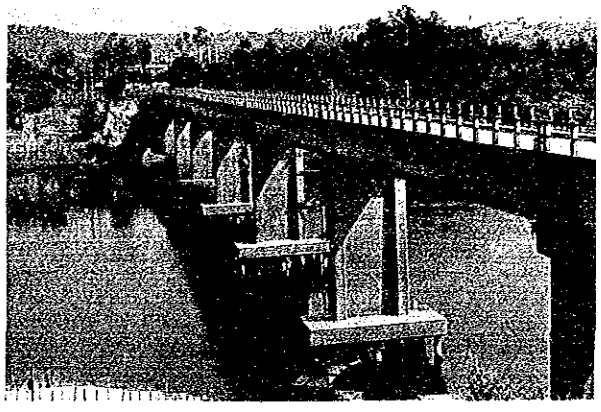


Hatsiao Ferry



Ban Hai Bridge





Thin Keo Bridge

CONCLUSION AND RECOMMENDATION

1. CONCLUSION

As the results through the Project, Construction costs were computed as follows:

Description	Financial cost (100 US$)
Bridge	43,952
Approach road	13,337
Temporary bridge	8,260
Rivetment work	4,636
Indirect construction cost	59,574
Land Acquisition Cost	952
Engineering Service Cost	16,338
Contingency	6,479
Total Project Cost	153,527

Based upon these figures and results of traffic estiamtion, socio-economic study and others, results of Economic Evaluation are summarized as follows:

Case	EIRR (%)	NPV(US$1,000)
Base case	11.90	8,345
Construction cost 10% up	11.17	7,164
Construction cost 25% up	10.22	5,392
Traffic growth rate 10% down	9.35	2,494

Gross Domestic Product

Lao economy grew at a relatively high pace between 1982 and 1986. In 1987, the severe drought hampered Lao economy. The economy, however, significantly recovered from the down. The average annual growth rate during the period of 1982-89 is 4.9% which is excess of population growth rate.

Year	1982	1983	1984	1985	1986	1987	1988	1989
GDP(bil.kip)*	190	196	205	221	244	223	228	265
Growth rate(%)		3.0	4.5	7.7	10.4	-8.2	0.1	16.0

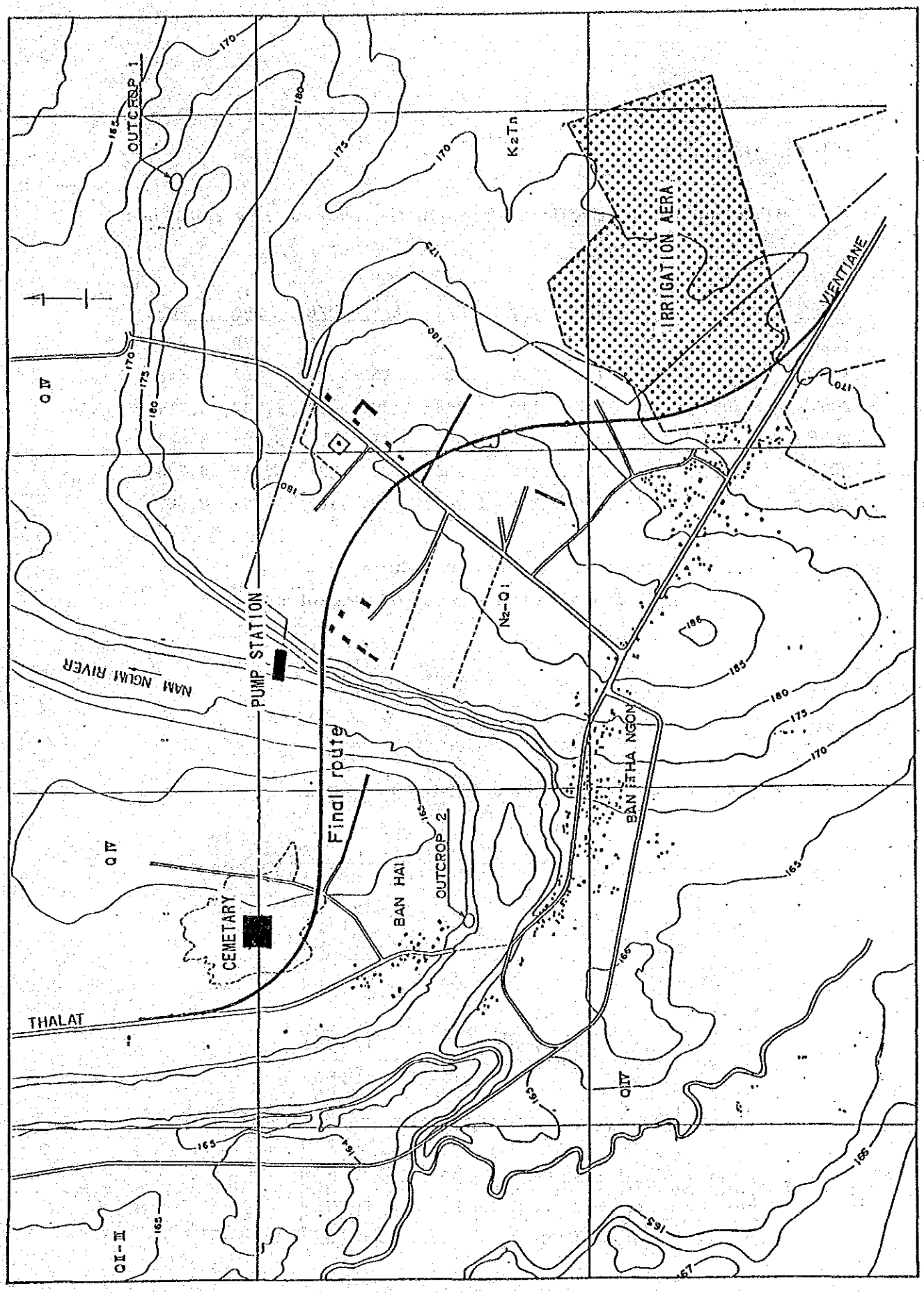
Note : * means GDP in 1988 constant prices

Preliminary Design

Under these economic growth, however, present manner to cross the Nam Ngum River is only the way by means of ferry boat having capacity of 45 tons. This is the bottle neck for traffic on Route 10.

Construction site of the proposed bridge is on the alternative route No.4 as shown in the attached Figure on next page. Bridge length is planned 230m with 5 spans. Substructure is consisting of Reverse Circulation Method's concrete pile with pier, and superstructure shall be the PC concrete beams. The bridge has 2 lanes and one carriageway is 3.0 meters width. 2.5 meters side walk and balcony on the upper stream side were prepared with lighting facility.

On the other hand, approach road is having 3,350 meters in total. The carriage width is 3.0 meters and surface course is designed Double Bituminous Surface Treatment(DBST).



Alignment of Final Route

Future Traffic Volume

Estimated future traffic by year on the planned new route is ;

Year	M/C	P/C	P/U	M/T	H/T	L/B	H/B	Sum	PCU
1990*	228	61	58	23	79	14	16	479	575
1996	647	156	143	71	224	26	33	652	1,548
2000	1,054	229	212	110	348	39	50	2,042	2,414
2005	1,755	346	322	179	564	61	77	3,304	3,883
2010	2,923	523	486	289	909	195	121	5,345	6,238
2015	4,006	699	650	396	1,246	130	165	7,292	8,507

Note : * shows present traffic volume
PCU means passenger car equivalent unit

Costs

Estimated construction costs for the Project are ;

Description	Financial cost (100 US$)
Bridge	43,952
Approach road	13,337
Temporary bridge	8,260
Rivetment work	4,636
Total Direct construction cost	70,184
Preliminaries and general items	11,938
Packing and transport	14,771
Dispatch of expatriate technician	12,503
Site on cost	12,093
Overhead	8,269
Total of Indirect construction cost	59,574
Total of Construction Cost	129,758
Land Acquisition Cost	952
Engineering Service Cost	16,338
Contingency	6,479
Total Project Cost	153,527

Benefits

Economic costs without the Project are;

1) Time cost of passengers crossing Nam Ngum River at Tha Ngon
2) Economic loss due to no ferry operation
3) Extra vehicle operation cost(VOC) and time costs due to diversion from Route 10 to Route 13
4) Extra VOC and time cost of diverted traffic from Route 13 to Route 10
5) Ferry operation and maintenance costs
6) Replacement of ferry boat

Economic benefit with the Project are;

1) VOC saving of generated and developed traffic
2) Salvage value of the ferry coat
3) Residual value of the proposed bridge and approach roads

Economic Evaluation

The economic internal rate of return(EIRR) is calculated at 11.90% for 20 year project life with an assumption that the Project initiates in 1992 and the proposed bridge opens at the beginning of 1996. Net present value of the Project is about US$ 8.34 million with discount rate of 8%. The Project is relatively sensitive to future trafic volume.

The results of sensitivity analysis are as follows.

Case	EIRR (%)	NPV(US$1,000)
Base case	11.90	8,345
Construction cost 10% up	11.17	7,164
Construction cost 25% up	10.22	5,392
Traffic growth rate 10% down	9.35	2,494

2. RECOMMENDATION

As the results of this Feasibility Study, it is found that the Project is feasible with EIRR of 11.90% (base case). It is clearly understood that the Project will rush the national socio economic development schem and also give great assistance to the public activities.

The Project needs only US$ 15 million consisting of US$ 7 million direct construction costs, 6 million of indirect costs and others. Besides total benefits is counting about US$ 80 million.

Other than above, uncountable national economic losses are born from ferry troubles. Thus it is strongly recommended that the Project shall be started as soon as possible.

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1. Introduction

In response to the request of the Government of Lao People's Democratic Republic(hereinafter referred as "Lao PDR"), the Government of Japan decided to carry out the Feasibility Study of Tha Ngon Bridge Construction Project(hereinafter referred to as "the Study"). The Study was consigned to the Japan International Cooperation Agency(hereinafter referred as "JICA"), the official executing agency for implementing the technical cooperation of the Japanese Government.

JICA organized an advisory committee headed by Mr. NAMBU to oversee the Study and simultaneously selected consultants to carry out the Study in accordance with the Scope of Work agreed between the Lao PDR and the Government of Japan.

Lao PDR assigned the Vientiane Municipality as the counterpart agency. Department of Communication, Transport and Construction (hereinafter referred to as "DCTC") was appointed as the actual counterpart department.

As of 1989, the population of Lao PDR was 4,053,000 with a population density of 17.1 persons per sq.Km. Lao PDR is a landlocked country surrounded by Vietnam, Cambodia, Myanmar, Thailand and China with an area of 236,800 sq.Km.

Two thirds of the country is classified as mountainous terrain.

Administratively, whole land is divided into 16 provinces and Vientiane Municipality. Each province consists 3 to 13 districts and each district is parted in villages (Muang). Vientiane Municipality has eight such administrative districts as follows;

1) Chanthabouri
2) Sisattanak
3) Xaysettha
4) Sikhottabong
5) Hatxayfong
6) Xaythani
7) Naxaythong
8) Phialat

Mean while, Vientiane Province has nine districts as follows;

1) Xanakham
2) Muang Fuang
3) Phonehong
4) Kasi
5) Vangvieng
6) Xaysomboun
7) Keo Oudom
8) Muang Hom
9) Thourakhom

With an are of 3,920 sq.km and a population of 416,000(106 person per sq.km) in 1988, Vientiane Municipality accommodates 10.5% of the total population.

The roads in Lao PDR and Vientiane Municipality are classified by type of pavement in the following table:

	Nationwide	Vientiane Mun.
Total	13,100 Km	1,300 Km
Paved	2,560 Km(19%)	230 Km(19%)
Lateritic	3,750 Km(29%)	530 Km(44%)
Unpaved	6,790 Km(52%)	540 Km(37%)

In the country of Laos, 91.2% of freight and 80% of passenger flow depends on the road transportation system.

	Freight transport Mil. Ton-Km(%)	Passenger transport Mil. Person-Km(%)
Road	170.9(91.2%)	283.7(80.0%)
Water	16.1(8.6%)	35.1(9.8%)
Air	0.4(0.2%)	36.0(10.2%)

Lack of network and poor maintenance of the roads significantly are causing much constraints in regional development.

Recently, a part of route 10 was rehabilitated with the Loan of Asian Development Bank(ADB). Because bridge construction at Tha Ngon included was included in the above mentioned rehabilitation program, traffic, including bicycles and pedestrians, are obliged to cross the Nam Ngum River by means of a ferry boat.

Inadequate accessibility to Vientiane is, therefore, seriously affecting the regional development in the left side of Nam Ngum River.

Most of the villages and large cultivated lands are located on the left bank of the River. Vientiane Municipality/Vientiane Province produces 23% of rice and 20% of vegetables of the total national product. The area, therefore, is very important in supplying agricultural products to Vientiane Municipality.

In this point of view, Tha Ngon Bridge is expected to be constructed soon.

2. Present Socio Economic Situation

2.1 Overview of Socio Economic Situation of Lao PDR

Geographical Setting

Lao PDR covers 236,800 square kilometers, stretching about 1,000 kilometers from north to south and between 200 and 400 kilometers from east to west. Lao PDR is a landlocked country bordered by Thailand, Myanmar, China, Vietnam and Cambodia.

Population

Total population in 1985 was 3.585 million. At present, the growth rate is estimated at around 2.9%. In terms of population size, Vientiane Municipality is the third rank and Vientiane Province is the fifth rank.

Gross Domestic Product

Lao economy grew at a relatively high pace between 1982 and 1986. In 1987, the severe drought hampered Lao economy. The economy, however, significantly recovered from the down. The average annual growth rate during the period of 1982-89 is 4.9% which is excess of population growth rate.

Year	1982	1983	1984	1985	1986	1987	1988	1989
GDP(bil.kip)*	190	196	205	221	244	223	228	265
Growth rate(%)		3.0	4.5	7.7	10.4	-8.2	0.1	16.0

Note : * means GDP in 1988 constant prices

Agriculture & forestry sector has kept the giant share of GDP by about 60%. Industry and service sectors have similar shares by around 20%. Transport storage & communication and wholesale & retail subsectors increased their shares by about one percent for the last five years.

Agricultural Sector

Vientiane Municipality has the largest share of rice production by 12.5, followed by Vientiane Province. Also, Vientiane Province has relatively high shares of buffaloes and cows/oxen.

Exploitable surface water resources exceed any foreseeable demand. Thus, it is easy to increase agricultural production if required inputs and infrastructure are provided.

Manufacturing Sector

There were 257 public industrial enterprises in 1987. The larger enterprises are located in and around Vientiane Municipality.

Services Sector

With the removal of restrictions on shipment of goods across provinces, transport services have increased at a faster rate than GDP. At the same time, the 1987-1988 removal of restrictions on private sector activities in services and commerce lead to growth in private corresponding sectors.

In comparison with development countries with similar level of GDP per capita, the service sector in Lao PDR has an insufficient infrastructure, and weak inter-linkage among production sectors.

Labor Force

Labor force in Lao PDR in 1986 was estimated at 1.55 million, which was 42% of the total population. The employment shares of industrial sectors in 1988 were estimated at 80% for agriculture, 2% for industry, and 18% for service sector.

Trade and Balance of Payment

Historically, the Lao PDR's external trade is characterized by a persistent disequilibrium. The export-import ratio, however, has been slightly improved. Principal exported goods are electricity, coffee, and processed wood, while major imported goods are vehicles, fuel, construction materials ad textile.

The current deficit significantly increased from 1984 to 1987. On the other hand, in recent years, net capital inflows rose steadily due to larger disbursements of long-term loans from multilateral institutions.

External public debt outstanding is estimated to have increased from $445 million in 1984 to $839 million at the end of 1987. The debt service ratio decreased to 15.6% in 1988 from 22.4% in the peak year, 1985.

Foreign Exchange Rate

In 1987, the multiple exchange rates were unified into a single rate reflecting the market. As of August 1990, the official exchange rate is 1US$ = 715kip.

Inflation

Since the Lao Government decreased money supply in the short term and reformed the price system, the inflation rate declined to 7% in 1987 from 115% in 1985. However, the inflation rate again increased to 33% in1988 mainly due to the abolition of most price controls, the devaluation of Kip, elimination of subsidies and the adjustment of official prices with market prices.

National Development Plan

The Second Five Year Plan(1986-1990) set the target annual growth rate at 10% during the planing period. Lao Government plans to invest one and half times of the actual investment amount of the First Five Year Plan during the Second Five Year Plan period. Transport sector received the highest investment share(slightly over one quarter) during both the First and Second Five Year Development Plan periods. Fully four-fifths of investment in the transport sector was for road rehabilitation and construction. The remainder was for transport facilities.

The two main priorities in the capital investment in 1990s are likely to be given to the expansion of hydroelectric power generation and the continued development of transport and communication. Due to lack of revenues, however, both at the central and provincial levels, it has been very difficult to allocate domestic financial resources to government capital investment.

The sectoral target annual growth rates of Vientiane are 12.2% for agriculture, 10.0% for industry, and 11.7% for commercial sector.

2.2 Present Socio Economic Situation of Influence Area

Vientiane Plain and Influence Area

The Vientiane Plain is an alluvial flood plain formed by Mekong and Nam Ngum Rivers. The Plain is primarily a rural area in nature and thus its economy is predominantly dependent on agriculture and forestry.

The area which receives influence from the Project spreads in a part of Vientiane Municipality (Xaythani District). Land use near the project site is mainly agricultural field.

Population

Population of Vientiane Municipality and Vientiane Province in 1990 are estimated at 409,000 and 305,000, respectively.Estimated population growth rate is 3.4% for the Municipality and 2.9% for the Province. Xaythani District is the most populated district in the Municipality (79,000) and Thourakhom District is the second in the Province(44,000).

Gross Regional Product

Gross regional product of Vientiane Municipality is estimated at 23 billion kip in 1989. The GRP shares by industrial sector in 1989 were 78% for agriculture, 12% for industry, 5% for commerce, 4% for transportation, communication and construction, and 1% for others.

Agricultural Sector

Xaythani District significantly increased agricultural production during the last five years. About 1,450 ha of new rice fields were developed in five years and rice production increased at 9.6% per year.

The agricultural sector in Thourakhom District grew at a similar pace. The high growth rates are brought mainly by introduction of market oriented economy. The increasing loan amount to the farmers in the influence area stimulates agricultural production.

The Ministry of Agriculture and Irrigation considers the influence area as the target area for irrigation after the right bank of Nam Ngum River. There are about 8,000 ha of possible lands for irrigation in the influence area. About half of these lands are not yet irrigated. There are many projects on the left side of Nam Ngum River: irrigation at seven sites, cattle breeding, rehabilitation of Nam Ngum Reservoir, and Pou Kao Kouay Integrated Development Project. In addition, there is 45,000 ha of possible land for logging on the left side of Nam Ngum River.

Industrial Sector

In the influence area, there are 4 sawmills, 29 rice mills, 4 drying tobacco factories, 1 salt factory, and more than 20 small brick factories.

Mineral resources except salt have not been discovered in the influence area. By the UNDP mineral exploration study, mine(s) of copper, silver, lead, zinc, tin and/or antimony are expected to be found in the mountainous area at north and east sides of Nam Ngum Reservoir.

New 22 kv line was installed between Nam Ngum Dam and Napheng, and between Tha Ngon and Tongmang in 1990. The area receiving power supply stretches along Route 10 and some feeder roads. Supply capacity is sufficient for certain level of industrial development.

Tourism

In 1985, the central government re-opened Laos to international tourism. Nam Ngum Reservoir Area is given the first development priority in the regional level. Some 20% of foreign travelers to Laos visit

the reservoir. Tour busses take Route 13 to the reservoir an drive back to Vientiane via Route 10. When Tha Ngon Ferry does not work, the tour bus has to go back to Vientiane by the same route(Route 13). This is unpopular among tourists. Pou Kao Kouay Area has been considered as another potential tourism development area in the Vientiane Plain.

3. Road Transport

3.1 Trend of Registered Vehicles

At the end of 1989, total number of registered vehicles in Vientiane Municipality was some 46,000 as shown below. Nearly half of them are motorcycles and about 25% of total vehicles are and 60% of trucks belong to public sector.

During the first half of 1980s trucks increased with two-digit growth rates. Along with relaxation on vehicle imports, vehicles increased drastically in 1989. The rapid increase in vehicles is also observed this year(1990).

Year	Motorcycle	Passenger car & Pick up	Truck	Total
1980	6,454	10,105	2,552	19,111
1981	6,894(6.8%)	10,474(3.7%)	2,909(14.0%)	20,277(6.1%)
1982	7,361(6.8%)	10,912(4.2%)	3,500(20.3%)	21,773(7.4%)
1983	7,650(3.9%)	11,419(4.6%)	4,041(15.5%)	23,110(6.1%)
1984	7,861(2.8%)	11,826(3.6%)	4,599(13.8%)	24,286(5.1%)
1985	7,996(1.7%)	12,071(2.1%)	4,712(2.5%)	24,749(1.9%)
1986	8,369(4.7%)	12,504(3.6%)	5,104(8.3%)	25,977(5.0%)
1987	8,554(2.2%)	12,691(1.5%)	5,223(2.3%)	26,468(1.9%)
1988	9,838(15.0%)	12,985(2.3%)	5,642(8.0%)	28,465(7.5%)
1989	22,290(126.6%)	15,768(21.4%)	7,927(40.5%)	45,985(61.5%)

Note : Figures in ( ) are annual growth rates
Source: Vientiane Municipality

3.2 Road Transport Industry

Freight Transport

In 1988, monopoly on state transport companies was terminated in parallel with the introduction of new economic mechanism. With open market policies, goods transport has increased rapidly, along with the share of private transport companies increased. The freight transport company under Vientiane Municipality operates in Vientiane and its vicinity with 35 trucks. While private freight transport companies (cooperatives) operate with 350 trucks in total. In Vientiane Province, there are four public freight transport companies and private ones district by district.

Under the MCTPC, there are four transport companies. State Company No.1 (Vientiane) covers Vientiane and Northern Lao and State Company No.2 (Savannakhet) covers Vientiane and Southern Lao. State Company No.3 (Vientiane) transports heavy goods and equipments while State Company No.4 is specialized in fuel transport.

Transport charge has been raised parallel with an increase in gasoline prices. Present charge, except heavy goods, is 35 Kip per ton. Heavy goods are charged 15 to 20% more, depending on road conditions: good, fair, bad, or very bad.

Freight transport increased at over 10 percent per annum during 1982-1989 as shown below. During the same period, GDP increased at 4.8 percent per annum. Namely, the growth rate of freight transport is 2.13 times larger than that of GDP. This is equivalent to elasticity of 1.75 between foreign transport and GDP. Especially, mainly due to dispersion of the new economic policies including privatization of transport industry, freight transport tremendously increased. In Vientiane Province, freight transport recorded high growth rates of over 10 percent during the last 5 years.

Year	Nation		Vientiane Province	
	ton/a ('000)	ton-km (million)	ton ('000)	ton-km (million)
1982	835	82		
1983	891(6.7%)	91(11.3%)		
1984	916(2.8%)	98(7.4%)		
1985	954(4.1%)	114(16.5%)	39	2.58
1986	1,040(9.0%)	159(39.5%)	47(20.5%)	2.50(- 2.9%)
1987	954(-8.3%)	167(5.0%)	37(-21.3%)	3.65(45.8%)
1988	1,254(31.5%)	171(2.4%)	39(5.4%)	3.15(-13.8%)
1989	1,658(32.3%)	244(42.7%)	58(48.7%)	4.20(33.6%)
1990/b			63(8.6%)	4.62(10.0%)
82-89	(10.3%)	(16.9%)		
85-89	(16.0%)	(21.0%)	(10.4%)	(13.0%)

/a Figures in ( ) are growth rates
/b planned

Source: Vientiane Province and State Planning Committee, "10 Years of Socio-Economic Development in the Lao People's Democratic Republic," and Ministry of Economy, Planning and Finance, "Basic Data, 88, 89."

Passenger Transport

Passenger transport increased along with growth of Lao economy at 7 percent during 1982-1988 as shown below. Data in 1989 seem to be an outlier because of negative growth against a large positive value of GDP growth rate. This growth rate is 2.31 times larger than GDP growth rate during the same period. This corresponds with elasticity of 1.52 between passenger transport and GDP. Vientiane Area recorded over 30 percent growth rate in 1989 and it is expected over 50 percent for this yeas.

Year	Vientiane Mun. and Prov. persons/a ('000)	Vientiane Mun. and Prov. persons-km (million)	Nation persons ('000)	Nation persons-km (million)
1982	7,285	201		
1983	8,019(10.1%)	246(22.7%)		
1984	8,967(11.8%)	271(9.9%)		
1985	9,470(5.6%)	285(5.6%)		
1986	10,507(11.0%)	262(-8.2%)	3,264	
1987	9,455(-10.0%)	242(-7.6%)	2,581(-20.9%)	102
1988	11,006(16.4%)	284(17.4%)	3,090(19.7%)	93(-8.8%)
1989	10,709(- 2.7%)	276(-2.8%)	4,085(32.2%)	117(25.9%)
1990/b			6,377(56.1%)	169(44.4%)
82-89	(5.7%)	(4.6%)		
82-88	(7.1%)	(5.9%)		
87-8	(5.4%)	(3.6%)	(7.8%)	(9.0%)

/a Figures in ( ) are growth rates
/b planned

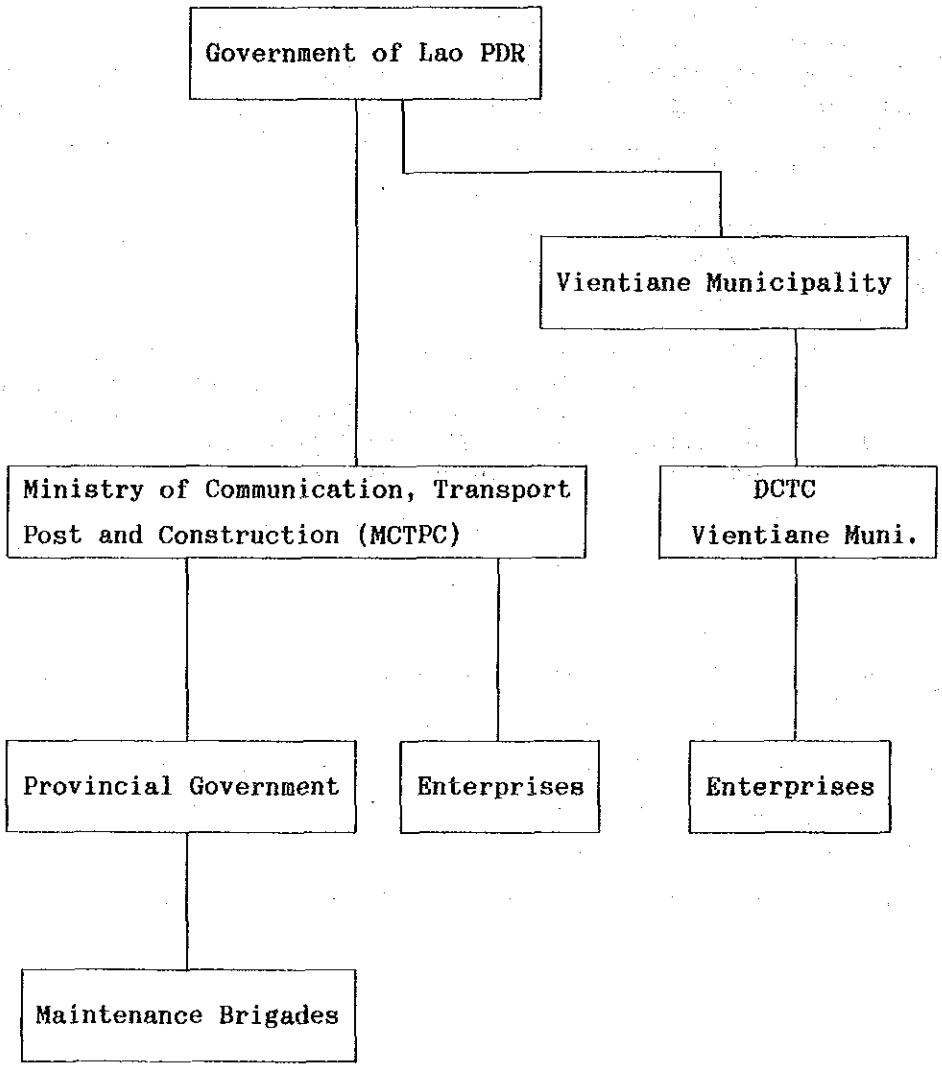
Source: Vientiane Municipality, Vientiane Province, and State Planning Committee, "10 Years of Socio-Economic Development in the Lao People's Democratic Republic," and Ministry of Economy, Planning and Finance, "Basic Data, 88, 89."

The bus company under Vientiane Municipality operates 35 routes with 32 large buses (66 passengers) and 18 micro buses (29 passengers). There are three bus routes crossing Nam Ngum River at Tha Ngon: Vientiane - Ban Keun (3 trips per day). Vientiane - Tanpiao (3 trips per day), and Vientiane - Nakhanthoung (2 trips per day). Private companies also operate buses crossing Nam Ngum River.

3.3 Road

Administration of Roads and Bridges

Administration system for roads and bridges in Lao PDR is as follows:



As mentioned above, roads and bridges in Lao PDR is mainly administrated by the Ministry of Communication, Transport, Post and Construction (MCTPC) with Provincial Governments and Enterprises concerned. MCTPC and enterprises under MCTPC are responsible for construction and maintenance works of the national roads.

A provincial government has responsibility for maintenance and repair works on roads and bridges except national ones by using maintenance brigade.

Road Network in Lao PDR

Road network in Lao PDR is composed of primary road, secondary road, feeder road and special road. All national roads and most provincial roads are classified as primary roads. Other provincial roads belong to the secondary roads.

Total length of road network in Lao PDR is about 13,094km, of which National Roads share 3,486km, Provincial Roads 6,149km and District Roads 3.456km as shown below. Road density in Lao PDR is about 0.055km/sq.km (13,094km/236,800sq.km).

Category	Length(km)
National Road	3,486 Km
	(3,356 Km)/a
Provincial Road	6,149 Km
District Road	3,459 Km
Total	13,094 Km

Note : /a shows figure obtained from CDRI's map.

The trunk route in the Lao PDR is Route No.13 which starts from the southern border of Cambodia, via Vientiane and ends in Luangprabang as shown in Figure. Length of national roads in 1990 are shown as blow.

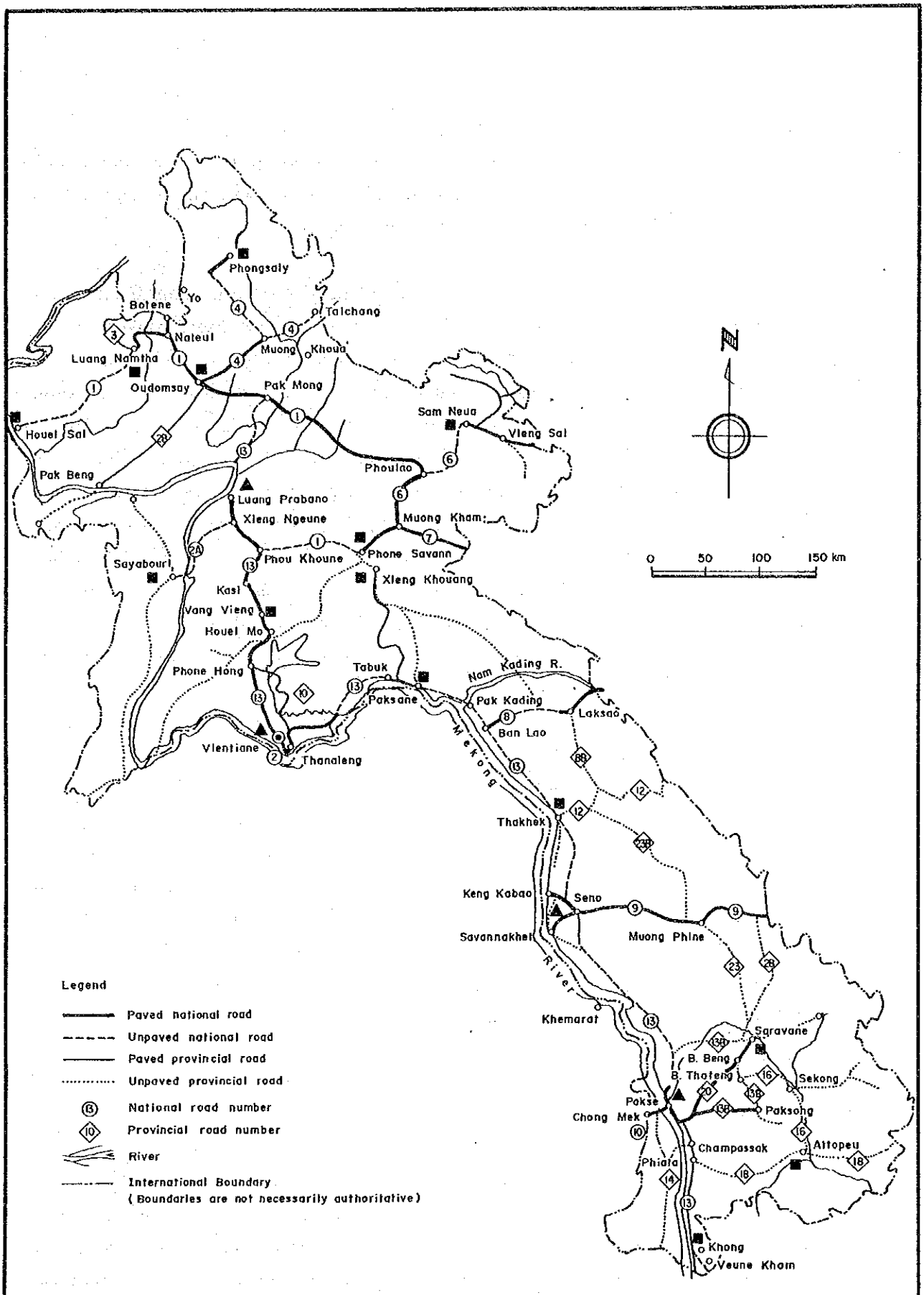
Route Number	Length(km)
No.1	633
No.2	85
No.4	332
No.6	241
No.7	279
No.8	132
No.9	243
No.10	40
No.13	1,371
Total	3,356 km

Source: Communication, Design, Research Institute

Road Conditions

Road lengths classified by the surface type are presented as follows.

Category	Length
Paved	2,560 km
Lateritic/Gravel	3,750 km
Unpaved/Earth	6,790 km
Total	13,100 km



Road Network in Lao PDR

As it can be seen above, paved roads account for only about 2,500 Km or 19.6% of total road length. The remainder is classified as lateritic/gravel or unpaved/earth surface roads.

Since the last decade, the Government of Lao PDR has intended to improve the existing roads and develop new ones to facilitate commodity and passenger flow across the country. As a result, most of Route 13 is upgraded to a good condition with some parts are still being under construction with ADB and Swedish Government assistance. A part of Route 10, the section between Ban Hai and Nam Ngum river was improved with ADB Loan. Route 10 is consisting of two (2) of three (3) meter carriageway, one and a half (1.5) meter shoulders on both sides. Pavement consists of DBST (Double Bituminous Surface Treatment), prime-coat, base course(Laterite mixed with sand or aggregate), subbase course(Laterite). Lime stabilization or cement stabilization with a mix percentage of 1-1.5% was rarely used for base course in Lao PDR.

3.4 Bridges Over Nam Ngum River

Only two permanent bridges at Thinkeo and Ban Hai cross the Nam Ngum River within Vientiane Plain. The other bridges in Vientiane Plain crossing the rivers other than Nam Ngum mostly have a short span or they are of temporary purposes. The existing conditions visually observed on these bridges gave that revier bed protection against scouring are important for this project.

3.5 State Enterprises

Construction and maintenance works for roads and bridges are carried out mainly by the state enterprises. They are primarily established to cover the whole range of each main route. However, only 11 enterprises are active as of July 1990 according to the authorities concerned.

Other than those 11 enterprises mentioned above, 9 maintenance brigades operate for road and bridge maintenance across the Lao PDR. Each brigade is obliged to maintain approximately 200 km of road annually with less amount of equipment compared with other state enterprises. Fundamentally these brigades are required at least for each province. Which means, six(6) or seven(7) more maintenance brigades are necessary in Lao PDR to carry out a sufficient maintenance work. Due to lack of maintenance work, erosion at pavement edges, heavy damages on the pavement (pot holes) in many places have occurred.

4. Ferry Crossing Over Nam Ngum River

4.1 Operation of Tha Ngon Ferry

The public ferry at Tha Ngon operates all day long. The ferry charges are set relatively high to cover operating costs. Since January 1990, the ferry con not be operated in many days because of mechanical problems. No ferry operation has resulted in economic loss due to additional costs of travel on longer alternative routes.

Transport capacity of the public ferry was observed at around 40 passenger car units per hour during dry season. The Nam Ngum crossing time including waiting time at Tha Ngon is about 10 minutes during the dry season.

The ferry boat at Muangkao, upstream of Nam Ngum River was abandoned. The other ferry crossing Nam Ngum River at Hatsiao is small and not accessible during the rainy season.

4.2 Simulation of Nam Ngum Crossing

A simulation based on observations of actual ferry operation revealed that the transport capacity of the ferry is some 18 cars per hour per one direction. With a daily trafic volume of 600 excluding motorcycles, the average crossing time is one hour. The waiting time tremendously increases with more than 600 cars per day.

Hourly traffic volume(one direction)	20	21.5	25	30
Daily traffic volume(two direction)	560	602	700	840
Average crossing time(minute)	31	60	172	447

5. Traffic Survey and Future Traffic Forecast

5.1 Traffic Volume on Route 10, at Tha Ngon

Ban Tha Ngon about 23 km north of Vientiane on Route 10 has a ferry boat facility to cross the Nam Ngum River. At Ban Tha Ngon, traffic volume, number of ferry crossings, alternative routes during no ferry operation and crossing time were surveyed.

As the result of cross-sectional traffic volume survey at Ban Tha Ngon, existing daily traffic is considered between 380 and 740 unit vehicles, including motor-cycles in both directions. In the average, except Sundays and the days when ferry is not in operation, daily traffic volume (day time) is 515 units on both directions, which consists of 246 motorcycles, 64 passenger cars, 61 light trucks (pick-up), 25 medium trucks, 86 heavy trucks, 15 light buses, and 18 heavy buses. If the night volume is considered, this daily traffic volume becomes 524 units instead of 515, this is in accordance with the percentage of night traffic against day time traffic (Night/Day Ratio, 4% max. for passenger car).

The ferry is basically operated 24 hours. In night (10pm - 5am), however, there are following difficulty that driver has to wake up ferry operator to ask operation and night-time fare is 150% of day-time fare. Night time traffic volume, therefore, is very small.

Existing Night/Day Ratio(NDR) at Tha Ngon is very small, when compared with the NDR of Naxaythong. Therefore, the NDR of Naxaythong, shall be used for future traffic volume forecast.

5.2 Cross-sectional Traffic Volume

As aforementioned, cross-sectional traffic volume survey was carried out on February 1990 at Tha Ngon and Naxaythong. Observed daily traffic volume at Tha Ngon, including night traffic, is as follows:

M.cycle	P.Car	L.Truck	M.Truck	H.Truck	L.Bus	H.Bus	Total
250	67	63	25	86	15	18	524

According to the local information, traffic volume in rainy season is usually smaller than dry season. February belongs to dry season in Lao PDR, therefore additional traffic survey was conducted on the 6th of July 1990 at Tha Ngon, from six(6) o'clock in the morning to five(5) o'clock in the evening.

Absolutely, traffic volume is lower than dry season and it takes six (6) to ten (10) minutes to cross the river. This means that crossing time is more than three (3) times that of dry season which is only two and a half (2.5) minutes to cross the river.

Traffic volume however, was about 74% (not a half) that of dry season. Component of traffic was nearly the same as in dry season.

Following figures show observed traffic volume at Tha Ngon on the 6th of July 1990 by the Study Team, during an 11 hour survey.

M.cycle	P.Car	L.Truck	M.Truck	H.Truck	L.Bus	H.Bus	Total
136	40	28	19	57	16	16	312

Therefore daily traffic volume at Tha Ngon, which was observed in February 1990, shall be modified with scrutinized figures obtained through the additional survey.

Adjusted average daily traffic volumes are as follows:

M.cycle	P.Car	L.Truck	M.Truck	H.Truck	L.Bus	H.Bus	Total
224	60	55	24	81	17	18	479

5.3 O-D Survey

Zoning

Before starting the O-D survey, the project area was divided into 12(twelve) zones considering the existing road network, administrative boundary, population and actual traffic flow based upon the collected informations.

O-D Survey Form

O-D survey form was consisting of following questionnaires.

1) Time
2) Type of vehicle
3) Origin
4) Destination
5) Ownership
6) Aim of trip
7) Number of passenger
8) Weight of Load/goods
9) Kind of cargo

Vehicle type was categorized into seven kinds, such as Motorcycle, Passenger car, Pick-up, Medium truck, Heavy truck, Light bus and Heavy bus. Bicycle and pedestrian also counted, but at Tha Ngon only.

5.4 Alternative Route During No Ferry Operation

Because of poor telecommunication system in the Vientiane Plain, most of the vehicles must take alternative routes after arriving at Tha Ngon when the ferry is out of order.

Slightly more than half of the northbound traffic (for Ban Keun/the reservoir) for back to Vientiane and take Route 13. Other alternative routes (take bypass of Route 13 starting from Dongdok and the earth road between Tha Ngon and Naxaythong) can be driven only during the dry season.

As for the southbound traffic (for Vientiane), about two-thirds answered to take the ferry at Hatsiao. Hatsiao ferry,however, is accessible only during the dry season. Hence, during the rainy season, all of the southbound traffic has to take Thinkeo Bridge.

Both southbound and northbound traffic is obliged to travel additional long distance when the ferry does not work.

5.5 Vehicle Operating Costs(VOC)

Vehicle operating costs are divided into two groups: distance related costs; and time related costs. The distance related costs are 1) fuel, 2) oil, 3) tires, and 4) maintenance. On the other hand, time related costs are 5) depreciation, 6) interest, 7) crew costs, and 8) overhead.

VOCs on an actual paved road are estimated as follows:

	M/C	P/C	P/U	M/T	H/T	L/B	H/B
Speed(km/h)	45	70	70	45	45	40	40
VOC (US$/1,000km)	43	149	154	245	555	151	430

Note: M/C=motorcycle, P/C=passenger car, P/U=pick-up, M/T=medium truck, H/T=heavy truck, L/B=light bus, H/B=heavy bus

5.6 Future Traffic Volume Forecast

Traffic Growth Rate

Hence, growth rates of traffic volume be vehicle type at Tha Ngon are estimated as follows:

Period	M/C	P/C,P/U	M/T,H/T	L/B,H/B	Total
1990-2000	13.0%	10.1%	11.5%	10.8%	11.8%
2001-2010	10.7%	8.6%	10.0%	9.3%	10.0%
2011-	6.5%	6.0%	6.5%	6.5%	6.4%

Future Traffic Volume

In accordance with the results of traffic count, and estimated volume of diverted, generated, and developed traffic and estimated growth rates, future traffic volume is forecasted at about 2,000 and around 5,400 in 2010 as shown below.

Year	M/C	P/C	P/U	M/T	H/T	L/B	H/B	Sum	PCU
1990	228	61	58	23	79	14	16	479	576
1996	649	155	144	71	224	27	32	653	1,552
2000	1,172	248	232	121	384	45	53	2,255	2,661
2005	1,776	344	326	178	567	65	75	3,321	3,901
2010	2,948	520	492	288	916	102	117	5,383	6,279
2015	4,021	690	653	393	1,249	139	159	7,304	8,517

Note : PCU = passenger car unit

Without the Project, Nam Ngum crossing time will increase and a part of traffic will switch from Route 10 to Route 13. It is assumed that buses operated up to Nam Ngum River on both sides when the crossing time exceeds an hour and that traffic volume of passenger cars and trucks in Tha Ngon does not exceed the volume which yields average crossing time is 60 minutes. From 2000, no bus crosses Nam Ngum River and from 1999, some traffic diverts from Route 10 to Route 13. In 2010, diversion rate exceeds 50% as follows:

Year	Crossing time(min)	Traffic Volume		Diversion rate(%)
	A	Rt.10 B	Rt.13 C	D=C/(B+C)
1990	11	251	0	0.0
1996	12	465	0	0.0
2000	71	602	11	1.8
2005	763	602	358	37.3
2010	3,634	602	900	59.9
2015		602	1,418	70.2

Note : Crossing time is estimated with total traffic volume(B+C). Motorcycles are not included in traffic volume.

6. Route and Bridge Type Selection

6.1 Route Selection

Alternative Routes

As candidates of the new route, Six(6) alternative routes were selected.

Route No.1

On the existing ferry crossing with maximum use of the existing road

Route No.2

To facilitate the construction of substructure, 100 meter down stream of the existing ferry crossing, use of sandbar/holm

Route No.3

Eschew sweeping bend of the Nam Ngum River, minimum bridge length

Route No.4

As an alternative to No.3, to shun the political school

Route No.5

Shift 600-700 meters upstream of Route No.6 to avoid inundated area on Route No.6

Route No.6

Bypass the Ban Tha Ngon Village, Pass-over the River through Tha Ngon Farm

Final Route Selection

Among the six alternatives, most suitable route, as the final candidate, were selected with following check items.

1. Stability of river bed
2. Length of bridge
3. Relation with twonship
4. Existing land use
5. Length of approach roads
6. Erosion/scouring by water flow

Comparison study among the alternatives was conducted and selected route as final candidate is Alternative No.4. After that, detailed site investigation was implemented such as topographic survey, site reconnaissance.

In accordance with the actual circumstances along the selected route, modification and shifting the selected route was made from the view point of;

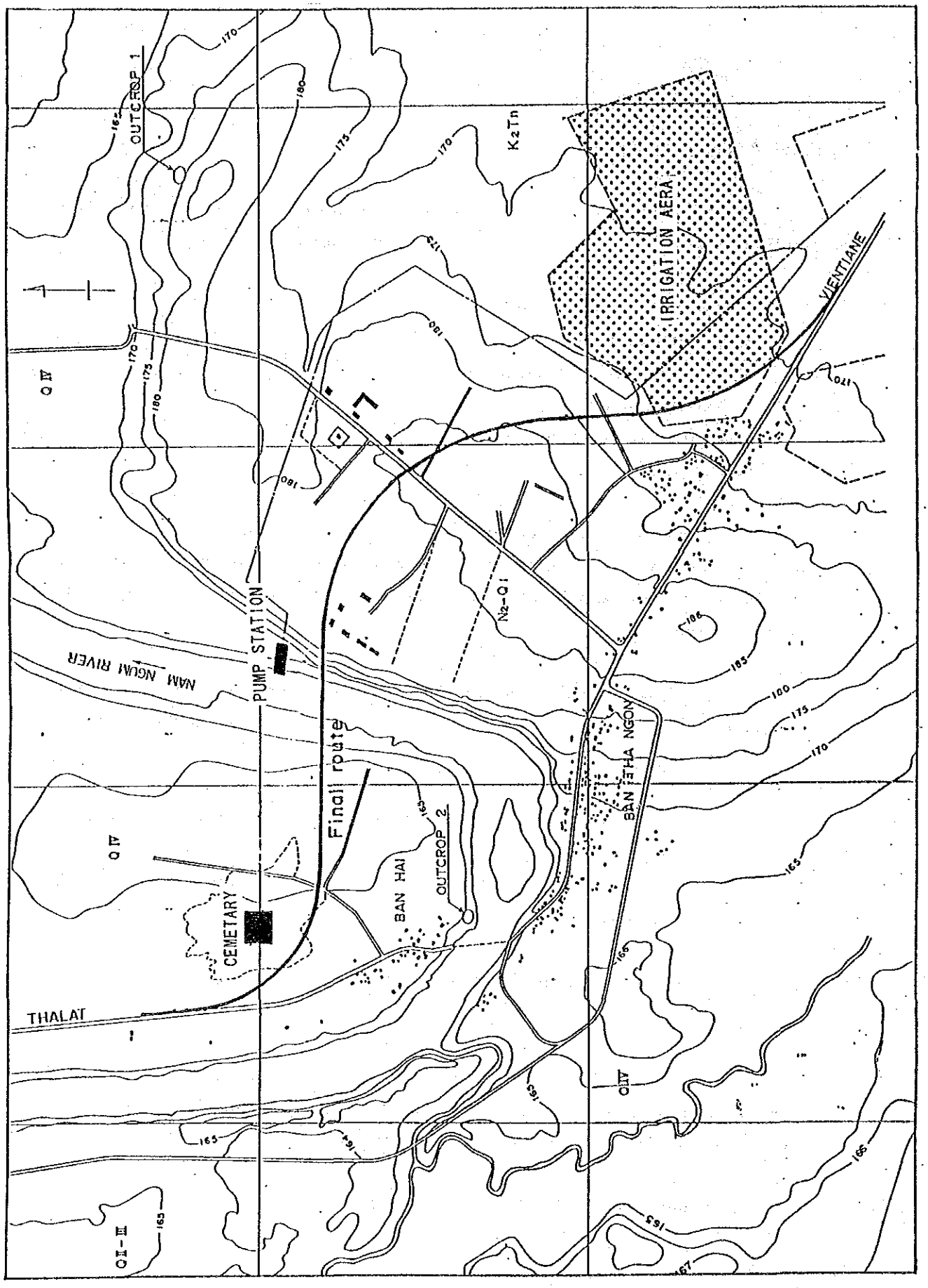
1. to eliminate disturbances to the irrigation area (under planning)

2. provide more space between pump station for the irrigation project and the bridge; and

3. to avoid the cemetery in Ban Hai area.

Above mentioned conditions along the route caused the center line to move or shift from original planned location. In Ban Tha Ngon area, the center line was moved to west and/or upstream side, in two places.

Alignment of the final route is shown in the following figure.



Alignment of Final Route

6.2 Bridge Type Selection

Selection Flow

11 types of superstructure were proposed for the evaluation mainly in terms of the split number of the spans with expression of the structural characteristics and materials of the bridge. Subsequently, 6 alternatives were entailed for selecting the type of substructure. After a comparative study on the superstructures of the alternatives, 4 bridge types were chosen for further detailed comparison. Consequently, one out of 4 alternatives was finally concluded for the basic design through the precise comparative studies on the basis of several evaluation criterions as indicated in the figure. As of the type of the substructure, one of the alternatives was chosen by direct comparison in order to cope with the requirements of the superstructure, and will be employed for the basic design.

Type of Pier/Foundation

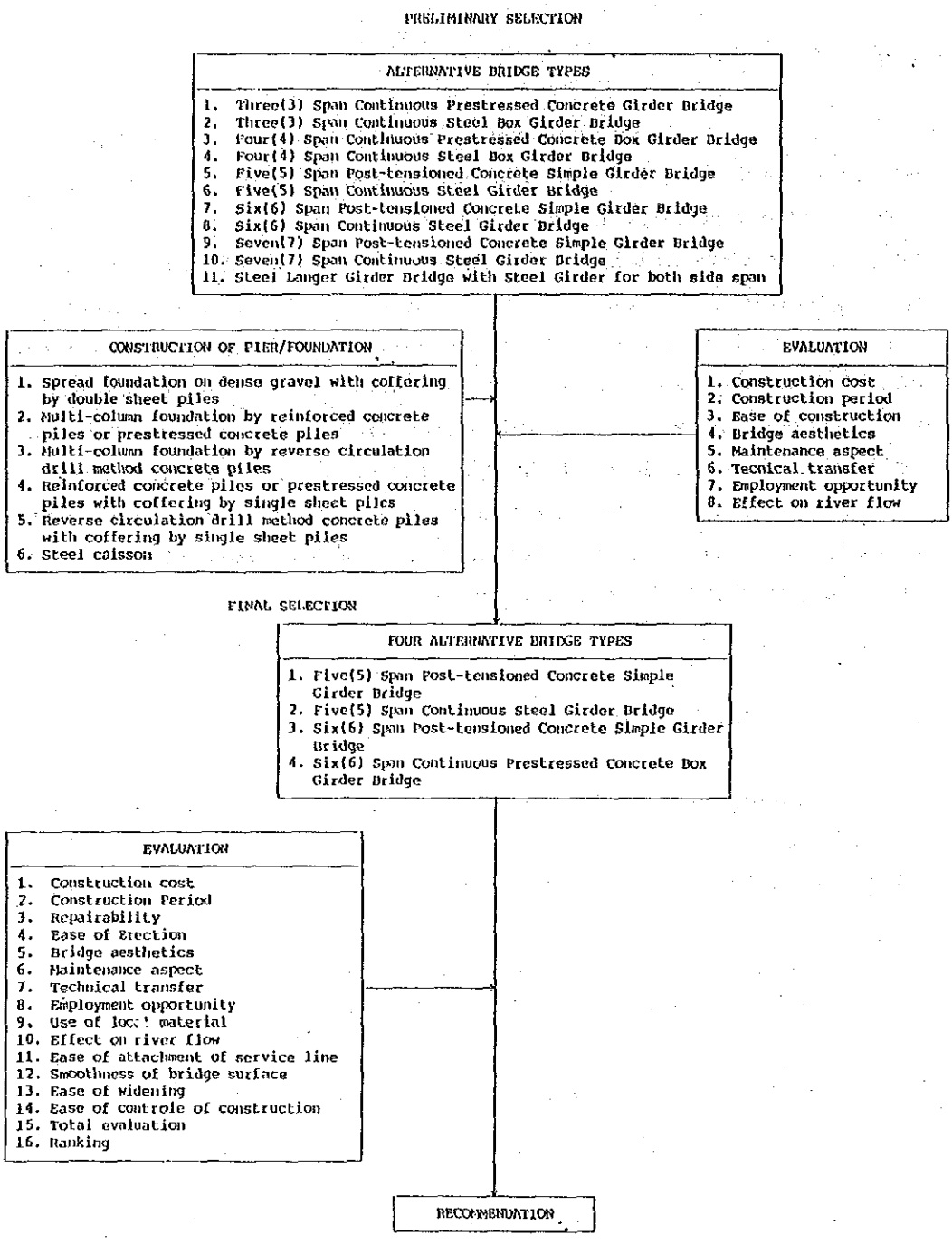
Considering that the type of pier/foundation and its construction method directly affects the cost and term (time), several possible alternatives, with regards to the foundation, are proposed as follows:

a) Spread foundation on dense gravels, which requires the coffering work by double sheet piles in the river

b) Multi-column foundation by reinforced concrete piles or prestressed concrete piles

c) Multi-column foundation by reverse circulation drill method concrete piles, the foundation is constructed below the L.W.L.

d) Reinforced concrete piles or pre-stressed concrete piles, the foundation is constructed below the L.W.L., and requires coffering by single sheet piles



Flow Chart for Selection of the Bridge Type

e) Reverse circulation drill method concrete piles. The foundation is constructed below the L.W.L. and requires coffering by single sheet piles

f) Steel caisson

Above 6 construction methods for foundation have been examined. After that, it was decided to employ the Multi-column Foundation by Reverse Circulation Drill Method Concrete Piles (Method C) for the foundation works.

Final Selection

The 4 alternatives which are given higher marks in the preliminary selection are:

1) 5 span post-tensioned concrete simple girder bridge (Type 5)

2) 5 span continuous steel girder bridge (Type 6)

3) 6 span post-tensioned concrete simple girder bridge (Type 7), and

4) 6 span continuous pre-stressed concrete box girder bridge (Type 7.2)

As a result of the evaluation developed above, the type of 5 Span Post-tensioned Concrete Girder (Type 5) has been finally selected for the basic design.

7. Physical Condition Survey

7.1 Topography

Collection of topographic maps and aero-photographs were a part of topographic survey as preliminary or preparation works. Sounding of the Nam Ngum River Bed was also conducted during the field work.

Topographic survey was implemented on the selected route(Alternative Route No.4 which was selected as the most suitable route) to identify detailed circumstances along the route, in a manner to employ a local surveying company.

Topographical Survey

The Survey and Design Institute of Vientiane Municipality was employed as the local survey team to carry out topographic survey on alternative route No.4. This topographic survey consisted of route survey, and site mapping as described in detail below:

a) route survey(1/2,000)

traverse, centerline setting, longitudinal, cross section, bench mark setting

b) site mapping(1/300)

bridge site survey consisting of plane, cross section,

Route surveying and centerline setting was carried out on each 20 meters as minimum distance with survey width of 200 meters along the centerline. Five(5) Bench Marks along the route, three(3) in Ban Tha Ngon side and Two(2) in Ban Hai side were also set.

Site mapping at bridge site was carried out for 200 meters x 100 meters(20,000 sq. meters or 2-ha) on each bank with a total survey area of 40,000 sq.meters(4-ha).

Total length of surveying ran into 3,700 linear meter including river crossing.

Sounding

Sounding of river bed where the bridge crosses Nam Ngum river was conducted with a total width of 100 meters both upstream and downstream side from road centerline. River crossing is approximately 250 meters.

7.2 Geology and Soil

Geology along the proposed route shows that the construction site is generally composed of alluvial low lands and diluvial highlands. The basement complex is sandy rock belonging to Neogene period. There is a firm strata of diluvial gravels from the Neogene period under the alluvial deposits at both banks where the proposed bridge is crossing Nam Ngum. Most of the access road on the right bank is passing through the diluvial highlands and will be constructed by cutting the diluvial deposits with a maximum cut slope of 5 meters deep. The materials to be excavated from the surface layer of about 5 meters is of sandy soils containing gravels, and can be used for fill works, however, those to be excavated from the deeper layers are swelling clays, which the use of such materials require cautious examinations.

All of the access road on the left bank will be constructed on the alluvial low lands composed of soft clays, and considerable consolidation characteristics shall be taken into consideration for the design of fill works.

Soil Condition

Project area is divided into two geological categories; the diluvial plateau formed on the Vientiane valley of the Neogene and alluvial deposits on the low lands belonging to the diluvial layers.

The soil profile on the bridge section shows that the foundation of the abutments and piers will be established in the layer of alluvial gravels or the hard sandy rocks of Neogene period. The thickness of these alluvial gravels extend about 6 to 7 meters.

It is observed that considerable extent of erosion have occurred due to repeated swelling of water on the right bank slopes of alluvial deposits around the elevation 166.0 meter.

On the other hand, the bore hole investigation shows that the following problems will occur during the construction of the abutment on the left bank.

a) Settlement of the back fills
b) Lateral flow of the abutment
c) Negative frictions on the pile foundations
d) Deformation of the bank due to the change of river water level

Bridge Foundations

Bore hole investigations show that piles should be established in the sandy gravel stratum approximately 5 meters below the riverbed. Soil bearing capacity on this stratum, with SPT value of more than 30, empirically provide about 300t/sq.m of ultimate bearing capacity.

However, it should be ensured that the foundation depth is below the level of eroded riverbed by scour during floods. It is recommended to provide a means of protection for the pier footing such as gabion or concrete blocks.

Left bank abutment should be founded in the same stratum with the piers, approximately 14 meters below the existing ground level.

For right bank abutment, the bearing capacity of the soil at 6 meters below the existing ground level is expected to be 40ton/sq.m. This abutment is envisaged to impose ground pressures of 24t/m^2 on 7 meters x 11 meters foundation.

The abutment height would be more than 15 meters when foundation on the level described above is employed, which will cause a higher construction cost. So as to reduce the abutment height and construction cost, soil will be replaced with lean concrete up to a depth of 3 meters below the foundation level.

7.3 Material Investigation

River sand and gravel, available from the Nam Ngum river, have been used for construction material in the project area. However, these materials are not suitable for the use of bridge construction due to poor quality and limited quantity.

River gravel and sand from Mekong river in Vientiane city is also commonly used as construction material but the gravel is produced unscreened without quality control. It is not recommended to use these materials for bridge structure which requires a high strength concrete. Sand suitable for concrete is available around Vientiane city, and no crushed stones are produced around the project area.

7.4 Meteorology

Temperature

The annual mean temperature is around 26 degree Celsius, it is dry and cool from October to may. The highest temperatures are

usually recorded in April before the start of the monsoon, while the lowest temperatures are normally recorded in December and January. The project area lies in humid a subtropical area with monthly mean relative humidity of 70%.

Rainfall

The project area is in a humid subtropical zone. Dry and wet seasons are the two distinct seasons, with dry season lasting from October to May and the wet season from June to September. Monsoon season starts in June and ends in September. Annual average rainfall is approximately 1,640 mm, of which 70% is concentrated during June and September. Monthly mean rainfalls are as follows:

Monthly mean rainfall (1970-1989)

Month	Rainfall(mm)	Month	Rainfall(mm)
Jan.	7.1	July	271.4
Feb.	12.5	Aug.	326.9
Mar.	35.1	Sep.	283.2
Apr.	81.5	Oct.	98.6
May	244.7	Nov.	8.8
Jun.	268.6	Dec.	3.8

Year Total : 1642.2-mm

Wind

Strong winds with heavy rains occur during summer monsoon which comes in June and ends in September. Annual mean instantaneous maximum wind velocity is 20.3m/sec.

Earthquake

Project area is located in the western edge of the earthquake belt referred as the Burma arc, frontal structures of the Trans-Asiatic zone in Asia. Intermediate shocks are frequent near the north of Burma (24 degree North, 93 degree East). One of the mountain ranges of the Burma arc extends to northern part of Laos. Shallow earthquakes have occurred on this mountainous area with the magnitudes from 3.4 to 4.4.

7.5 River Hydrology

River Conditions

The Nam Ngum River is one of the major tributaries to the Mekong (main stream for Lao PDR). It takes its origin in the plateau of Xiangkhoang at 1,000 to 1,500 meters above mean sea level. It flows down about 240 km to reach Nam Num Reservoir, which was constructed in 1971. The Nam Lik river, the largest tributary to the Nam Ngum with a catchment area of 5,115 sq. km at Hinhoup gauging station, flows into the Nam Ngum river at Tha Lat about 4 km downstream from the Nam Ngum dam. After joining with the Nam Lik, the Nam Ngum river meanders through Vientiane Plain for about 80 km southerly to reach Tha Ngon and another 80 km easterly until it flows into the Mekong river at Pak Ngum.

1) *Catchment area*

The surface water catchment area of the Nam Ngum river at the Nam Ngum Dam is 8,460 sq.km. It increases to 14,200 sq.km after joining with Nam Lik at Tha Lat. At Tha Ngon, the catchment area is 16,500 sq.km and 17,340 sq.km. at Pak Ngum confluence with the Mekong.

2) Flood Frequency Analysis

The peak discharge for different return periods at Tha Ngon gauging station have been analyzed by Gumbel method from the annual flood records for past 18 years, since the completion of Nam Ngum Dam.

The results are as follows:

Year	Return Period(year) 2	5	10	25	50	100
Discharge (qu.m/sec)	2,460	3,180	3,670	4,280	4,730	5,180
Flood Level(m)	164.5	166.4	167.3	167.5	167.6	167.7

Design Discharge and High Water Level

The following were considered for determining the design discharge.

a) More increased discharge would be expected in future due to development of logging, cultivation, etc. in the catchment area

b) There is a backwater effect from the Mekong river

c) Maximum recorded water level was 167.62 meter in 1981

From these factors it is recommended that the design flood level is to be taken as 168.0 meters, which is associated with approximately 100-years return period.

Scouring

Results of river sounding conducted at the proposed bridge shows that cross section of the river bed is triangular with the greatest depth at the right bank side. It seems to be eroded due to the effect of sharp upstream bend. The piers on the right bank would be inducing more scour than the ones on the left bank.

River bed consists very loose fine sand to a depth of 3 to 4 meters. This layer is underlain by gravel which will likely to resist scouring.

It is considered that this loose fine sand of the river bed would be scoured when piers are constructed. Thus, the pier foundation should be established on the hard layer below the loose fine sand and protection against scouring be provided around piers, according to the information obtained from construction records of Thinkeo Bridge as mentioned before.

8 Preliminary Design

8.1 Design Policy

As a design policy for the Project, following matters shall be taken into consideration:

a) use of Lao's design standards as much as possible
b) provide countermeasures for scouring
c) ease of maintenance in the future
d) technology transfer

Other than above, there are some environmental aspects to be considered both during the project planning and post construction.

Construction Stage(during construction work)

a) Silt runoff into river from cut sections of approach roads and bored pile construction might affect the pump operation which has been planned downstream of the Project

b) Silt runoff from fill sections into paddy fields

Post Construction

Borrow pits left without a proper resurfacing or replacement would result in continuous excessive erosion.

8.2 Design Requirement

Standards for previous projects in Lao PDR shall be studied for the maximum use of Lao standards.

Design standards used for road construction in Lao PDR are established by modifying the Lao standards with foreign countries' standards. They differ by project. No definite standards, therefore, is yet provided.

For the Project, therefore, design standards used for Road No.10 improvement project will be employed as basic standard with several modifications based on the Japanese standards.

Meanwhile, Lao PDR has no design standards for bridges. Thus Japanese bridge standards will be applied.

8.3 Road Design Standard

Standards to be used for the Project are established and summarized as follows.

Item	Figure
Average Daily Traffic(for Design)	500 - 4,000
Terrain	Flat
Design Class	Grade 3-1 & I
Design Speed(Km/hr)	80
WIDTH	
One Lane(m)	3.0
Shoulder(m)	L=1.50 R=1.50
Roadway(m)	9.00
Minimum Radius(m)	450.00
Maximum Gradient(%)	4.00
SIGHT DISTANCE	
Passing(m)	160
Stopping(m)	500

8.4 Bridge Design Standard

Bridge Design Standard

The following basic design criteria will be applied for the bridge design.

1) Design Standards:

The current Japanese Standard "Specifications for Highway Bridges" will be used.

2) Carriageway loadings:

The decks are designed to carry T-20 loadings, and L-20 loadings for the main girders, as in Japanese Standards.

3) Sidewalk loadings:

The sidewalk loading is 350 kg/m^2.

4) Seismic loading:

Surface acceleration of 0.05G will be adopted for design.

5) Wind Speed:

The design basic wind speed is 40 m/sec.

6) Temperature:

The design temperature range is $\pm$15°C.

7) Collision load on parapet:

2 ton/m

8) Materials and allowable stress:

a) Concrete for main structure;

	Bored Pile	Substructure & Curb	Main Girder
Specified compressive strength (kg/cm^2)	σck=300	σck=240	σck=350
Young's modulus (kg/cm^2)	$2.8x10^5$	$2.5x10^5$	$2.95x10^5$
Unit weight (t/m^3)	2.5	2.5	2.5
Flexural extreme fiber stress (kg/cm^2)	70	80	125
Axial compressive stress (kg/cm^2)	65	65	85
Shear stress (kg/cm^2)	3.9	3.9	5.0

b) Prestressing bar:

Prestressing strand will be used for longitudinal steel and prestressing bar for lateral steel.

c) Reinforcing bar

Reinforcing bar conforming SD35 of JIS G3112 (Deformed steel bar) or equivalent will be used.

Allowable stresses are shown below.

For ordinary members : 1,800 (kg/cm^2)
For slab : 1,400 (kg/cm^2)
For members in water or below ground-water level
: 1:600 (kg/cm^2)
Yield stress : σsy= 3,000 kg/cm^2

9) Backfill Material

Unit weight: r = 1.8 t/m^2

Internal friction angle: ϕ = 30°

Cohesion of soil: c = 0

Earth pressure coefficient in passive earth pressure between concrete wall and soil:

In normal case; kah = 0.304 kav = 0.054

At the time of earthquakes; kah = 0.363 kav = 0

10) Stability

Stability against overturning:

In normal case; e<B/6

At the time of earthquakes; e<B/3

Stability against sliding

In normal case; F>1.5

At the time of earthquakes; F>1.2

Stability for bearing:

In normal case; qa = 40t/m^2

At the time of earthquakes; qa = 60t/m^2

Coefficient of friction between foundation ground and bottom of foundation; μ= 0.6

11) Design flood level:

Bsed upon the flood records, 168.0 meter was employed as design flood level. This figure is same as flood level of 100 year return period, unexpectedly.

168.00m (100-years return period)

12) Applicable Standard:

"Specifications for highway Bridges" issued by Japan Road Association shall be applied.

I. Common specifications

III. Concrete Bridge

IV. Substructures

8.5 Preliminary Design for Road

Outline of the Construction Site

Construction site belongs to the Ban Tha Ngon, Ban Na and Ban Hai. These villages are in the administrative area of Xaythani of Vientiane Municipality.

Area spreads on a flat and hilly terrain with elevation varying from 168 meters to 187 meters above sea level. Both left and right sides at the starting point are occupied with paddy fields and a few houses are located on right hand side of the existing road. This area has an irrigation system development plan which will be implemented in the near future.

Following to pass the flat terrain, the route enters the out skirts of Ban Na residential area. The route crosses the existing feeder road which is separated from Route No.10 in front of Tha Ngon market and heads to reach the Tha Ngon firm through the fish pond. This feeder road crossing on the route, locates the highest point in the Project. Area where route is passing along is mainly categorized as bushy lands and a small few part is classified as residential areas (out skirts of villages) and paddy fields.

Beyond the intersection with existing feeder road, route takes place close to the cooperative training school of the Ministry of Agriculture, after running along the bushy area between meteorological station and political school.

After crossing the Nam Ngum river, route runs through the wild-cultivated areas with straight alignment and skirts the forest to avoid disturbance to the local cemetery in the forest. There are only two houses close-by the route in Ban Hai side.

Right of Way

In accordance with Lao PDR's regulations, there is two standards for Right of Way. 30 meters of Right of Way is used for Provincial Roads and 40 meters for National Roads. Because this project is planned on the Provincial Road No.10, 30 meter Right of Way will be adopted to reduce the land acquisition cost.

Structure of Road

Existing road connected with the approach road has two(2) lanes of three meter carriageway (total 6-meters) and 1.5 meter shoulders on both sides.

The carriageway and shoulder widths in the Project, therefore, are to be at least same with the existing Route No.10 and no stage construction method is considered for the approach road.

Layer system(structure) of the road shall be durable for the planned life time of the pavement. Usually it would be 20 years including annual and periodic maintenance. Layer system for the project will follow the existing pavement structure employed in the actual Route No.10.

Pavement

Pavement shall consist Subbase Course, Base Course and Surface Course. Subbase Course having a 20 cm thickness shall be constructed with lateratic soil and/or lateratic soil mixed with river gravel. Base course, on the other hand, is a mixture of river gravel with lateratic soil. It should have a thickness of 15 cm.

Road surface will be covered by DBST(Double Bituminous Surface Treatment) by using screened river gravel. This type of pavement, however, is considered as a "Low Cost Pavement" and therefore annual maintenance is indispensable. Periodic maintenance shall also be required every 7 years to keep serviceability of the road for a safe and comfortable drive.

8.6 Preliminary Design for Bridge

The overall length is so defined that front face of the abutments will be located at the intersection of high water level with the extension of bank slope, this results with an overall bridge length of 230 meters and bridge is skewed about 5 degrees towards upstream.

Overall width of the bridge will be 11.0 meters, consisting 7.5 meters of carriageway, 2.5 m of sidewalk on one side, and 0.4 m and 0.6 m of parapet on both sides.

The 7.5 m of carriageway have two of 3 meters traffic lanes and 0.75 meters of reduced shoulder, which corresponds to the Class III of the Design Standard currently used in Lao PDR.

Sidewalk and balcony will be provided on the upstream side as the area has become prosperous on that direction.

8.7 Preliminary Bill of Quantities for the Works

The following table shows the quantities of the work based on the preliminary design.

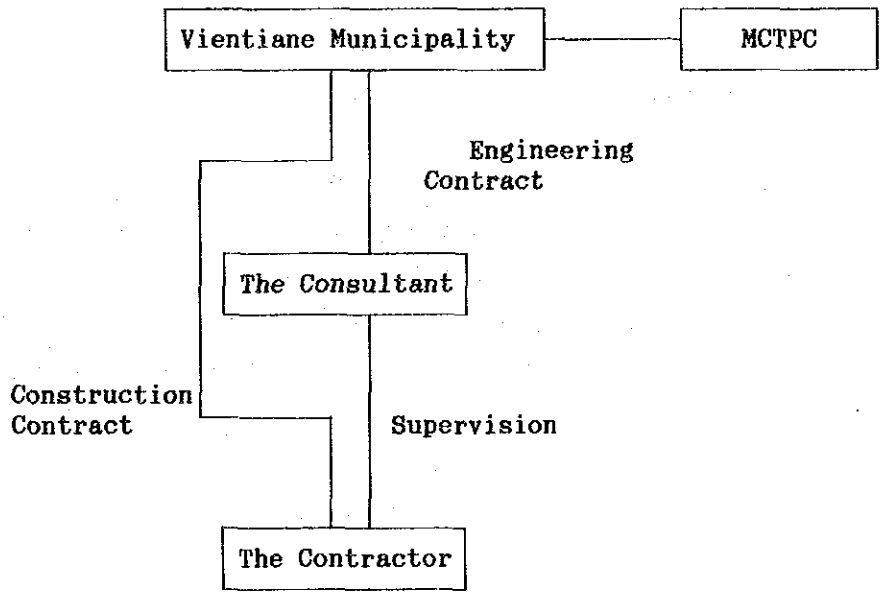
Description	Class	Unit	Quantity	Remarks
(1) Pile Foundation				
Bored pile	1.5m dia		30	15m length
Concrete	$\sigma 28$=300kg/cm^2	m^3	890	
Reinforcing Steel	D13-D25	t	93	
Casing		m	394	
(2) Sub-structure				
Excavation		m^2	10,600	
Concrete	$\sigma 28$=240Kg/cm^2	"	1,790	
	$\sigma 28$=150Kg/cm^2	"	490	
Formworks		m^2	2,190	
Reinforcing Steel	D13-D25	t	237	
(3) Super-structure, 30 nos. of girder				
Concrete	$\sigma 28$=350Kg/cm^2	m^3	1,190	
	$\sigma 28$=240Kg/cm^2	"	390	
Formworks		m^2	1,400	
Prestressing steel		kg	71,500	
Grouting		m	11,500	
Reinforcing Steel	D13-25	t	181	
(4) Approach Road, 3.35 km length				
Subgrade		m^2	33,585	
Base course		"	31,234	
Double bituminous surface treatment		"	26,868	

9. Construction Plan and Cost Estimate

9.1 Implementing Agency

The Vientiane Municipality will be the agency to superintend the Project under the jurisdiction of the Government of Lao People's Democratic Republic.

The project implementing organization is proposed as follows:



It is proposed that MCTPC should assist Vientiane Municipality with implementing the project for relating to the engineering arrangement.

9.2 Construction Plan

Maximum Use of Local Resources

The following should be given a particular consideration through the project implementation:

a) Maximum use of local construction material and equipment,
b) Creation of employment opportunity in the locality.

Special Consideration

Capacity of Local Contractor

The competent foreign contractors shall be involved in the construction works. Subletting of primary part of the bridge works to the local contractors will not be expected, as they have no qualified engineering personnel with part of experience for this type of bridge construction. As for approach road, a few local construction enterprises have a capacity to undertake the subletted work but their work output will be substantially limited.

Local Labour

There are no governing labour laws in Lao PDR. The foreign contractors shall recruit labour through the local firms and provide safety control measures spontaneously to prevent conflict with local labour.

Construction Material

The local construction material are very scare. The available materials are limited to aggregates, bitumen and timber only. Almost all the major construction materials will be generally imported from foreign countries.

Construction Equipment

Most major construction equipment and facilities will be mobilized from abroad except for some earth moving machines which can be hired out from local contractors.

Rainy Season

As all the pier construction work will be carried out in the river, the construction time will be limited especially in rainy season, during which there should be paid special care to safety control for the construction work.

Erection of Girder

The girder of proposed bridge weighing more than 100 ton will be erected by using a temporary erection steel girder, which requires high technical control of safety. Careful planning should be made prior to starting the work.

9.3 Work Plan

Temporary yard of some 18,000 m^2 will be opened on Tha Ngon village side to accommodate the site office, concrete plant, warehouse, workshop and other temporary facilities.

PC girder casting yard will be provided adjacent to the site of the right abutment, where two fabricating bases and stock yard for 20 girders will be prepared.

Water used for construction are to be taken from the river. Contractor's staff houses and liaison office will be arranged in the Vientiane city.

Temporary Bridge and Platform

Six meter wide temporary bridge facility will be erected crossing Tha Ngon at around El.161.00 for submergible works of in situ concrete piles and pier construction, and for transportation of construction material to left bank side. The facility comprises steel H-pile bent and H-beam with steel deck plate. H-pile will be driven by vibrating hammer. 5-platform for in situ concrete piles of steel H-pile bent and steel deck plate are separately constructed at around El 155.70.

In Situ Concrete Pile

In situ concrete piles are constructed for the foundation of the piers and left bank abutment. The piles are designed of 1500 mm in diameter and 15 meter long. All the piles are constructed by the reverse circulation method which comprises power unit and crawler crane mounted on the separate pontoons, and rotary table on the platform.

a) Driving stand pipe by vibrating hammer.
b) Drilling by reverse circulation drill
c) Measuring excavation depth and removing slime
d) Insert reinforcing cage
e) Placing concrete by tremie method

Footings and Piers

Footings and Piers

The footing of piers will be so constructed that the top of piles be submerged at the expected low water level(154.5m) to prevent the piles from deterioration due to the repeated dry and wet conditions.

Approach Road

Considerable amount of fill material of about 50,000 m^3 in Ban Hai side will be required for the road section on Ban Hai Side. Material from side borrow will not be enough for the work and most of all material have to be hauled from the borrow pits near Hatkiang. The rate of filling work should be limited to nearly 10 cm high per day to prevent possible ground failure because of the soft ground area. Pavement work also should commence about 6 months later of the completion of filling work in order to mitigate residual settlements. *Selected material from borrow pit will be used for the subgrade.*

Right Side Bank

Construction of access road to bridge site Ban Tha Ngon on the Ban Na Side is primarily required for starting the bridge works. The erection of temporary bridge facility and girder casting yard of approximately 39,000m^2 will be prepared along the access road. These material will be disposed at low ground around the site.

Access to the Construction Site

Existing straight road originating in the front of Tha Ngon market directing to Tha Ngon firm will be used for preliminary access means to the site for preparation works. This existing road has 6 meters width carriageway in general with one meter wide shoulder on both sides. The pavement of this road, however, is of single surface dressing which,